

Effects of Problem-Solving and Collaborative Strategies on Students' Performance in Geometry in Zaria Local Government Area Kaduna State, Nigeria

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ABSTRACT

The study investigated the effect of problem-solving and collaborative strategies on performance in geometry among senior secondary school students in Zaria Local Government Area, Kaduna State. The sample for the study consisted of 148 SS2 students, including 77 males and 71 females, selected using simple random sampling from a population of 3,200 SS2 students (1,780 males and 1,460 females) across twenty-eight senior secondary schools in the area. Two research questions and two null hypotheses were formulated to guide the study. Three schools were randomly selected, with two used for the experimental groups—Experimental Group A (Problem-Solving Strategy) and Experimental Group B (Collaborative Strategy)—while the third school served as the control group (Conventional Method). The Geometry Performance Test (GPT) was used as the research instrument for both the pre-test and post-test. The collected data were analyzed using Mean and Standard Deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the null hypotheses at a 0.05 level of significance. The findings revealed a significant difference in academic performance between students exposed to Problem-Solving and Collaborative Strategies compared to those taught using the Conventional Method, with the experimental groups performing better. Additionally, the findings indicated no significant difference in the academic performance of male and female students taught using problem-solving and collaborative strategies, suggesting that both genders benefited equally from these approaches. However, within the experimental groups, male students performed slightly higher than their female counterparts. The researcher recommended that collaborative and problem-solving strategies should be adopted for teaching geometry. Furthermore, training programs such as workshops, conferences, and seminars should be organized for mathematics teachers to equip them with the necessary skills to implement these strategies effectively.

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INTRODUCTION

Mathematics is a compulsory subject at primary and secondary levels of education in Nigeria. Mathematics is used as a basic entry requirement into courses like medicine engineering among others. Usman (2016) observed that in order to secure admission into higher level of education, a credit pass in mathematics is a prerequisite for most programmes. Valt and Maree (2017) opined that mathematics can be described as an important

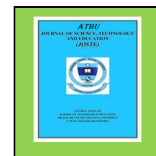
subject in secondary education, and as an adequate learning facility that is very important in any country. Mathematics is an indispensable tool for development of science and technology. This implies that no nation can develop scientifically and technologically without proper foundations in school mathematics (Okafor, 2005). Therefore, mathematics serves as a means of sharpening man's reasoning ability and developing man's personality. Mathematics is therefore indispensable in nation building.

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There are some aspects of mathematics that have posed lots of problems to students' academic achievements. These are: negative indices, application of rule of BODMAS in solving problems, trigonometric relations/values of angles, longitude and latitude, scale drawings and geometry (WAEC Chief Examiners Report, 2019). Reports from other examination bodies indicate students' poor performance in mathematics. WAEC Chief Examiners' Reports of 2019-2024 shows that in 2019, 2020, 2021, 2022, 2023 and 2024 May/June WAEC results, 31.28%, 36.68%, 52.97%, 50.22%, 54.33% and 50.98% of the students in the respective years had credits in mathematics. However, it was noted that students' weakness manifested mostly in geometry in almost all the year under review. The reports show that students are very weak in geometry and also exhibited poor knowledge of circle theorems and geometrical construction. In addition, many candidates were unable to draw the tangent at a given point to determine the gradient at that point (West Africa Examination Council 2019 and 2020). According to Abakpa (2018) define Problem solving and collaborative as a level of thinking that involves active control over the process of thinking that is used in learning situations. Problem solving and collaborative Strategy refers to one's knowledge concerning one's own cognitive processes. Cognitive processes or activities mean elaboration of the method used in teaching. The function of cognition is to solve problem to bring cognitive enterprises to a good end (Mac, 2016). Okeke (2017) further stated that planning the way of strategizing a learning task, monitoring comprehension and evaluating the progress towards the completion of a task are skills that are problem solving and collaborative in nature. Problem solving and collaborative activities involve necessary components for successful problem solving, such components include mathematical knowledge and experience separating relevant from irrelevant information and the ability to use a variety of strategies. According to Igbo (2014) problem solving and collaborative strategies is the monitoring and control of thought. Kuhn and Dean (2017) regard problem solving and collaborative strategies as awareness and management of one's own thought. Based on Kuhn and Dean Work, Meta-Cognition is what enables a learner who has been taught a

particular strategy in a particular problem context to retrieve and use that save strategy in a similar context. Hence, learning strategy is what a teacher or learner arranged to established interaction between the teacher, the students and the subject matter of any combination of these three dimensions. Cognitive strategy is used to help an individual achieve a particular goal. (Understanding text) while Meta-Cognitive strategies are used to ensure that the goal has been reached. Therefore, Problem solving and collaborative strategies are action which goes beyond purely cognitive devices and which provide learners to coordinate their own learning process (Mbaba, 2016).

Research findings of some studies that employed Meta-Cognitive Instructional strategies shows that Problem solving and collaborative Strategies enhances student's achievement in various subjects. For instance, Xiying and Gang (2017), found out that students performed higher in English when taught using Problem solving and collaborative strategies. Similarly, students' performance in Biology was enhanced and effective correlates of success in college anatomy and physiology when Problem solving and collaborative approach was used (Okoza, Aluede and owensuglo, 2018). The above evidence suggests that Problem solving and collaborative strategy enhances students' academic performance. However, according to Okoza and Aluede (2017) that there are some strategies that make up the Problem solving and collaborative Strategies, these are, Collaborative approach, Simulation approach, Modelling approach, Self-Regulation approach, Concept Mapping approach and Problem-Solving approach. There is need, therefore, to investigate which Problem solving and collaborative Strategies can best improve student's performance in geometry. This study investigates effect of the Problem Solving and Collaborative Strategies on students' performance. The rationale for choosing the two strategies was based on the fact that from available literature. Very little work has been done on the two Strategies compared to other Problem solving and collaborative Strategies in other subjects than Mathematics.

Collaborative learning strategy is an educational strategy in teaching and learning that involves groups of learners working together to solve a

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problem, complete tasks, or create a product. In collaborative learning environment, the learners are challenged both socially and emotionally as they listen to different perspectives and are required to articulate and defend their ideas (Nwagbo, 2016). In so doing, the learners began to create their own unique conceptual frameworks and texts framework. In a collaborative learning setting learner have the opportunity to converse with peers, present and defend ideas, exchange diverse beliefs, question other conceptual frameworks. And are actively engaged. (Igbo, 2014). Collaborative learning strategy represent a significant shift from the typical teacher-cantered in secondary school classrooms to learner-cantered. In collaborative classroom, the lecturing, listening and note taking process may not disappear entirely, but it lives alongside other processes are best in student's discussion and active work with the course material. From the literature, there is evidence that collaborative learning strategy exposed students in other subjects achieve a higher level of thought and retain information longer than learners who work quietly as individuals (Abakpa, 2018).

Problem solving strategies is a way of analysing situation and of using skills to reason out what cannot be learnt by memorizing specific facts, but by absorbing our self in the problem-solving process. (Mac, 2016). In another word problem solving is a technique of seeking answer or solution to a given unfamiliar situation. A problem-solving strategy is a plan of action used to find a solution. Different strategies have different action plans associated with them. According to Nwagbo (2014) that problem solving is the act of defining a problem, determining the cause of the problem, identifying, prioritizing and selecting alternates for a solution. The process of problem solving includes; defining the problem, generate new ideas, Evaluate and select solutions and implement and evaluate the process. The problem-solving strategy contributes to the development of reflective thinking, creative expression, critical analysis and logical reasoning (Obodo, 2016). In problem solving strategy, Abakpa (2018) suggested that teachers should make sure that learners have the following;

1. Understanding; determining what information is given in a problem what you need to find.
2. Plan; after you understand the problem, select a strategy for solving it.
3. Carryout the plan; solve the problem by carrying out the plan.
4. Evaluate solution; examine your answer carefully to see if it fits the given in the problem.
5. Posting related problems; pose a related Mathematical problem by simple changing the unknown in the solved problem i.e. change the conditions of the current problem.

In line with the above discussion therefore, there is need to investigate the effectiveness of Problem solving and collaborative Strategy on secondary school student's performance in geometry in Zaria Local Government Area Kaduna State.

Statement of the Problem

Student's performance in geometry at senior secondary level has been observed to be consistently low. This low performance has been linked to the poor teaching strategies employed by the teachers in teaching geometry concepts. These poor teaching strategies have been attributed to the constant use of lecture teaching methods in teaching and learning of geometry. Mathematics as a science subject is practically oriented, hence there is the need to use learner-cantered innovative strategies such as the problem solving and collaborative strategies which are part of Problem solving and collaborative instructional strategy that ensures students active participation in the teaching and learning processes. Previous studies have shown that Problem Solving and Collaborative Strategies could enhance students' performance in subjects like English, Biology, Physics, Psychology and Mathematics (Isah, 2016). The extent to which Problem Solving and Collaborative Problem solving and collaborative Instructional Strategies could help students to improve their performance in geometry is not known, since very little study has been done on them. Hence, the major problem of the study put in question form is; would the use of the Problem solving and collaborative strategies in

teaching geometry enhance performance among senior secondary school students?

Objectives of the Study

The general purpose of the study is to determine the effectiveness of Problem solving and collaborative strategies on student's performance in geometry; specifically, the study seeks to determine the;

1. Effects of Problem solving and collaborative strategies on performance in geometry among secondary school students
2. Effects of Problem solving and collaborative strategies on gender performance.

Research Questions

The following research questions were posed to guide the study;

1. What is the mean performance score of students taught geometry using problem solving, collaborative strategy and those exposed to conventional method?
2. What is influence of problem solving and collaborative strategies on gender mean performance?

Null Hypotheses

The following null hypotheses were formulated to guide the study and were tested at 0.05 level of significance.

Ho₁; There is no significant difference in the mean performance scores of students taught geometry using Problem Solving, collaborative strategy and those taught using conventional method.

Ho₂; There is no significant difference in the mean performance scores of male and female students taught geometry using problem solving and collaborative strategies

METHODOLOGY

This study adopted Quasi-experimental research design, this is a type of research design that allows for the investigation of the main and interactive effects between two or more independent variables

The population of the study consist of 28 public senior secondary school in Zaria local Government Area Kaduna state. The population is made of 1780 male and 1460 females' students. The sample size for the study is 146 SS II students. Simple random sampling techniques was employed. At the first state simple random sampling techniques was used to sample three schools out of 28 public senior secondary schools in Zaria Local Government Area. The second stage, in each of the school selected another simple random sampling technique was used to select one intact class each from the three school.

Table 1: Summary of the Sample for the Study

GROUPS	MALE	FEMALE	TOTAL
Problem Solving Strategy A	33	20	53
Collaborative Strategy B	29	18	47
Control	26	20	46
TOTAL	88	58	146

Geometry performance text (GPT) was developed by the researchers and was used for data collection in this study. The instrument was developed with the use table of specification (Text Blue Print). The text items were also constructed based on the SS II geometry contents, such contents include perimeters, arcs, sector of a circles and surface area of a common solids. The GPT consist of twenty-five (25) multiple choice questions with options lettered from A-C. The instrument GPT

was subjected to both face and content validity. The validation was done by senior lecturer from the department of Mathematics Federal University of Education, Zaria.

To determine the reliability of the instrument, the researchers administered 20 copies of the instrument to SSII students from school in the population but not in the sample selected for the study. The scores obtained was analyse using Pearson's product moment correction coefficient (PPMC) with 0.78 which

indicate that, the GPT items is suitable for the study. Before the commencement of the treatment, pre-test was administered to the sample students in the different experimental groups. This is done to enable the researchers to determine the performance of the subject before treatment. The result from the pre-test indicate that sampled students are homogenous. Hence treatment was done to the two groups that is Problem Solving strategy was used to teach geometry concepts to experimental group A while Collaborative strategy was used to teach geometry concept to experimental group B and conventional method was used to teach geometry concept. The

treatment was for the period of four week in 2023 / 2024 academic session. The data generated from the post-test was used for analysis. Descriptive Statistics (Mean and standard deviation) was used to describe research questions while inferential statistics (ANCOVA) was used test the null hypotheses at 0.05 level of significance.

RESULTS

Research Question one: What is the mean performance score of students taught geometry using problem solving, collaborative strategy and those exposed to conventional method?

Table 2: Mean and Standard Deviation on Performance between Problem Solving, Collaborative Strategy and Conventional method Groups

Groups	N	Mean	St. Div.
Problem Solving	53	31.53	4.11
Collaborative Strategy	47	33.87	2.37
Conventional Method	46	16.46	4.82

It can be seen from the Table 2 that, Experimental group A exposed to PS strategy has (N = 53, M = 31.53, SD = 4.11) while Experimental group B exposed to collaborative strategy (CS) has (N = 47, M = 33.87, SD = 2.37) and Control Group exposed to Conventional Method has (N = 46, M = 16.46, SD = 4.82). This indicates that the students exposed to Problem Solving and Collaborative

Strategy performed higher than those exposed to Conventional method.

H₀₁: There is no significant difference in the mean performance scores of students taught geometry using Problem Solving, Collaborative Strategy and those taught using Conventional Method.

Table 3: Result of ANCOVA Analysis on Students Performance between Experimental group A and Experimental group B and Control group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8405.021 ^a	3	2801.674	184.414	.000	.796
Intercept	2975.396	1	2975.396	195.849	.000	.580
PRETEST	26.547	1	26.547	1.747	.188	.012
METHODS	7856.218	2	3928.109	258.559	.000	.785
Error	2157.308	142	15.192			
Total	121250.000	146				
Corrected Total	10562.329	145				

a. R Squared = .796 (Adjusted R Squared = .791)

b. Computed using alpha = .05

Table 3, the result showed that, there is significance different between the means performance scores of students when exposed to Problem Solving, Collaborative Strategy and

Conventional method. The value of $F_{(2,142)} = 258.559$ is obtained with associate exact probability value of 0.000. Since the associated probability value is less than alpha value of 0.05

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level of significance. Therefore, for p-value observed is less than alpha value it means the difference is significant. Therefore, the null hypothesis one is hereby rejected.

Research Question two: What is the influence of gender on students' performance taught geometry using problem solving and collaborative strategies?

Table 4: Mean and Standard Deviation on Mean performance of Male and female students exposed to Problem Solving and Collaborative Strategy

Teaching Strategies	Gender	N	Mean	Std. Dev.
Problem solving A	Male	33	34.03	2.87
	Female	20	34.15	2.11
Collaborative B	Male	29	34.72	3.40
	Female	18	33.89	2.05

Table 4: reveals that mean and standard deviation on mean performance scores of male and female students exposed to problem solving (male N = 33, M = 34.03 SD = 2.87 and Female N = 20, M = 33.15, SD = 2.05) while collaborative strategy is (Male N = 29, M = 33.72, SD = 2.72 and Female N = 19, M = 33.89 SD = 2.05) respectively. This shows that both male and female students exposed to problem solving strategy performed higher than

their counterparts exposed to collaborative strategy. However, within the collaborative and problem-solving strategies, male students performed higher than their female counterparts.

HO₂: There is no significant difference in the mean performance scores of male and female students taught geometry using problem solving and collaborative strategies

Table 5: Result of ANCOVA Analysis on Performance of Male and Female Students exposed to Problem Solving, and Collaborative Strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	255.155 ^a	17	15.009	.857	.624	.151
Intercept	4870.117	1	4870.117	278.177	.000	.772
Pretest	39.772	1	39.772	2.272	.136	.027
Gender	16.916	1	16.916	.966	.329	.012
Methods	83.147	8	10.393	.594	.780	.055
Gender * Methods	80.561	7	11.509	.657	.707	.053
Error	1435.595	82	17.507			
Total	108293.000	100				
Corrected Total	1690.750	99				

a. R Squared = .151 (Adjusted R Squared = -.025)

In table 5 the result showed that, there is no significance different between the means performance scores of male and female students when exposed to Problem Solving and Collaborative Strategies. The value of $F_{(2,82)} = 0.657$ is obtained with associate exact probability value of 0.707. Since the associated probability value is greater than alpha value of 0.05 level of significance. Then, the p-value observed is greater than alpha value it means the difference is not significant. Therefore, the null hypothesis two is hereby retained.

DISCUSSION

The findings of the results in Table 2 revealed that students exposed to collaborative teaching strategy had higher mean performance scores compared to students exposed to problem solving strategy. The results implies that problem solving and collaborative teaching strategy significantly enhanced students' performance in geometry when compared to problem solving strategy. The implication is that problem solving and collaborative strategies

when used in teaching geometry is capable of producing positive effects on students' performance.

The result was not surprising because, peer tutoring learning strategy allows the students to take active participation in constructing their own knowledge. In support of the assertion, Isah, (2016) opined that collaborative strategy involves group of students working together to solve a problem, complete a task or create a product and Obeta (2020) who reported that primary school pupils taught mathematics using peer collaborative teaching strategy achieved higher than those taught using conventional method.

This finding is in disagreements with Muhammed and Binji (2017) and Akinsola (2016) who states that male tend to perform higher than female counterpart when exposed to activity-based method of teaching geometry. The result also in agreement with Bolaji, (2016) which state differently that, when students are exposed to practical approach, male and female students tend to performed equally in geometry proficiency.

CONCLUSION

The result of this study established the following

1. Problem solving strategy, Collaborative learning strategy significantly enhanced students' academic performance in geometry when compared with.
2. There is no significant influences of gender on performance in geometry when exposed to problem solving and collaborative strategies

RECOMMENDATIONS

Based on the findings of this study, the following recommendations were made by the researchers:

1. Mathematics teachers should adopt the use of collaborative teaching strategy and problem-solving strategy in their lessons in order to enhance students' academic performance in geometry.
2. Government agencies and professional associations whose responsibility is to design and revise the curriculum for secondary schools to incorporate and emphasize the use of problem solving and collaborative teaching strategy in teaching

geometry concepts in senior secondary schools.

3. State Government in conjunction with other professional associations should organize workshops, seminars, conferences and in-service training on a regular basis to train teachers on the use of problem solving and collaborative teaching strategy, since the strategy have been found to be effective in enhancing students' academic achievement in geometry.
4. Mathematics teachers should endeavour to note that gender does not account for students' academic achievement rather the method used by the teachers in teaching a particular subject. Therefore, mathematics teachers should often change their method of teaching in order to promote students' academic performance in geometry in senior secondary schools.

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