

Effect of Polya's Problem Solving Instructional Strategy on Senior Secondary School Students Academic Achievement in Geometry in Gombe State

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Abstract

This study examined the effect of the Polya problem-solving instructional strategy on the academic achievement of senior secondary school students in geometry in Gombe State, Nigeria. This investigation was prompted by the consistently poor academic performance of students in mathematics within the state. The study addressed two research questions and tested two null hypotheses using a pre-test, post-test, quasi-experimental design with experimental and control groups. The research questions were answered using mean and standard deviation, while the null hypotheses were tested using Analysis of Covariance (ANCOVA) at a 0.05 alpha level. A multistage sampling technique was employed to select a sample of 128 students from a total of 17,939 SS II mathematics students in the state. The sampled students, drawn from various schools, were randomly assigned to either the experimental group or the control group. The experimental group received instruction using the Polya problem-solving strategy, while the control group was taught using the traditional lecture method. The Geometry Achievement Test (GAT) was utilized for data collection. To ensure face and content validity, the instrument was validated by experts in Mathematics Education. A reliability coefficient of 0.82, determined using Kuder-Richardson (KR 21), indicated that the GAT was suitable for the study. One of the key findings revealed no significant difference in the academic achievement of male and female students exposed to the Polya problem-solving instructional strategy. It is recommended that the government, through school head teachers, encourage the use of Polya's problem-solving strategy in teaching mathematics and other science subjects by organizing workshops and training sessions for classroom teachers.

Keyword: Academic Achievement, Gender, Geometry, Polya Problem Solving,

Introduction

Mathematics Education which includes the practice of teaching and learning of mathematics has consistently generated interest among scholars over the years. This is because of its importance which affects every facet of human activity such as: politics, economy, science and technology (Kadala, 2014). It is the importance of mathematics that compelled the Federal Government of Nigeria to make mathematics a compulsory subject at the primary and secondary levels of education and consequently a necessary requirement for admission into the Nigerian universities Matthew & Kenneth, (2013). According to Adenegan (2003). Mathematics is the study of numbers, set of points and various abstract elements together with relation between them and operation performed on them. Despite the importance of mathematics as a tool for societal and national development, its study according to Unodiaku (2011) in Nigerian secondary schools is bedeviled by incessant poor achievement among the students. In fact, the problems of teaching and learning of mathematics in secondary schools have continued to

be topical and worrisome to mathematics teachers, researchers, parents and examiners. It is common

knowledge that many students do not assimilate the mathematical concepts taught in schools and so engage in examination malpractice to pass mathematics examinations. This may be attributed to the way the subject is taught. Oloruntegbe and Omoifo (2008) asserted that the success of teaching depends on the method of teaching adopted by the teachers.

Problem solving is one key area of research which has attracted a lot of interest. This is not only because it enjoys special mention under the goals of science education, but it also forms the nucleus of reasons for preparing the young ones for the future through the instrument of education. Many researches carried out by Olaniyan, Omosewo & Nwankwo (2015); Bot (2013); Nekang (2013); Samuel (2013); have pointed out that methods/strategies of teaching affect the performance of students in Mathematics and other mathematics related subjects. In his book "How to solve it" (Polya, 1957); Polya identified four

basic stages to use when solving problem namely: i. Understanding the Problem ii. Devising a plan iii. Carrying out the plan. iv. Reflecting back. These stages were further amplified by Chamot, Dale, Malley and Spanos (1992) as follow:

- **Understand the Problem:** Activities include reading the mathematics problem aloud, discussing prior knowledge about the problem type, drawing a picture or image of the problem, rewriting the question as a statement with a blank for the answer, paraphrasing the question.
- **Devising a plan:** Activities include deciding if one step or multiple steps are called for, choosing the mathematics question(s), make a table or other graphic representations, guessing and checking, write a mathematics sentence, or otherwise setting up the problem.
- **Carrying out the plan:** Activities include working with pencil and/or calculator to compute the answer to the mathematic problem(s) set up in (ii).
- **Looking back:** Activities include comparing the answer to the representation made in step (i) to see if it makes sense, reviewing the problem solving steps, looking for more information in the problem, estimating the answer, checking calculations. In some mathematical problems, solve from the answers back to the original problems or questions.

Therefore, the researchers advocated the need for the use of students' centered methods/strategies that will boost the students' active participation and academic achievement in Geometry which is the rational for the current researcher's choice of Polya's problem-solving instructional strategy

Academic achievement is the learning outcome that shows the level to which a student has completed specific goals that were the focus of activities in an instructional environment such as school. Along this view, Ali (2013) defined academic achievement as a measure of the degree of success in performing specific tasks in a subject or area of study by the students after a learning experience. Also Tenty and Awe (2011) defined academic achievement as the gain in knowledge of students as a result of taking part in a learning activity or program. However, despite the importance of mathematics to the individual and the society, literature review constantly reveals persistent low students' academic achievement at all levels. For instance, Fasasi (2015), argues that low

academic achievement in mathematics is caused by teachers'

non- utilization of the appropriate teaching methods. Fasasi further stated that the teaching of mathematics in Nigeria is teacher centered, students are not fully involved in the teaching-learning process and this method does not yield good result. This can also be seen in the low achievement of students who attempt to answer questions that involved geometry.

The importance of geometry to human life cannot be overemphasized because the world we are living in today is surrounded by different shapes and occupied spaces. Geometry help us to understand a spatial relationship, it creates a clear perception of space and position through studying the size and shapes of everything in the world. Geometry helps to understand the measurement and relationships of points, lines, angles, surface and solids shapes found in everyday world (Jones, 2002). The emphasis of geometry is increased as students' progress from primary to secondary education. Unfortunately despite the importance of geometry and its relation to human development, the achievement of students in this aspect is poor (Adolphus, 2011; Ali, Bhagawati & Sarmah, 2014; WAEC Chief Examiners' Report 2013; 2014; 2015).

Another variable that can influence students' academic achievement is gender. Jimoh, Idris and Olatunji (2016) collaborated by explaining that gender is the ascribed attributes that differentiate feminine from masculine. Kiamanesh, (2014) also observed that female students are less successful in learning mathematics, due to their low interest and confidence in learning mathematics and their low academic expectation. He further asserted that, girls initially have more positive attitudes towards mathematics than boys do, but as they continue in school, girls' attitudes become more negative. Thorough studies such as Else-Quest, Hyde and Linn (2010) and Linderberg, Hyde, Petersen and Linn (2010) reported that gender differences among male and female is closing and both male and female perform similarly. There is a general belief in Nigeria that male are superior to female in terms of physical fitness, cognition, logical reasoning and even academic achievement (Anigbogu, 2002). Hence this research tends to investigate whether this argument is true or not in terms of academic achievement in geometry.

Research Questions

In order to achieve the objectives of the study, the following research questions raised guided the study:

1. What is the difference in the mean achievement scores of Senior Secondary

School Students taught geometry using polya's problem solving instructional strategy and those taught using the lecture method?

2. What is the difference in the mean achievement scores of male and female Senior Secondary School Students taught geometry using the polya's problem solving instructional strategy?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance

H₀₁: There is no significant difference between the mean achievement scores of Senior Secondary School Students taught geometry using polya's problem solving instructional strategy and those taught using the lecture method.

H₀₂: There is no significant difference in the mean achievement scores of male and female Senior Secondary School Students taught geometry using the polya's problem solving instructional strategy.

Materials and Methods

This study employed a pretest-posttest, nonrandomized quasi-experimental design which involved a treatment and a control group. The design was used because there was no randomization of subject, instead intact classes were used which were experimental and control groups. The design is considered appropriate for the study because it was much more reliable to use natural intact classes than forming a group through randomization of subjects. Furthermore, school authorities do not allow a researcher to disrupt their normal class setting for the purpose of forming a true experimental group. A multi-stage sampling technique was used to draw 126 out of 17,939 students for the study. At the first-stage, a simple random sampling technique (raffle draw) was used to select two local governments (Gombe and Akko) out of the 11 local governments in the study area. While purposive sampling technique was used at the second stage to select four schools (GDSS Orji and GSSS II from Gombe LGA and GDSS Wuro Birji, and GDSS from Akko LGA) out of 99 mixed senior secondary schools in the state. The criteria used for selecting the schools are:

- i. School should be a co-educational (male and female)
- ii. School should have graduated SS III students for at least three years and
- iii. School should have a resident mathematics teacher with a minimum qualification of B.Ed. Mathematics, BSc. Mathematics, B.Tech Ed

mathematics or has a teaching experience of not less than five years. The schools that met these criteria were selected for the study.

Finally, one intact class was selected from the four schools randomly by balloting, and was assigned to experimental group or control group using random sampling techniques. In the four schools selected for the study, two SS II intact classes in two of the schools were selected and exposed to polya problem instructional strategy which was referred to as the experimental group. The polya problem instructional strategy was followed during lesson presentations, The other two SS II intact classes were exposed to lecture method and are referred to as the control group. The choice of SSII is because they are the stable class unlike SSI that are just coming into the SS class while SSIII are preparing for their SSCE. The instrument used for data collection is the Geometry Achievement Test (GAT). The GAT consisted of 50 multiple choice items with options A-D developed by the researcher from WAEC past questions (2010 to 2019). Only one option is correct while the remaining three were distractors. The items in GAT were based on the selected topics that were covered during the experiment. Each correct answer attracted two marks, totalling 100 marks. To ensure face and content validity, the instrument was presented to a Lecturer from Mathematical science Department of Gombe state university, Gombe state. Also three qualified mathematics teachers from public senior secondary schools helped in validating the instrument. They looked at the appropriateness of the instruments, ensuring that it measures the intended outcome of the study. They also checked the contents of the instrument ensuring that it is in tandem with the selected topics and the class (SS II) for the study. All the necessary criticisms and corrections proffered by the validators guided the production of the final draft of the instrument. The internal consistency of Geometry Achievement Test (GAT) was determined to be 0.82

using Kuder-Richardson's formula-20 (KR₂₀). Furthermore, the researcher prepared two different sets of lesson plans that were used in teaching during the study. One set of lesson plans is based on Polya problem instructional strategy which was used for experimental group and the other set is based on lecture method which was used for the control group. The sets of the lesson plan prepared were used by the four research assistants who participated in the four schools selected for the study, The lesson lasted for eight weeks with six contacts. The first and the last weeks were used for the administrations of the pretest and posttest. The

decision rule stated that: if the p-value is less than 0.05, the null hypotheses is rejected, otherwise, the null hypotheses is accepted.

To minimize the likely effect of extraneous variable on the outcome of the study, the following measures were taken.

1. Teacher Variable: To control the teacher variable, the researcher trained the four teachers that taught both experimental and the control groups. This became necessary because certain trait/characteristics that would distinguish the teachers such as

qualification, teaching experience could be eliminated.

2. Class Interaction: To solve the problem of interclass discussion among students, one intact class each was selected from four different schools.
3. Effect of Pre-test on Post-test: The research lasted for eight weeks. It was expected that the period was enough as not to permit the pre-test scores affect the post-test score Also, the items were rearranged before administering the post-test.

Results

Table 1: Mean and Standard Deviation of Pretest and PostTest Scores of Students Taught Geometry using Polya Problem Solving Instructional Strategy and those Taught using the Lecture Method.

Teaching Strategy	n	Pre-test Mean		Post-test Mean		Mean Gain
		Score	SD	score	SD	
Polya Problem	67	29.22	9.95	52.20	13.91	22.98
Lecture	59	24.53	10.24	45.49	12.87	20.96

Table 1 revealed that, Polya’s problem Instructional strategy group with 67 students has a pretest mean score of 29.22 and standard deviation of 9.95 While in the posttest Polya’s problem Instructional strategy had the highest mean score of 52.20 with a standard deviation of 13.91. Lecture method group had 59 students with a mean score of 24.53 and standard deviation of 10.24 at pretest level

and mean score of 45.49 with standard deviation of 12.87 at posttest level. In summary, the mean difference between pretest and posttest is higher which means the instructional strategies under study (Polya’s problem solving instructional strategy and lecture method) were equally important at improving students’ performance at different levels. With the polya method more effective.

Table 2. ANCOVA of Students’ Achievement Taught Geometry using Polya Problem Solving Instructional Strategy and those Taught using the Lecture Method.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9495.777 ^a	2	4747.888	26.906	.000
Intercept	21602.649	1	21602.649	122.420	.000
PRETEST	.238	1	.238	.001	.971
TEACHMETH	9091.892	1	9091.892	51.523	.000
Error	25234.333	119	176.464		
Total	496852.000	121			
Corrected Total	34730.110	120			

a. R Squared = .273 (Adjusted R Squared = .263)

The results of the analysis in Table 2 shows that, there is significant difference between the teaching strategies on students’ academic achievement with $F = 51.52$ (df 1, 145), $P = 0.00$. Since the computed p-value (0.00) is less than 0.05

level of significant, therefore, the null hypothesis of no significant difference is rejected, which means there is significant difference between the teaching strategies on students’ achievement in Geometry.



Table 3: Descriptive Statistics of Pretest and Posttest Scores of Male and Female Students Taught Geometry with Polya Problem Solving Instructional Strategy.

Gender	N	Pretest Mean	SD	Posttest Mean	SD	Mean Difference
Male	29	29.38	7.90	54.21	10.76	35.03
Female	38	29.09	11.49	50.54	16.01	35.33

The descriptive statistics in Table 2 revealed that polya problem instructional strategy based on gender with 67 students, male have pretest mean score of 29.38 and standard deviation of 7.90. In the posttest male have the mean score of 54.21 with a standard deviation of 10.76. Female group has a mean score of

29.09 and standard deviation of 11.49 at pretest level and mean score of 50.54 with standard deviation of 16.01 at posttest level. In summary, the mean difference between male and female students at posttest is negligible. With the female students achieving better.

Table 4. ANCOVA of Students Academic Achievement Taught Geometry using Polya Problem Solving Instructional strategy Based on Gender.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	54.845a	2	27.423	.127	.881
Intercept	16969.631	1	16969.631	78.557	.000
PRETESTS	.001	1	.001	.000	.998
GENDERS	54.845	1	54.845	.254	.616
Error	15769.155	61	216.016		
Total	327120.000	64			
Corrected Total	15824.000	63			

a. R Squared = .003 (Adjusted R Squared = -.024)

The results of the analysis in Table 4 shows that, there is no significant difference on the mean achievement score of male and female students with $F = 0.25$ (df 1, 6), $P = 0.62$. Since the computed p-value (0.62) is greater than 0.05 level of significant. Therefore, the null hypothesis of no significance difference between the mean achievement scores of male and female Senior Secondary School Students' (SS II) taught geometry using polya problem solving strategy is upheld.

Discussions of Findings

The finding in Table 1 showed that students taught geometry through polya problem solving instructional strategy recorded a posttest mean of 52.20 with a standard deviation 13.91 while the posttest mean for students taught through lecture method was 45.49 with standard deviation 12.87. This is further clarified in Table 2 which shows that, there is significant difference between the teaching strategies on students' academic achievement. With F

$= 51.52$ (df 1, 145), $P = 0.00$. Since the computed p-value (0.00) is less than 0.05 level of significant, therefore, the null hypothesis of no significant difference is rejected, which means there is significant difference between the teaching strategies on students' achievement in Geometry. The superiority of the Polya problem instructional strategy over the lecture method could be due to the roles played by the research assistants in providing guidance, assistance and mentorship for the students in dealing with problems in mathematics. The use of Polya's problem solving instructional strategy has helped in informing the students on the ways and strategies of tackling mathematical problems thereby giving the students the independence in the use of ideas and initiatives in their dealing with mathematical problems which removed the perception of the dogmatic nature of mathematics. The findings agree with the findings of Olaniyan, Omosewo and Nwankwo (2015), Femi (2015), Okoronka and Hayatu (2014), Samuel (2013), Bot

(2013), Iji & Obarakpo (2017) and Kausar (2010) who found that students taught using Polya's problem solving instructional strategy significantly perform better than those taught using the lecture method. Base on the result it could be inferred that Polya's problem solving can enable the students independently and confidently tackle a problem and come up with solutions without waiting for the teacher to supply them all that is needed by the problem.

The findings indicated that there was no significant difference in the academic achievement of male and female students who were exposed to the Polya problem-solving instructional strategy. Table 3 presents the data showing that male students, comprising 29 individuals, had a pretest mean score of 29.38 with a standard deviation of 7.90. In the posttest, their mean score improved to 54.21, with a standard deviation of 10.76. Female students, on the other hand, had a pretest mean score of 29.09 with a standard deviation of 11.49, and a posttest mean score of 50.54 with a standard deviation of 16.01. Although female students demonstrated slightly better performance at the posttest level, the mean difference between male and female students was minimal.

Table 4 shows the results of the statistical analysis, which reveal no significant difference in the mean achievement scores of male and female students. The F-value was 0.25 with degrees of freedom (df) of 1 and 6, and the p-value was 0.62. Since the p-value (0.62) exceeds the 0.05 level of significance, the null hypothesis, which posits no significant difference between the mean achievement scores of male and female Senior Secondary School (SS II) students taught geometry using the Polya problem-solving strategy, is upheld. These results align with the findings of Adeniran (2011) and Olaniyan, Omosewo, and Nwankwo (2015).

Conclusion

Base on the findings of this study, it can be concluded that the use of Polya's problem solving instructional strategy enhances students' academic achievement in Geometry at the senior secondary school level. It can then be deduced that the polya's problem solving instructional strategy used in guiding the students enhanced their academic achievements. Also polya problem solving has no effect on gender as it can be seen from the results. Hence, it is hope that when mathematics teachers and teachers in other subjects use polya's problem solving instructional strategy in guiding the students their academic achievement would be enhanced.

Recommendations

On the bases of the findings emanating from this study, the following recommendations are made:

1. Teachers should be encouraged to use Polya's problem solving instructional strategy in teaching of mathematics and other science subjects.
2. Government should organize an In-service training for mathematics and science teachers in form of seminars, workshops and conferences on how to use Polya's problem solving instructional strategy in teaching of mathematics and other science subjects
3. Mathematics educators, professional associations in mathematics as well as mathematics textbook developers should use Polya's problem solving instructional strategy procedures in their future publications for enhanced students' academic achievement in geometry.

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