

# Effect of Polya Problem Solving Teaching Method on the Achievement of Students in Algebra

\*Ndukwe Oji Nnachi, Irene Egbe, Nwoke Ndubuisi and Obute Patrick  
Department of Science Education  
Ebonyi State University, Abakaliki, Nigeria  
ndukwennachi@yahoo.com

## Abstract

The study investigated the effect of Polya problem solving teaching method on the achievement of students in algebra. The study employed quasi-treatment design. Three (3) research questions were asked and three (3) null hypotheses were formulated for the study. The population of the study was made up of 3600 SSII students in all the thirty one (31) secondary schools in Nsukka education zone of Enugu State. The sample for the study comprised of 300 SSII students drawn from four (4) co-educational schools out of 31 co-educational schools in Nsukka Education Zone of Enugu State drawn through simple random technique. In each of the 4 co-educational schools drawn 8 intact classes of SSII were randomly drawn. 4 intact classes out of the 8 intact classes were assigned to treatment group, while the 4 intact classes were assigned to control group. The treatment group consisted of 160 students who were taught algebra using Polya problem solving teaching method and the control group comprising 140 students who were taught algebra using the conventional method. Data were collected using algebra achievement test (AAT) for both pretest and post-test. Data were analyzed quantitatively using mean and standard deviation, while null hypotheses were tested at 0.05 level of significance using ANOVA. It was revealed from the study that polya problem solving teaching method increased the achievement of students in algebra and is superior to the conventional method of teaching algebra. Also, the study revealed that there was no significance difference in mean achievement scores of males and females in algebra. Based on the findings of the study, the researcher recommended among other things that polya problem solving teaching method should be used in teaching algebra and that mathematics teacher should be trained through workshops, in-service training, seminars etc on the uses of Polya problem solving teaching method approach in teaching algebra in all senior secondary schools for higher academic excellence mathematics generally and algebra in particular. In conclusion, students taught algebra with polya problem solving teaching method had higher mean achievement score than those taught with conventional teaching method. It was therefore concluded that Polya problem solving teaching method enhances students' achievement in algebra.

**Keywords:** Polya, problem solving, teaching method

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## 1.1 Introduction

Over the years, students' poor achievement in Mathematics has been an issue of great concern to Mathematics educators. This ugly trend defiles efforts made by the Federal Government of Nigeria by making the subject compulsory at primary and secondary school levels and the emphasis laid on the importance of the subject. Many researchers have carried out investigations to find out the causes of the poor performance in mathematics and how to remedy the situation. The West African Examination Council (WAEC) Chief Examiners' reports from 2015-2021 years indicated that most students avoided algebra questions while some attempted them haphazardly. In General Mathematics Paper 2, WASSCE, 2019, the Chief Examiner reported that candidates showed significant weakness in interpretation and solutions to word problems in Mathematics in general and algebra in particular. In WASSCE 2018 General Mathematics paper 2, the Chief Examiner pointed out that candidates exhibited weakness in the areas of inequality and graphical solutions to quadratic equations and which are algebraic topics.

Olunlogé (2010) stated that many reasons account for the students' poor achievement in algebra. Among these are poor teaching methods, incompetent teachers, environmental influence, and unavailability of instructional materials, among others. Instructional method employed by mathematics teachers is one of the most important reasons for students' poor achievement in mathematics and algebra in particular. Shafi (2010) stated that conventional method of teaching (talk and chalk) is still a common practice in our nation's secondary schools and has continued to dominate the mathematics classroom. He stressed that when this method is used during instructional delivery, students acquire mathematical skills and concepts by imitating demonstration by the teacher and absorbing textbook communications. The issue of gender differences on students' achievement in mathematics in general and algebra in particular and the effect of using different methods in teaching mathematics have also attracted the attention of previous researchers with mixed results (Azuka, 2013; Imokor Isaollo, 2015).

The ordinary teaching method (talk and chalk) and lecture method have been accused as weak and incapable of inculcating and enhancing students' achievement in algebra (Imokor Isaollo, 2015). Although efforts at improving algebra instruction has been made through improvisation and use of an array of instructional techniques, the status of algebra education in our secondary schools in terms of algebra concept and achievement continues to dwindle (Iji, Omakwu, & Ufubaku, 2015).

One of the innovative and practically oriented instructional methods is Polya problem solving method. Polya George, a professor of mathematics in his problem solving - method in (Anton, 2018, Pnaydon & Suarniati, 2017) identified four (4) stages viz: understanding the problem, devising a plan to solve the problem, carrying out the plan, and looking back.

Polya's first principle is to understand the problem: Polya taught teachers to ask students questions based on their understanding of the topic. The second principle is to devise a plan: In his problem-solving method, the skill at choosing an appropriate strategy is best learned by solving many problems. The third principle is to carry out the plan: In this step, Polya noted that it is usually easier than devising the plan. In general, all you need is care and patience, given that you have the necessary skills. Persist with the plan that you have chosen. If it continues not to work discard it and choose another. The fourth principle is: Look back. He mentions that much can be gained by taking the time to reflect and look back at what you have done, what worked, and what didn't. Doing this will enable you to predict what strategy to use to solve future problems.

### 1.2 Objective of the Study

The main purpose of this study is to find the effect of Polya's Problem-Solving Teaching Method on students' achievement in algebra. Specifically, this study determined:

1. Effect of Polya's problem-solving teaching method on students' mean achievement in algebra;
2. Mean achievement scores of male and female students taught algebra using Polya problem-solving teaching method.
3. Find the interaction effect of method and gender on students' achievement in algebra.

### 1.3 Scope of the Study

This study focused on the effect of Polya's problem-solving teaching method on senior secondary school students' achievement in algebra covering the following topics linear equation, quadratic equation, change of subject formula and simultaneous equation. The study was delimited to senior secondary II (SS 2) in Nsukka Education Zone of Enugu State Nigeria. Senior Secondary two (SS 2) students were chosen because the contents (topics) to be taught fall within SS 2 core curriculum in addition SS 2 students are not final year examination class and hence will be available for the study.

### 1.4 Research Questions

The following research questions guided the study:

1. What are the mean achievement scores of students taught algebra using Polya problem-solving teaching methods and those taught using the conventional teaching method?
2. What are the mean achievement scores of male and female students taught algebra using Polya problem-solving teaching methods?
3. What are the interaction effects of method, and gender on achievement in algebra?

### 1.5 Hypotheses

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

- H<sub>01</sub>:** There is no significant difference in the mean achievement scores of the students taught algebra using the Polya problem-solving teaching method and those taught using the conventional teaching method;
- H<sub>02</sub>:** There is no significant difference in the achievement scores of male and female students taught algebra using the Polya problem-solving teaching method
- H<sub>03</sub>:** There is no significant difference in interaction between methods and gender (male and female) on students' achievement in algebra.

### 2.1 Research Method

The study employed quasi-experimental design of non-equivalent control group design because of the use of intact classes for the study. In this type of study, there was no randomization of subjects since this may disrupt school organization and control groups respectively. The specific design the researcher adopted were pretest, post-test non-equivalent control group design, symbolically represented thus;

**Figure 1: Post-test Design with Non Randomized Experimental and Control Group**

Group	Pre-test	Experimental	Post-test
E	T <sub>1</sub>	X	T <sub>2</sub>
C	T <sub>1</sub>	O	T <sub>2</sub>

Here, E - Treatment group or experimental group

C	-	Control
T <sub>1</sub>	-	Pre-test
T <sub>2</sub>	-	Post-test
X	-	Treatment/Experiment
O	-	Conventional method

## 2.2 Population of the Study

The population of the study was 3600 SS II students in all the thirty-one (31) secondary schools in Nsukka Education Zone. Out of the 31 secondary schools, 7 schools are single sex comprising of 3 males and 4 females schools. The remaining 24 are co-educational secondary schools totaling 2400 students (male 1600 and female 800).

## 2.3 Sample and Sampling Technique

The sample for the study comprised 300 SS II students made up of 193 male students and 107 female students. The simple random sampling technique was used to drawn 4 co-educational schools. Co-educational schools were chosen for the study because of gender influence in the study. In each of the schools drawn, two intact classes were drawn and used for the study by simple random technique. This technique was used to avoid contamination of the experiment by exchange of ideas between the experimental group and control groups.

## 2.4 Instrument for Data Collection

The instrument used for data collection was algebra achievement test (AAT). The test consisted of 40 items multiple choice objective questions, developed by the researchers from the content taught during the study using a table of specification as a guide.

## 2.5 Validation of the Instrument

The algebra achievement test (AAT) was subjected to face and content validation and item analysis. For the face validation, the instrument were scrutinized in terms of relevance, general test format, suitability and clarity. The table of specification (test blue print) was used to ensure the content validity of the instrument in order to ensure that the items were true representative of the content areas.

## 2.6 Reliability of the instrument

The researcher administered the 40-items of the Algebra Achievement Test (AAT) to 30 SSII students from outside the state of study to trial-test the instrument. The trial-test using Kuder-Richardson's estimate methods yielded a reliability coefficient of 0.85 indicating that the instrument was reliable.

## 2.7 Experimental Procedures

Before the experiment which lasted for 12 weeks started, the researchers trained the research assistants that were the classroom mathematics teachers of the four (4) sample schools. The research assistants were training on how to apply the 4 principles of polya problem-solving teaching method on solving algebraic problems involving

1. Understanding algebraic problem.
2. Devise a plan to solve the algebraic problem.
3. Carry out the plan to solve the algebraic problem.
4. Looking back i.e. taking time to reflect and look back at what you have done.

The researchers also guided the research assistants on the essential steps In using polya problem-solving teaching method approach and teaching using conventional teaching approach through the use of clearly and vividly written lesson notes (Lesson plan) as may be applicable to the teachers of each group.

After the training of the research assistants, pre-test was administered to the research subjects (students in the 4 sampled schools) in both treatment and control groups and their scores recorded and kept for data analysis. For achievement of good quality work, the training period and conduct of pre-test lasted for 2 weeks.

After the pre-test, the subjects (students) in both groups were taught the topics in algebra by the research assistants using the relevant lesson notes designed for them. At the end of the treatment which lasted for 9 weeks, Polya problem solving algebra achievement test (PPSAAT) was administered again to the two groups as post-test, Treatments in the two groups were of equal duration by the research assistants. The researcher, at intervals, visited the schools to monitor the instructional delivery. After the administration of the post-test, the research

assistants marked the scripts and scored them and submitted to the researcher. The scores were analyzed to get the mean and standard deviation. The research questions were answered using the mean and standard deviation gotten earlier while the hypothesis were tested at 95% confidence level using ANCOVA.

### 2.8 Control of Extraneous Variables

The following measures were adopted to minimize variability and control of the extraneous variable that could have influenced the finding of the study.

- 2.8.1. Teacher Variable:** To ensure that errors that came from teacher variable did not interfere with the findings of the study, the researcher during the co-ordination of teachers for the conduct of the study identified individual differences of the teachers and provided the remedy. This was done by explaining the contents in the lesson note very well and answering the individual questions of the teacher. The teachers were then assumed to be of equal status academically
- 2.8.2. Hawthorne Effects:** The researchers did not teach by themselves to avoid Hawthorne effect. However, to ensure uniformity of instruction, the researcher developed the lesson plans for the experimental and control groups. Co-ordination of regular teachers for the conduct of the study was properly done by the researcher for uniformity of instruction,
- 2.8.3. Instrumental situation Variable:** The variable which may be introduced as a result of misinterpretation of the instruments for data collection by the subjects was eliminated by trial-testing the instrument before actual experimentation. Any ambiguity found was corrected as a result of validation of the instrument. The researcher issued out the lesson plans to the teachers in each group. The teaching was conducted in all streams/ classes of SS2 in the sampled schools used for this study. A regular supervision was made by the researcher to ensure that the teachers used the polya problem solving teaching method to teach the treatment group while the conventional method was used to teach the control group.
- 2.8.4. Inter Groups Variable:** For this study, since intact classes were used for the study, the inter-group variables introduced as a result of intact classes were controlled using analysis of co-variance during data analysis.

## 3. Results

### 3.1 Research Questions

#### 3.1.1 Research Question 1

What are the mean achievement scores of students taught algebra using Polya problem solving teaching method and those taught using the conventional teaching method?

Data collected for the treatment and control group for both the pretest and posttest were used to answer this research question. Summary of data analysis is presented on Table 4.

**Table 1: Mean Achievement Scores of Students taught Algebra using Polya Problem Teaching Method and those taught Using the Conventional Teaching**

Methods	Adjusted mean	SD	N
Polya Problem Solving Teaching Method	22.22	4.83	166
Conventional Teaching Method	11.00	2.99	94

Summary of the results presented in Table 1 revealed that students taught algebra using polya problem solving teaching method performed better than those students taught using conventional teaching method. This is because the mean achievement score of those taught using polya problem solving teaching method of 22.22 with a standard deviation of 4.83 is higher the mean achievements score of those taught using conventional method which is 11.00 with a standard deviation of 2.99.

#### 3.1.2 Research Question 2

What are the mean achievement scores of male and female students taught algebra using polya problem solving teaching method?

Data collected from males females in the treatment group only in both the pretest and posttest were used to answer this research question. Summary of data analysis is presented on Table 2.

**Table 2: Mean Achievement Score of Male and Female Students Taught Algebra using Polya Problem Solving Teaching Methods**

Gender categories	Adjusted mean	SD	N
Males	21.99	4.72	69
Females	22.39	4.92	97

Summary of results in table 2 revealed that mean achievement score of male students' taught algebra using polya problem solving teaching method is 21.99 with a standard deviation of 4.72 while mean achievement score of female students taught using the same teaching method is 22.39 with a standard deviation of 4.92. Based on

this, the female students taught using polya problem solving teaching method obtained a higher mean achievements score than their male counterpart.

### 3.1.3 Research Question 3

What is the interaction effect of method and gender on the mean achievement scores of students in Algebra?

Data collected from the treatment and control group (in both the pretest and posttest) for were used to answer this research question. Summary of data analysis is presented on Table 3.

**Table 3: Interaction Effect of Method and Gender on the Mean Achievement Scores of Students in Algebra**

Methods	Gender Categories	
	Males	Females
Polya Problem Solving Teaching Method	21.99	4.83
Conventional Teaching Method	11.00	2.99

Summary of results presented in Table 3 revealed that there is no interaction between gender and teaching method on students mean achievement score in algebra. Result presented in the table indicated that polya problem solving teaching method is higher than that of the conventional me two levels of gender (male and female). As a result of interaction effect of method on gender, male students have mean achievement score of 21.99 and standard deviation of 10.60. The female students had mean achievement score of 22.39 with standard deviation of 11.30.

### 3.2 Hypotheses

**3.2.1 H<sub>01</sub>:** There is no significant difference in the mean achievement scores of the students algebra using Polya problem solving teaching method and those taught using the conventional teaching method.

**3.2.2 H<sub>03</sub>:** There is no significant interaction between method and gender on students mean achievement scores in algebra.

Data collected from the treatment and control group for both the pretest and posttest, for male and female students were used to test the two null hypotheses at an alpha level of 0.05. Summary of data analysis is presented on table 4.

**Table 4: ANCOVA Test of Significance of Difference in the Mean Achievement Scores of Students in Algebra by Methods and Interaction.**

Sources of Variation	Sum of Squares	DF	Mean Squares	F	Sig of F
Covariates	3689,721	1	3689.721	274,676	.000
Main Effects	5054.919	3	1684.973	125.435	.000
Methods	4771,844	1	4771.844	355.232	.000
Gender	.002	1	.002	.000	.990
2-way interactions	119.521	3	39.840	2.966	.033
Method & Gender	6.941	1	6.941	.517	.473
Explained	8864,195	8	1108.024	82.485	.000
Residual	3371.693	251	13,433		
<b>Total</b>	<b>12235.888</b>	<b>259</b>	<b>47.243</b>		

For hypothesis 1, the ANCOVA Table 4 showed that the level of significance (0.05) is greater than significance of F (0.00). Since the level of significance is greater than the significance of F value, the null hypothesis was rejected. The researcher therefore, concludes that there is a significant difference in the mean achievement scores of students taught algebra using polya problem solving teaching method and those taught using conventional teaching method.

For hypothesis 3, results presented in Table 4 reveals that for the two way interaction, the significance of F-value at 0,05 level is 0.473, Based on the decision rule, the researcher upholds the null hypothesis and concludes that there is no significant interaction between teaching method and gender on the achievement scores in algebra.

**3.2.3 H<sub>02</sub>:** There is no significant difference in the mean achievement scores of male and female algebra using Polya problem solving teaching method.

Data collected from males and females in the treatment group only in both the pretest and posttest were used to test this null hypothesis at 95% confidence level. Summary of data analysis is presented on Table 5.



**Table 5: ANCGVA Test of Significance of Difference in the Mean Achievement Scores of Students in Algebra by Gender for Treatment Group only**

Sources of Variation	Sum of Squares	DF	Mean Squares	F	Sig of F
Covariates	799.602	1	799.602	42.883	.000
Main Effects (Gender)	3.841	1	3.841	.206	.651
Explained	803.444	2	401.722	21.545	.000
Residual	3039.309	163	18.646		
<b>Total</b>	<b>3842.753</b>	<b>165</b>	<b>23.289</b>		

For hypothesis 2, results presented in Table 5 reveal that level of significance value of (0.05) is less than significance of F-value of (0.651). Based on the decision rule, the researcher upholds the null hypothesis and concludes that there is no significant difference in the mean achievement scores of male and female students taught algebra using polya problem solving teaching method.

### 3.3 Summary of Results

Students taught algebra with Polya problem-solving teaching method had higher mean achievement score of 22.22 than those taught with conventional teaching method with mean achievement of 11.00. Since the level of significance of 0.05 is greater than the significance of F-value (0.00), the researcher concludes that:

1. There is significance difference in the mean achievement scores of students taught algebra using Polya problem-solving teaching method.
2. Female students had higher mean of 22.39 than the mean achievement of male with mean of 21.99. Since, the level of significant value of 0.05 is less than significance of F-value of 0.651, the researcher concluded that there is no significant difference in the mean achievement scores of male and female students taught algebra using Polya problem-solving teaching method
3. There was no interaction between gender and teaching method on students' mean achievement score in algebra. There was no significance difference in interaction between method and gender (Male & Female) on students' achievement in Algebra. Table 4 reveals that the significance of F-value at 0.05 alpha level is 0.0473. Based on decision rule, the researcher upholds the null hypothesis and concluded that there was no significant interaction between teaching method and gender on students mean achievement in algebra.

### 4.1 Discussion

The result of the study revealed that teaching students algebra with polya problem solving teaching method is superior and students achieve higher to that of conventional teaching method. The finding of the study is in line with those of Schoen (2010) who compared the use of polya problem solving teaching method/learning with a conventional teaching method in the development of concepts in algebra in high school form four (4) in country school, Sierra Leone and Syahrole (2016) who investigated the impact of polya problem solving teaching method in the development of the basic concepts of algebra in senior secondary schools II. Students taught algebra using polya problem solving teaching method perform significantly better than students taught using the conventional method.

Again, female students had higher achievement scores than their male counterpart when taught algebra using polya problem solving teaching. The finding of the present study disagrees with that of Schoedler (2010) whose result revealed no gender difference in students academic achievement when taught using polya problem solving teaching method. The study equally disagrees with that of Nneji (2013) who studied the effects of polya problem solving strategy on students achievement and interest in linear inequalities in one and two variables.

However, there are significant difference in the achievement of male and female students while the authors cited found a significance difference in favour of male students, the current study reveals that the difference in achievement is in favour of the female student.

The results of the study equally revealed that there was no interaction effect of method of teaching and gender of students on their mean achievement scores in algebra. The polya problem solving teaching method is superior to the conventional method in fostering academic achievement. The results from this study indicated that the students in the experimental group obtained higher mean scores in academic achievement than those in the control group.

### 4.2 Summary of the Study

1. There is significant difference in the mean achievement scores of students taught algebra with polya problem solving teaching method and those taught with conventional teaching method.
2. Though female students performed better than their male counterpart, there is no significant difference in the two groups when taught algebra with polya problem solving teaching method.

3. There is no significant interaction between instructional approach and gender on the mean achievement scores in algebra.

#### 4.3 Conclusion

1. Students taught algebra with polya problem solving teaching method had higher mean achievement score than those taught with conventional teaching method. It was therefore concluded that polya problem solving teaching method is effective in enhancing students' achievement in algebra.
2. Female students had higher mean achievement score than their male counterparts when taught algebra with polya problem solving teaching method but the difference is not significant.
3. There was no interaction between gender and teaching method on students' mean achievement score in algebra. Gender had no influence on students' achievement in algebra.

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