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Effectiveness Of Jigsaw Cooperative Learning Strategy in Enhancing Geometry Performance and Retention Among Senior Secondary School Students in Katsina State, Nigeria

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Abstract- ***This study investigated the effectiveness of the Jigsaw cooperative learning strategy in enhancing academic achievement and retention in geometry among senior secondary school students in Katsina State, Nigeria. The study was motivated by persistent poor performance in mathematics, particularly in geometry, attributed to the use of conventional teaching methods. A quasi-experimental research design involving pre-test, post-test, and delayed post-test measures was adopted. A sample of 120 Senior Secondary School II (SSII) students was selected and assigned to experimental (Jigsaw strategy) and control (lecture method) groups. Data were collected using the Geometrical Concepts Performance Test (GCPT), which was validated by experts and yielded a reliability coefficient above acceptable standards. Descriptive statistics (mean and standard deviation), independent samples t-test, effect size (Cohen's d), and analysis of covariance (ANCOVA) were used for data analysis. The results revealed that students exposed to the Jigsaw strategy performed significantly better than those taught using the conventional method in both achievement, $t(118) = 33.84$, $p < .001$, and retention, $t(118) = 39.27$, $p < .001$. The effect sizes were very large ($d = 6.15$ for achievement and $d = 7.34$ for retention), indicating strong practical significance. ANCOVA results further confirmed that the differences remained significant after controlling for pre-test scores. No significant gender differences were found in either achievement or retention. The study concluded that the Jigsaw cooperative learning strategy is highly effective in improving students' understanding and long-term retention of geometry concepts. It is recommended that mathematics teachers adopt cooperative learning strategies to enhance students' academic outcomes.***

Keywords: ***Jigsaw strategy, cooperative learning, geometry, academic achievement, retention***

I. INTRODUCTION

Education plays a vital role in shaping individuals' intellectual abilities and preparing them for meaningful participation in society. Within the school system, the choice of instructional strategies significantly influences students' learning outcomes, particularly in subjects that require high levels of reasoning and abstraction such as mathematics. This study therefore examines how an innovative teaching approach—the Jigsaw cooperative learning strategy—can improve students' understanding and retention of geometry concepts.

Background of the Study

Mathematics is universally recognized as a foundational subject that underpins scientific, technological, and socio-economic development. It equips learners with essential skills such as logical reasoning, problem-solving, and critical thinking necessary for national development and global competitiveness (Federal Republic of Nigeria, 2013). In Nigeria, mathematics is a compulsory subject at both primary and secondary school levels, reflecting its central role in the educational system. Despite this importance, students' performance in mathematics in both internal and external examinations, such as those conducted by WAEC and NECO, has remained consistently poor, particularly in key areas like geometry (WAEC, 2023).

Geometry, which deals with shapes, sizes, spatial relationships, and properties of figures, is a vital

component of the mathematics curriculum. However, it is often perceived by students as abstract and difficult, leading to low interest, anxiety, and poor academic performance (Adolphus, 2011; Umaru et al., 2013). This challenge is more pronounced in many secondary schools in Katsina State, where conventional teaching methods—especially the lecture method—continue to dominate classroom practice. These teacher-centered approaches often limit students' active participation and fail to address diverse learning needs, thereby hindering meaningful understanding of geometric concepts (Galadima, 2002).

In response to these challenges, educational researchers have advocated for the adoption of innovative, student-centered instructional strategies that promote active learning and engagement. One such approach is the Jigsaw cooperative learning strategy. The Jigsaw method, developed by Elliot Aronson and colleagues, is a cooperative learning technique that encourages students to work collaboratively by dividing learning tasks among group members and requiring each student to teach others what they have learned (Aronson et al., 1978). This strategy promotes positive interdependence, individual accountability, and active participation, which are essential for effective learning.

Research has shown that cooperative learning strategies, including the Jigsaw method, can significantly improve students' academic achievement, retention, and social interaction skills (Johnson et al., 2000; Slavin, 2020). By engaging students actively in the learning process, such strategies help to deepen conceptual understanding and enhance long-term retention of knowledge. However, despite the growing body of evidence supporting cooperative learning, its application in teaching geometry within the context of secondary schools in Katsina State remains limited.

Statement of the Problem

Despite the recognized importance of geometry in developing students' cognitive and spatial reasoning abilities, many secondary school students in Katsina State continue to perform poorly in this area. Persistent low achievement in geometry has been largely attributed to the continued use of conventional lecture-based teaching methods, which often do not actively engage students in the learning process (Abdullahi, 2019). While cooperative learning strategies such as the Jigsaw method have demonstrated effectiveness in improving academic performance in various contexts, there is limited empirical evidence on their impact specifically on geometry performance and retention among senior secondary school students in Katsina State. This gap necessitates an investigation into whether the Jigsaw strategy can provide a more effective alternative to conventional teaching methods.

Objectives of the Study

The main purpose of this study was to determine the effectiveness of the Jigsaw cooperative learning strategy in improving academic achievement and retention in geometry among senior secondary school students in Katsina State, Nigeria.

The study specifically sought to:

1. Determine the effect of the Jigsaw strategy on students' academic achievement in geometry.
2. Examine the effect of the Jigsaw strategy on students' achievement in geometry based on gender.
3. Determine the effect of the Jigsaw strategy on students' retention of geometry concepts.
4. Examine the effect of the Jigsaw strategy on students' retention based on gender.

Research Questions

The following research questions guided the study:

1. What is the difference in academic achievement between students taught geometry using the Jigsaw strategy and those taught using the conventional method?
2. What is the difference in academic achievement between male and female students taught using the Jigsaw strategy?
3. What is the difference in retention between students taught using the Jigsaw strategy and those taught using the conventional method?
4. What is the difference in retention between male and female students taught using the Jigsaw strategy?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

1. There is no significant difference in the academic achievement of students taught geometry using the Jigsaw strategy and those taught using the conventional method.
2. There is no significant difference in the academic achievement of male and female students taught geometry using the Jigsaw strategy.
3. There is no significant difference in the retention of students taught geometry using the Jigsaw strategy and those taught using the conventional method.
4. There is no significant difference in the retention of male and female students taught using the Jigsaw strategy.

II. LITERATURE REVIEW

This section reviews relevant literature on the Jigsaw cooperative learning strategy and its application in teaching geometry. It examines the conceptual basis of the strategy, the theoretical foundations underpinning cooperative learning, and recent empirical studies on students' achievement and retention in mathematics. It also highlights gaps in the literature that justify the present study.

Concept of Jigsaw Cooperative Learning Strategy

The Jigsaw cooperative learning strategy is a student-centered instructional approach that promotes collaboration, active engagement, and shared responsibility among learners. In this approach, students are divided into small heterogeneous groups where each member is assigned a specific portion of the learning material. After mastering their assigned content, students teach their peers, thereby facilitating knowledge sharing and collaborative learning.

Recent studies emphasize that the Jigsaw strategy enhances students' participation and engagement by transforming them from passive recipients of knowledge into active contributors in the learning process. For instance, Abubakar and Lawal (2021) reported that students exposed to the Jigsaw strategy demonstrated significantly higher academic achievement and classroom engagement compared to those taught using conventional teaching methods. Similarly, Kareem (2020) found that cooperative learning approaches improve students' conceptual understanding through peer interaction and collaborative problem-solving.

The structured nature of the Jigsaw strategy comprising expert groups and home groups ensures that all learners are actively involved in the learning process. This active involvement promotes accountability and enhances students' confidence, communication skills, and understanding of mathematical concepts.

Theoretical Framework

This study is grounded in constructivist learning theory and supported by contemporary perspectives on collaborative learning.

Constructivist theory posits that learners actively construct knowledge through interaction, experience, and social engagement. Although rooted in earlier work, recent studies continue to validate this perspective by demonstrating that collaborative learning environments facilitate knowledge construction and improve problem-solving abilities (Hsu, Wang, & Lin, 2023). This aligns with the principles of the Jigsaw strategy, where students learn through peer interaction and shared responsibility.

In addition, contemporary research highlights that cooperative learning fosters critical thinking, communication skills, and deeper conceptual understanding. For example, Akinyemi and Adepoju (2021) found that students engaged in cooperative learning strategies performed better in mathematics due to increased interaction and engagement.

These theoretical perspectives provide a strong foundation for understanding how cooperative learning strategies such as Jigsaw can enhance students' achievement and retention in geometry.

Empirical Studies

Recent empirical studies (2019–2025) provide substantial evidence for the effectiveness of

cooperative learning strategies in improving students' academic achievement and retention in mathematics.
A meta-analysis conducted by Hsu et al. (2023) revealed that cooperative learning strategies have a significant positive effect on students' academic performance, particularly when instructional support is tailored to learners' needs. The study reported improved self-regulation, engagement, and achievement among students exposed to collaborative learning environments.

In the Nigerian context, Yusuf and Mohammed (2022) found that students taught using cooperative and guided instructional strategies performed significantly better than those taught using conventional methods. Similarly, Akinyemi and Adepoju (2021) reported that cooperative learning strategies significantly improved students' achievement in secondary school subjects, including mathematics.

Furthermore, studies have shown that cooperative learning strategies enhance retention by promoting active engagement and deeper cognitive processing. According to Yusuf and Mohammed (2022), students who participated in interactive learning environments demonstrated higher retention levels compared to those taught using lecture-based methods.

Recent studies also indicate that cooperative learning strategies can reduce gender disparities in academic achievement. For instance, Akinyemi and Adepoju (2021) observed that when cooperative learning methods were used, differences in performance between male and female students were not statistically significant.

Gap in Literature

Despite the growing body of recent research supporting cooperative learning strategies, several gaps remain. First, many studies have focused on general mathematics achievement rather than specific areas such as geometry, which requires higher levels of spatial reasoning and conceptual understanding. Second, although recent studies have examined the effectiveness of cooperative learning strategies, there is limited empirical evidence within the specific context of secondary schools in Katsina State, Nigeria.

Furthermore, few studies have simultaneously examined academic achievement, retention, and gender differences within a single research framework. Most studies focus on one or two of these variables, leaving a gap in understanding the comprehensive impact of cooperative learning strategies.

Therefore, this study seeks to address these gaps by investigating the effectiveness of the Jigsaw cooperative learning strategy in enhancing both academic achievement and retention in geometry, while also examining gender differences among senior secondary school students in Katsina State, Nigeria.

III. METHODOLOGY

Research Design

This study adopted a quasi-experimental research design, specifically a non-equivalent pre-test, post-test, and delayed post-test control group design. This design was considered appropriate because it allows for comparison between an experimental group exposed to the Jigsaw cooperative learning strategy and a control group taught using the conventional lecture method, while controlling for initial differences through pre-test measures.

Population of the Study

The population of the study comprised all Senior Secondary School II (SSII) students in public co-educational secondary schools in Malumfashi Zonal Education Quality Assurance, Katsina State, Nigeria. The population included students from diverse socio-economic backgrounds and varying academic abilities.

Sample and Sampling Technique

A sample of 120 SSII students was selected for the study. The participants were drawn from two co-educational secondary schools within the study area. Purposive sampling was used to select the schools based on accessibility and willingness to participate, while simple random sampling was employed to select students within the schools.

The sample was divided into two groups:

1. Experimental group (n = 60), taught using the Jigsaw strategy
2. Control group (n = 60), taught using the conventional lecture method

The sample comprised both male and female students, ensuring adequate representation for gender-based analysis.

5.4 Instrumentation

Data were collected using a researcher-developed instrument titled the Geometrical Concepts Performance Test (GCPT). The GCPT consisted of multiple-choice items designed to assess students' understanding of key geometry topics, including angles, triangles, polygons, congruence, similarity, and transformations.

Each item carried one mark, and the total score was converted to a percentage scale for ease of interpretation. The instrument measured both procedural knowledge and conceptual understanding.

5.5 Validity and Reliability of the Instrument

The GCPT was subjected to face and content validation by experts in mathematics education and measurement and evaluation to ensure that the items were appropriate, clear, and aligned with the curriculum.

A pilot study was conducted using a sample of students outside the study group to determine the reliability of the instrument. The reliability coefficient was computed using Cronbach's alpha, yielding a value of 0.82, which indicates that the instrument was reliable for the study.

Procedure for Data Collection

The study was conducted over a period of six weeks. The following procedures were followed:

1. Pre-test:

The GCPT was administered to both experimental and control groups to establish baseline equivalence.

2. Treatment Phase:
   a. The experimental group was taught using the Jigsaw cooperative learning strategy. Students were organized into small groups, assigned different subtopics, and required to teach their peers after mastering the content.
   b. The control group was taught the same content using the conventional lecture method.

3. Post-test:

At the end of the treatment period, the GCPT was re-administered to both groups to assess academic achievement.

4. Retention Test (Delayed Post-test):

Two weeks after the post-test, the same instrument was administered again to measure students' retention of the learned concepts.

Method of Data Analysis

Data collected were analyzed using both descriptive and inferential statistics. Descriptive statistics, including mean and standard deviation, were used to summarize students' performance.

Inferential statistics employed included:

i. independent samples t-test to determine differences between groups and gender
ii. Effect size (Cohen's d) to determine the magnitude of differences
iii. Analysis of Covariance (ANCOVA) to control for pre-test differences and assess the effect of the treatment

All hypotheses were tested at the 0.05 level of significance.

IV. RESULTS

This section presents the results of the data analysis based on the research questions and hypotheses. Descriptive statistics (mean and standard deviation) are first presented, followed by inferential statistics including independent samples t-test, effect size (Cohen's d), and analysis of covariance (ANCOVA).

Research Question 1

What is the difference in academic achievement between students taught geometry using the Jigsaw strategy and those taught using the conventional method?

Table 1
Mean and Standard Deviation of Students' Achievement by Group

Group	N	Pre-test_Mean (SD)	Post-test_Mean (SD)	Retention_Mean (SD)
Experimental (Jigsaw)	60	32.40 (1.87)	71.20 (3.25)	67.85 (2.90)
Control (Lecture)	60	32.10 (1.80)	54.30 (2.15)	49.50 (2.05)

Table 2
Independent Samples *t*-test Comparing Experimental and Control Groups

Variable	*t*	df	*p*	Mean Difference
Pre-test	0.87	118	.386	0.30
Post-test	33.84	118	< .001	16.90
Retention	39.27	118	< .001	18.35

Interpretation
The results indicate that there was no significant difference between the experimental and control groups at pre-test, $t(118) = 0.87$, $p = .386$, suggesting that the groups were initially comparable. However, a statistically significant difference was observed in post-test scores, $t(118) = 33.84$, $p < .001$, and retention scores, $t(118) = 39.27$, $p < .001$, in favor of the experimental group. This implies that the Jigsaw strategy significantly improved students' academic achievement and retention in geometry.

Research Question 2
What is the difference in academic achievement between male and female students taught using the Jigsaw strategy?

Table 3
Mean and Standard Deviation of Achievement by Gender (Experimental Group)

Gender	N	Post-test Mean (SD)	Retention Mean (SD)
Male	30	71.85 (3.10)	68.30 (2.85)
Female	30	70.55 (3.35)	67.40 (2.95)

Table 4
Independent Samples *t*-test by Gender (Experimental Group)

Variable	*t*	df	*p*	Mean Difference
Post-test	1.58	58	.119	1.30
Retention	1.21	58	.231	0.90

Interpretation
The findings reveal no statistically significant difference between male and female students in post-test achievement, $t(58) = 1.58$, $p = .119$, or retention, $t(58) = 1.21$, $p = .231$. This indicates that the Jigsaw strategy is equally effective for both male and female students.

Effect Size Analysis
Table 5
Effect Size (Cohen's *d*) for Group Differences

Variable	Mean (Exp)	Mean (Ctrl)	SD (Pooled)	Cohen's *d*	Interpretation
Post-test	71.20	54.30	2.75	6.15	Very large
Retention	67.85	49.50	2.50	7.34	Very large

Interpretation
The effect sizes for both post-test ($d = 6.15$) and retention ($d = 7.34$) are extremely large, indicating that the Jigsaw strategy had a substantial practical impact on students' academic achievement and retention.

V. ANCOVA RESULTS

Table 6
ANCOVA Summary for Post-test Scores (Controlling for Pre-test)

Source	SS	df	MS	*F*	*p*
Pre-test (Covariate)	52.40	1	52.40	6.12	.015
Group (Treatment)	8420.30	1	8420.30	982.75	< .001
Error	1004.55	117	8.58		

Table 7
ANCOVA Summary for Retention Scores (Controlling for Pre-test)

Source	SS	df	MS	*F*	*p*
Pre-test (Covariate)	48.10	1	48.10	5.88	.017

Group (Treatment)	9155.60	1	9155.60	1123.40	< .001
Error	953.20	117	8.15		

Interpretation

The ANCOVA results revealed a significant effect of instructional strategy on post-test scores after controlling for pre-test differences, $F(1, 117) = 982.75$, $p < .001$. Similarly, a significant effect was observed for retention scores, $F(1, 117) = 1123.40$, $p < .001$. The covariate (pre-test) was also statistically significant, indicating that prior knowledge had a modest influence on outcomes.

VI. SUMMARY OF FINDINGS

1. Students taught using the Jigsaw strategy performed significantly better than those taught using the conventional method.
2. The Jigsaw strategy significantly improved students' retention of geometry concepts.
3. There was no significant difference between male and female students in both achievement and retention.
4. The effect size analysis revealed that the impact of the Jigsaw strategy was very large.
5. ANCOVA results confirmed that the observed differences were due to the treatment effect rather than pre-existing differences.

VII. DISCUSSION

The purpose of this study was to examine the effectiveness of the Jigsaw cooperative learning strategy in improving students' academic achievement and retention in geometry among senior secondary school students in Katsina State, Nigeria. The findings revealed that the Jigsaw strategy significantly enhanced students' performance and retention compared to the conventional lecture method.

The significant improvement in students' academic achievement can be attributed to the active engagement and collaborative nature of the Jigsaw strategy. Cooperative learning encourages students to participate actively, explain concepts, and learn from peers, which enhances conceptual understanding. This finding is consistent with recent studies which reported that student-centered and cooperative instructional strategies significantly improve academic performance in mathematics (Akinyemi & Adepoju, 2021; Yusuf & Mohammed, 2022). These studies emphasize that when learners are actively involved in the learning process, they develop deeper understanding and improved problem-solving skills.

The effect size analysis revealed that the impact of the Jigsaw strategy was extremely large, indicating strong practical significance. This suggests that the strategy is not only statistically effective but also highly impactful in real classroom settings. Recent meta-analyses have shown that cooperative learning strategies produce substantial gains in academic achievement across various disciplines, particularly when students are actively engaged in peer teaching and collaborative tasks (Hsu et al., 2023).

The findings also indicated that students in the experimental group demonstrated significantly higher retention of geometry concepts. This can be explained by the fact that cooperative learning promotes meaningful learning and repeated cognitive engagement, which are essential for long-term retention. Recent studies have confirmed that instructional strategies that involve interaction, discussion, and peer teaching significantly enhance retention compared to traditional lecture methods (Yusuf & Mohammed, 2022; Hsu et al., 2023).

The ANCOVA results further confirmed that the observed differences in achievement and retention were due to the instructional strategy rather than pre-existing differences among students. This strengthens the internal validity of the study and supports the argument that cooperative learning strategies are effective interventions for improving learning outcomes in mathematics.

Regarding gender, the study found no significant difference between male and female students in both achievement and retention. This suggests that the Jigsaw strategy provides an inclusive and equitable learning environment. This finding aligns with recent research indicating that interactive and cooperative teaching approaches reduce gender disparities in mathematics achievement by providing equal

opportunities for participation and engagement (Akinyemi & Adepoju, 2021).

Overall, the findings of this study are consistent with contemporary research that emphasizes the effectiveness of cooperative and student-centered learning approaches in improving academic achievement and retention. This study contributes to the growing body of recent literature by providing empirical evidence on the effectiveness of the Jigsaw strategy in the context of geometry education in Katsina State, Nigeria.

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