DOI: https://doi.org/10.67203/jhpesls.2023.dhd1jqv5

Journal of Health, Physical Education, Sports and Leisure Studies, Vol. 8, No. 1, Sept., 2023

EFFECT OF POLYA'S PROBLEM-SOLVING MODEL ON PERFORMANCE IN ALGEBRA AMONG SENIOR SECONDARY SCHOOL STUDENTS IN MINNA, NIGER STATE, NIGERIA

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Abstract

This study investigated the effect of Polya's problem solving model on performance in algebraic word problem among secondary school students in Minna, Niger state, Nigeria. The study adopted Quasi experimental control group design involving pre-test and post-test. The population comprised of SS11 mathematics students of public secondary schools from two local government areas in Minna metropolis. The sample of the study comprised of two hundred and forty (240) SS11 students from four schools randomly selected from Bosso and Chanchaga local government areas, Minna. Algebraic word performance test (AWPT) was the instrument used to measure the learners' performance. The instrument was validated by experts from Departments of Science Education, Guidance and Psychology and experienced secondary school mathematics teachers. After pilot testing, the reliability coefficient was 0.69. It was determined using Pearson Product Moment Correlation Coefficient (PPMCC) after test-retest was applied. Two schools were used for experimental group while the other two schools were used as control. The experimental group was taught using Polya's problem-solving model (PPSM) while the control group was taught using the conventional method. Two research questions were raised and answered, and two null hypotheses were tested. Descriptive statistics of mean, and standard deviation were used to answer the research questions while independent t-test was the statistical tool used for testing the hypotheses at 0.05 confidence level. The result revealed that: significant difference exists between the mean performance scores of the students in the experimental group and those in the control group. Significant difference does not exist between the mean performance of male and female students.

Male students performed better than female students in the experimental and control group. Based on these findings, it was concluded that Polya problem solving model enhanced the performance of the students in secondary school. The researcher recommends that Polya's problem- solving model should be used to help secondary school learners learn algebra effectively. Secondly, workshops and seminars should be organized to train teachers on how to teach algebraic word problem using Polya's problem-solving model.

Introduction

Mathematical knowledge has much to offer in solving problems of mankind in everyday living. It is the back bone of all scientific technology and all activities of human development. It is the only language and culture common to all studies (Golfing, 2005). According to Musa (2006), all professionals use mathematics in one way or the other. Examples include: the driver on the steering uses basic knowledge of numeracy in changing gears, the cook in the kitchen uses concept of measurement in preparing food and soup to know the quantity of what is required for each, the trader in the market tries to know the profit and loss made. The farmer uses mathematical knowledge for farm mechanization for optimization of output and minimization of cost production. It is in recognition of this that our curriculum planners include mathematics as one of the major compulsory subjects in school.

Adeleke (2007) stressed that one particular area which students' problem have been documented is algebra. Babatunde, Abdulrahim, Muhammadu and Zakariyya (2018), noted that algebra is a very technical and abstract aspect of mathematics which is always difficult for students to understand, which eventually makes students to memorize and learning would not take place. It then becomes the duty of the teacher to teach mathematics in a way to encourage the understanding of the required basic structure of mathematics. One way of achieving this is through a careful and thoughtful selection of appropriate teaching strategy (problem solving strategy) that will help students in understanding mathematics concepts especially in algebra rather than passive reception of ideas.

The Polya's problem-solving model is a four-step process. Polya (1957) set out his summary of the core verbal steps in problem-solving, thus: understand the problem, devise a plan, carry out the plan, and look back. This method is simple and generalizes well; it has become a classic method for solving problems. Danjuma (2005), observed that problem-solving activities encouraged the development of problem-solving skills, such as logical reasoning ability which refers to mathematical task that have the potential to provide intellectual challenges that can enhanced learners' mathematical development

and hence improved learners performance in mathematics. Sani (2021) revealed that a problem-solving approach to teaching mathematics defines the role of the teacher as a facilitator of learning rather than a transmitter of knowledge and the learner, as a manager and director of his or her own learning.

According to Ajoma (2009), conventional method is a process where by a teacher gives a talk on a subject to the students, while the students think about the lesson taught. He added that, this method has the advantage of being useful in a large class and in advanced level of learning; it should not be encouraged in the secondary schools. Usman (2010) was of the opinion that, lecture method (conventional method) is teacher centered with little or no participation of students, they remain passive listeners, and this is not an ideal method for them. Gender is another variable in this study. According to Khasanah, Usodo and Sabanti (2018), one of the differences between male and female is the brain. Female perform better than male in verbal memory and male better in spatial ability. Male tend to be good in abstraction, mathematical reasoning and more accurate on target, while female better understand concrete things, better in remembering and mathematical calculations. In problem solving, both male and female have different ways of thinking in accordance with their mathematical abilities. Yahaya (2021), defined gender as a set of characteristics that distinguished a male from a female. The research was designed to provide solution on algebraic word problem through this study, the effect of Polya's problem-solving model on performance in algebraic word problem among students in senior secondary school. It has been observed that many environmental factors affect a person's ability to concentrate, absorb and retain information, and this is a problem because learning is hindered. Another problem is that the preferred mode of teaching is often reflective of an educator's own cognitive preference. This is a commonly ascribed belief that, teachers teach the way they learn.

Furthermore, there is the problem of poor performance in mathematics (especially in algebraic word problem) and negative attitude towards the subject, (Kolawale & Iluagbusi, 2007). Many students seem to be afraid of the subject thereby losing interest. The abstract nature of mathematics is also a problem of itself. Students can only overcome this problem if they are helped to learn in a better way.

Finally, despite the parents efforts in guiding and helping the children at home in their school assignment, extra lessons and buying of learning materials, a good number of mathematics students still experience negative outcome as regards to their academic performance. The concern of this study is to investigate if the application of Polya's problem-solving model can be used to enhance the academic performance of students in algebraic word problem in senior secondary school. Furthermore, investigate the effect of

Polya's problem-solving model on the students' academic performance in algebraic word problem and establish the effect of Polya's problem-solving model on male and female performance in algebraic word problem.

Theoretical Framework

The study was guided by the experiential learning theory. Experiential learning theory draws on the work of prominent 20th century scholars who gave experience a central role in their theories of human learning and development. From Dewey's point of view, experiential learning theory can be understood as an instructional approach based on the idea that, ideal learning occurs through experience and that learning tasks require active participation of the learners in hands-on opportunities and must connect to the learner's life (Dewey, 1938). The theory is called "Experiential Learning" because it emphasizes the central role that experience plays in the learning process. In order for the learning to be meaningful, there has to be an experiential component to the lesson. In the case of learning meaningful strategies for solving algebraic word problems, learners should be given algebraic word problems which are related to their real world situations for them to reflect on their own experiences. Kolb, Boyatzis and Mainemelis (2000), argued that when a teacher focuses only on content without considering learners' background, the opportunity for learners to develop their own opinions of learning algebraic word problem strategies based on interaction with information is easily eliminated. Each learner's experience should be individualized based on past experiences, because not all learners will take away the same outlook of learning strategies. In a mathematics classroom, learners should be given an appropriate task that can lead to experiential mathematical learning or creative dialogues. Getting stuck for a while is very helpful because it provides an opportunity to experience the creative side of mathematical word problem thinking (Linsell 2008). According to Sikukumwa (2017), the theory has it that, learners should not be forced to apply given strategies but should be given choices where they can choose strategies to create their own strategies in order to solve given algebraic word problems provided that they yield sensible solutions. From the theoretical frame work above, the construct of this study is built on the fact that when learning is learner-centered, that is learners are allowed to participate actively in the teaching and learning process, their interest is aroused which in turn leads to positive academic performance.

Research Questions

1. What is the difference in the mean performance scores of students taught algebraic word problem using Polya's problem-solving model and those taught using conventional method?
2. Will there be any difference in the mean performance scores of male and female students taught algebraic word problem using Polya's problem-solving model?

Null Hypotheses

H_{01}: There is no significant difference between the mean performance scores of students taught algebraic word problem using Polya's problem-solving model and those taught using conventional method.

H_{O2}: There is no significant difference in the mean performance score of male and female students taught algebraic word problem using Polya's problem-solving model.

Method

The study employed pre-test post-test quasi-experimental control group design. The study used two groups; Experimental and Control. Experimental group was exposed to Polya's problem-solving model, while control group was taught using the conventional method. The two groups were taught algebraic word problem. Pre-test and Post-test were administered before and after the treatment to determine the effects of the two instructional methods on student's performance in algebraic word problem.

The research design is thus;

Group 1: EG O1 ⟶ X1 ⟶ O2 ⟶

Group 2: CG O1 ⟶ X0 ⟶ O2 ⟶

KEY:

EG: Experimental Group
CG: Control Group
O1: Pre-test
X1: Treatment
O2: Post Test
XO: No Treatment

The population of this study consists of senior secondary school, class two (SSII) Mathematics students admitted in the academic year 2022-2023 from the twenty-two (22) public conventional senior secondary schools in Bosso and Chanchaga local government areas Minna, Niger state. They have total population of six thousand, two hundred and sixty one (6261) SSII students.

Table : Population of SSII students in conventional public schools in Bosso and Chanchaga Local Government Areas, Minna, Niger State.

L.G.A	S/N	Name of Schools	Male	Female	Total
Bosso	1	ADSS Maikunkele	62	71	133
	2	BSS Minna	189	164	353
	3	DSS Gbada	86	120	206
	4	DSS ChanchagMinna B	210	263	473
	5	DSS Garatu	98	82	180
	6	DSS Maikunkele	78	65	143
	7	DSS MaitumbiMinna	200	241	441
	8	DSSPyataBosso	88	104	192
	9	DSS Shatta	67	58	125
	10	DSS Shakwatu	10	7	17
	11	GADSS Beji	121	106	227
	12	GDSS Gurusu	17	11	28
	13	GDSS Kadna	0	0	0
	14	HTMSS Maitumbi	322	410	732
	15	GSSS Kampala	78	81	159
Chanchaga	1	DSS Barikin Sale	112	88	200
	2	DSS Kwasau	121	89	210
	3	DSS Limawa	402	206	608
	4	GDSS Bosso road	411	66	477
	5	ZMS Minna	144	80	224
	6	GDSS Tunga	298	247	545
	7	ABSS Minna	428	160	588
Total			3542	2719	6261

Source: Academic Sourcing Committee, Ministry of Education, Minna Niger State (2023)

Four schools were used as sample for this study. Two schools were randomly selected from each local government area (Bosso and Chanchaga). Two hundred and forty (240) students were used as sample for the study with 60 students from each school. The choice of (240) as sample for the study is guided by scholar's view; Mugenda and Mugenda (2003), is of the opinion that a class size of at least thirty (30) students is enough in each group for quasi experimental research. Detail is presented in table 2 below.

Table 2: Sample of the Study

Group	Male	Female	Total
Experimental	60	60	120
Control	60	60	120
Total	120	120	240

Algebraic Word Performance Test (AWPT) was used as instrument for data collection. It is a six theory item test developed by the researcher from the algebraic topics to be taught. The AWPT contained two sections. The students are required to answer all the six questions. The total mark score is 60 while time allocated was one hour (1hr).

The instrument (AWPT) was validated for content, construct, and criterion related validity. The supervisors, lecturers from faculty of education, Ahmadu Bello University, Zaria and experienced mathematics teacher with minimum qualification of B.Sc. (Ed) Mathematics Education and at least five years of experience validated the instrument.

The (AWPT) was Pilot tested in one of the senior secondary schools that is not part of the study sample but part of the population to further determine the validity and reliability coefficient, and find out the administrative and logistic problems that may hinder the main study. It was administer for one hour. The results were subjected to statistical analysis for the reliability coefficients. The data was analyzed using Pearson Product Moment Correlation Coefficient (PPMCC) statistics. The reliability coefficient was 0.69.

The selected algebraic word problem topics were taught to the sampled students for six weeks. Polya's Problem-solving model was used for the experimental group and conventional method was used for the control group. Pre-test and post-test was given to students using AWPT as to ascertain the performance of both the experimental and control group.

For the purpose of data collection, a post-test of the AWPT was given to the students, marking scheme provided. The data was collected after marking the scripts. The scores were divided into experimental and control groups and were recorded respectively.

The students' scores from the post-test of algebraic word performance test (AWPT) were collected for analysis. The research questions were analyzed using mean and standard deviation while the null hypotheses were analyzed using independent t-test at $p \leq 0.05$ level of significance.

Research Question One

What is the difference in the mean performance scores of students taught algebraic word problem using Polya's problem-solving model and those taught using conventional method.

To provide an answer to this research question, the mean and standard deviation of students taught algebraic word problem using Polya's problem-solving model and those taught the same content using conventional method were used.

Table3*: Mean and Standard Deviation of Performance Scores of the Experimental and Control Group*

Group	N	Mean	Standard Deviation	Mean Difference
Experimental	120	37.06	6.71	18.19
Control	120	18.87	6.39	
Total	240			

Table 3above shows the mean and standard deviation of the performance scores of the experimental and control groups which showed that the mean scores of the experimental group 37.06 is found to be higher than the mean score of the control group 18.87.

Null Hypothesis One

H_{o1}: There is no significant difference between the mean performance scores of students taught algebraic word problem using Polya's problem-solving model and those taught using conventional method.

To test the hypothesis above, the independent sample t-test statistics was used. The result of the t-test analysis is shown in Table 4 below.

Table 4*: Independent Sample t-test Statistics for difference in Performance between Experimental and Control groups.*

Groups	N	Mean	Standard Deviation	Df	t-Value	P- Value
Experimental	120	37.06	6.71	238	21.51	0.000
Control	120	18.87	6.39			
Total	240					

$P<0.05$

The result presented in table 4 indicated that there is a statistically significant difference between the mean test scores of the experimental group and the control group. Specifically, the experimental group had a higher mean test scores (M=37.06, SD=6.71) than the control group (M=18.87, SD=6.39). $t(238)=21.51, P=0.001<0.05$). Based on this, the null hypothesis is rejected.

Research Question 2

Will there be any difference in the mean performance scores of male and female students taught algebraic word problem using Polya's problem-solving model?

To provide an answer to this research question, the mean, and standard deviation scores of male and female students taught algebraic word problem using Polya's problem solving model were used.

Table 5: Mean and Standard Deviation of Performance Scores of Male and Female Students

Gender	N	Mean	Standard Deviation	Mean Difference
Male	60	37.52	5.90	0.92
Female	60	36.60	7.46	
Total	120			

Table 5 above shows the mean and standard deviation of the performance of male and female students which showed that the mean scores of the male students 37.52 is found to be higher than the mean score of the female students 36.60.

Null Hypotheses 2

H_{o2}: There is no significant difference in the mean performance scores of male and female students taught algebraic word problem using Polya's problem-solving model.

To test this hypothesis, the independent sample t-test statistics was used.

Table 6*: Independent Sample t-test Statistics for difference in mean Performance scores of Male and female students*

Gender	N	Mean	Standard Deviation	DF	T-Value	P-Value
Male	60	37.52	5.90	118	0.75	0.46
Female	60	36.60	7.46			
Total	120					

P<0.05

The results in Table 4.6 indicated that there is no statistical significant difference between the mean performance test scores of the male and female students. Specifically, the male students had a higher mean test scores (M=37.52, SD =5.90) than the female students (M = 36.60, SD = 7.46). t(118)=0.75, p=0.46>0.05. Based on this, the null hypothesis is retained.

Discussion of Findings

The result of analysis presented in Tables 3 and 4showed that the students taught algebraic word problem using polya's problem-solving modelperformed significantly higher than

the students taught the same concepts using conventional method. The effectiveness of the result could be due to the fact that Polya's problem-solving model employed for the experimental group is student centered. This implies that Polya's problem-solving model is more effective than conventional method in teaching students algebraic word problem. This result is in agreement with the findings of Phuntsho and Dema (2019), "Effect of Polya' Problem-solving model on Mathematical Academic Achievement and Ability of the fourth grade students", Anietimfon and Abubaka 2021,"Effect of Poly's Problem Strategy on Senior Secondary School Students' Performance in Algebraic Word Problem", and Inah and Anditung (2021), "Effect of Polya's Problem-solving Strategy and Lecture Method on Performance in Geometry among Senior Secondary School Students". They concluded that students exposed to Polya's problem-solving model performed better than those exposed to the conventional method. The Polya's problem-solving model gives the students the opportunity to think, understand the problem, devise a plan, carry out the plan, and check under the supervision of the teacher. This is not so with conventional method of teaching.

The results of the analysis presented in Tables 5 and 6showed that the male students performed better than their female counterpart when taught algebraic word problem using Polya's problem-solving model. Anietmfon and Abubakar (2021), from their research, on "Effect of Polya's Problem solving Strategy Senior Secondary School Students' Performance in Algebraic Word Problem", noted that performance of male and female students taught using Polya's problem-solving model had slight difference in the favor of the male students. It was recommended among others that teachers should use Polya problem solving model in teaching mathematics mostly algebraic word problem.

Conclusion

1. The use of Polya's problem-solving model improved the performances of the students in algebraic word problem.
2. The polya's problem-solving model is very effective for the improvement in the academic performance of both male and female students.
3. Conventional method commonly used by teachers in secondary schools is not suitable for meaningful teaching and learning of algebraic word problem.

Recommendations

1. Mathematics teachers should use Polya's problem-solving model to teach the students algebraic word problem in secondary school.
2. Authorities in science education and professional bodies should regularly organize workshops, seminars and conferences to popularize the use of Polya's problem-solving model to solve algebraic word problem in schools.
3. The students irrespective of gender should be taught using Polya's problem-solving model as it enhances algebraic word problem academic performance.

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