EFFECTIVENESS OF POLYA & WOODS PROBLEM SOLVING MODELS ON STUDENTS' ACADEMIC PERFORMANCE IN SIMPLE LINEAR EQUATION IN ONE VARIABLE

By

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Abstract

The aim of this study was to investigate the effectiveness of Polya and Woods problem solving models on students' academic performance in simple linear equation in one variable among junior secondary school students in Obio Akpor Local Government Area of Rivers State, Nigeria. The study adopted a pre test post test quasi-experimental design. The study was guided by three (3) research questions and three (3) hypotheses which were tested at 0.05 level of significance. The population of the study was 6,045 students and a sample of two hundred (200) students was selected using the simple random sampling technique. The instrument used for data collection was titled "Simple Linear Equation Performance Test (SLEPT). Research questions were answered using the mean and standard deviation while the hypotheses were tested using t-test statistic. The result revealed that students who were taught linear equation in one variable using Polya problem solving model out-performed their counterpart who were taught with Woods problem solving model. The findings also revealed that there was significant difference in the performance of the male and female students who were taught simple linear equation in one variable using Polya problem solving model.A significant difference was found between the performance of low and high achieving students in the experimental group. To this end it was recommended that polya problem solving model should be used by Mathematics teachers most especially when teaching simple linear equation. The teachers should also be trained on how to use the model to teach different topics in Mathematics.

Keywords*: Problem Solving Models, Performance, Linear Equation, Polya, Woods.*

Introduction

Mathematics deals with quantifications as well as shapes, how they are spatially allotted and diverse ways of observing changes in them. It also formulates new conjectures using patterns. Natural projections become more realistic if mathematical structures related to everyday life are well formulated. Every nation needs Mathematics and science as these lead to national development. Stemming from the importance of Mathematics, the Nigerian Federal Ministry of Education made it a compulsory subject for all to offer. Mathematics is one subject students must pass at credit level in order to qualify for admission to tertiary institutions. Mathematics shares similar features with science and technology because it involves finding answers to fundamental problems. However, it differs from science and technology by relying on logic and creativity (Odogwu, 2015).

It is difficult to imagine any reasonable development in virtually any sphere of life without scientific and mathematical knowledge (Sherrod, Dwyer & Narayan 2009). It was as a result of this that most developing countries tended to put more interest and emphasis on mathematical studies. In every society, Mathematics has been made the central to the school curriculum. One cannot do without Mathematics in most aspect of our lives such as cooking, shopping, to recall a phone number from memory and also to dial a number on your phone. Mathematics is also useful in different vocations such as carpentry, bricklaying, tailoring and welding. Mathematics is also very useful in other school subjects, like the sciences, technology, geography and in most professions. All these disciplines need Mathematics in order to function well. The influence of

Mathematics on everyday life is all encompassing and central to the creation of national wealth. Mathematics is a subject that contributes to the origin of creations, without which the world cannot move an inch.

The study of Mathematics develops in the students the culture of logical thinking, intellectual independence, power of concentration, precision on writing, orderliness of thought, general discipline of the mind and the ability to handle abstract concepts and solve problems (Odogwu, 2015). The main purpose of teaching and learning Mathematics is to enhance the learners' fitness to undertake several different mathematical tasks whether easy or hard, regularly. In other words the study of Mathematics is perceived to be an avenue for inciting the thought form, building up thinking faculties and enhancing the total person to have a better technological and scientific standpoint in the society (Asiedu-addo & Yidana 2001)cited in (Attehet.al., 2017). The Nigerian Mathematics curriculum was designed to train individuals who can be self-confidence, creative, have critical thinking, problem solving ability, think logically and be innovative.

Problem solving has been the most important issues in school Mathematics and it has never lost its significance in the teaching-learning process. In Mathematics, problem-solving skills help students apply principles to scenarios found in the real world (Margaret, 2015). One of the most easiest way of studying Mathematics is through problem solving because problem solving skills help students to apply mathematical knowledge to the real life situation. Students develop problem solving skills when they are involved in the tasks of solving mathematical problems. It has been observed by Yali (2016) that most students struggle with mathematical problem solving as a result of the inefficient and ineffective strategies adopted. There abound problem solving models which problem solvers can employ when solving problems in Mathematics. A problem solving model (PSM) is a system or set of plans which guides a problem solver on the right track to handling and solving a problem. There are different types of problem solving models in Mathematics. Students are expected to be engaged in the use of different problem solving models to resolve problems in Mathematics. Polya, Schoenfeld, Krulik & Rudnik, Woods, Rubeinstein, Brandsford & Stein and Heuristic problem solving models can be employed to solve problems in Mathematics. A good knowledge and use of problem solving models discourages students from solving Mathematics problems using trial and error method.

Given that there are different problem solving models, it is crucial that teachers do not rely on one particular PSM but rather should introduce students to the different PSM. Polya (1957) who is known as the father of problem solving developed a four-phase problem solving model as cited in (Porntipa, 2017). The four-phase problem solving model as developed by Polya is characterized by: 1. Understand the problem 2. Devise a plan 3.Carry out the plan and 4. Look back. The model helps students to become better problem solvers and also show how students should help others develop their problem solving skills. In a bid to expand the problem solving ability and Mathematics achievement among students in the classroom, teaching and learning environment should be enabling and convenient to help students increase their problem solving ability and Mathematics achievement (Porntipa, 2017). Appeu(2014) posited that most of the people that succeed in problem solving tasks utilize some form of strategies that paves way for them. Centre for Teaching Excellence, University of Waterloo (n.d.) stated that Woods (1971) developed a five- step problem solving model by including a step known as "think about the problem". The five steps are:1. Define the situation of the problem 2. Think about the problem 3. Plan a solution 4. Carry out the plan and 5. Look back.

 Constructivists suggested that both teachers and educational planners have this expectation from society to design pragmatic processes of teaching and learning that can be generally applied to all learners, environment and our everyday life situations. Simple linear equation in one variable is a crucial part of the Mathematics curriculum because it forms the foundation or

springboard to other forms of mathematical equations of higher order or degree. NCTM (2010) affirmed that linear equations form an integral part of algebraic, geometrical and trigonometric problems as well as being independently relevant. Poon and Leuna (2010) asserted that linear equations is one of the most important topics in algebra and Mathematics as a whole. This implies that linear equation in one variable is a veritable springboard to the study of algebra. It is true from history, that linear equations have played central roles in the development of other branches of Mathematics and in solving real life problems(Dreyfus & Hock 2004) cited in (Atteh et al. 2017).

Even though school Mathematics has had a shift in its platform in recent times, linear equation continues to be an essential pivot in the study of algebra (Chazan, 2008). It is on this note that students are expected to understand the process, justify and explain the steps involved in tackling problems in linear equations. Richard (2002) pointed out that many students still have a difficult time learning algebra, particularly learning the principles and skills related to the solving of linear equations in one variable. Cai and Moyer (2008) agreed to this when they pointed out that problems in linear equations create confusion for students because of the improper handling by some teachers. Several teaching strategies are available to overcome these travails faced by students in this regard and to ensure that the Mathematics classroom is steered away from the teacher-centre instructional approach to student-centre instructional approach (Fujii, 2008). Andam et al. (2015) pointed out that learning is effective when the learner has the opportunity to contend with tasks, think about the solutions, employ strategies to solve and then do a check on the result. This study therefore sought to investigate the effectiveness of employing Polya's 4-phase PSM and Woods' 5-phase PSM in solving simple linear equations in one variable.

Problem Justification

The aim of teaching Mathematics is to prepare children for life and also to give to those who want to further their studies the opportunity to do so without struggles. Unfortunately, most students see Mathematics as a difficult subject. Understanding and solving the concept of linear equation in one variable is a problem that needs to be surmounted as a prerequisite for advancement into algebra and other aspects of Mathematics. A good knowledge of linear equation can be sequel to ability of pupils to solve problems of sets, power of numbers, numeration system and other mathematical topics. Mereku(2001) affirmed that the poor performance is as a result of non-usage of problem solving models to fine-tune students problem solving skills in the teaching of linear equation in one variable and other Mathematics concepts in general. The question one need to ask now is that, how can the students be guided to improve their knowledge and understanding of simple linear equation in one variable? Thus, this research was carried out to investigate the effectiveness of Polya & Woods problem solving models on students' academic performance in simple linear equation in one variable.

Objectives of the Study

The aim of this study was to investigate the effectiveness of Polya and Woods problem solving models on students' academic performance in simple linear equation in one variable among junior secondary students. The specific objectives of the study were to:
1. Find out the effect of the use of Polya PSM and Woods PSM on the academic performance of students in simple linear equation in one variable.
2. Ascertain the effect of the use of Polya PSM on the academic performance of the male and female students in simple linear equation in one variable.

3. Determine the effect of the use of Polya PSM and Woods PSM on the academic performance of the high achieving and low achieving students in simple linear equation in one variable.

Research Questions

The following research questions were answered:

1. What is the difference in the performance mean scores of students taught simple linear equation in one variable using Polya PSM and those taught with Woods PSM?
2. What is the difference in the performance mean scores of the male and female students taught simple linear equation in one variable using Polya PSM?
3. What effect does Polya PSM have on the performance mean scores of low achieving and high achieving students taught simple linear equation in one variable?

Hypotheses

Two null hypotheses were formulated and tested at 0.05 significant level.

H_{O1}:There is no significant difference between the performance mean scores of students taught simple linear equation in one variable using Polya PSM and those taught with Wood PSM.

H_{O2}:There is no significant difference between the performance mean scores of the male and female students taught simple linear equation in one variable using Polya PSM.

H_{O3}: There is no significant difference between the performance mean scores of low achieving and high achieving students taught simple linear equation in one variable using Polya PSM.

Research Methodology

The study employed the pretest-postest intact class quasi-experimental research design. A multi-stage simple random sampling technique was used to select two intact classes from two different sampled schools. The sample was two hundred JSS two students. This design presented one experimental group and one control group. The experimental group was taught the concept of simple linear equation in one variable using Polya problem solving model while the control group was taught the same topic using Woods PSM. The study was carried out in Obio/Akpor Local Government Area of Rivers State, Nigeria. The population from which the sample was drawn for this research comprised of all the 6,045 co-educational junior secondary two (JSS 2) students in Obio/Akpor Local Government Area.

The instrument used to collect data was titled Simple Linear Equation Performance Test "SLEPT". The Simple Linear Equation Performance Test was a 20-item multiple choice questions which was developed by the researchers from the content area used for the study. Each question had four options (letters A to D). Three of the options were distractors and only one option was the correct answer. The questions were drawn using the validated table of specification which was used to allocate the questions into the higher and lower order cognitive learning domains. SLEPT was subjected to both face and content validity. A reliability power of 0.82 was established using the test retest method. This reliability power revealed that SLEPT was reliable, hence it was used to collect the data. The previous term's class result in Mathematics was used to categorize students into high and low achievers.

At the beginning of the experiment both groups were given the pre test. After the administration of the pre test, the Mathematics teachers in the two schools conducted the experiment. The experimental group was taught simple linear equation in one variable using Polya PSM while the control group was taught same topic using Woods PSM. The experiment

was conducted during the normal school hours using the school time table for classes. The experiment was done for two weeks. At the end of the experiment, the post test was administered to the two groups by the teachers. The data collected from the pretest and post test were marked over one hundred. The mean, standard deviation and independent t-test were used to analyse the data.

Results

Research Question One: What is the difference in the performance mean scores of students taught linear equation in one variable using Polya problem solving model and those taught using Woods problem solving model?

Table 1: Mean and standard deviation of students taught simple linear equation in one variable using Polya PSM (experimental group) and those taught using Wood PSM (control group).

Group	N	Mean	SD	Mean Difference
Experimental	100	52.64	10.60	13.12
Control	100	39.52	18.49	

Table 1 above showed the mean and standard deviation of students taught simple linear equation in one variable using Polya PSM (experimental group) and those taught using Wood PSM (control group). The table showed that students in the experimental group who were taught simple linear equation in one variable using Polya PSM performed better (M= 52.64, SD= 10.60) than their counterparts who were taught with Woods PSM (M= 39.52, SD= 18.49). The difference in the performance mean scores for the two groups was (MD=13.12).

Research Question Two: What is the difference in the performance mean scores of the male and female students taught simple linear equation in one variable using Polya problem solving model?

Table 2: Mean and standard deviation of male and female students taught simple linear equation in one variable using Polya PSM

Sex	N	Mean	SD	Mean Difference
Male	59	49.43	12.62	10.50
Female	41	38.93	18.99	

Table 2 above showed mean and standard deviation of the male and female students taught simple linear equation in one variable using Polya problem solving model. The table showed that the male students taught simple linear equation in one variable using Polya problem solving model performed better (M= 49.43, SD.= 12.62) than their female counterparts who were taught with the same Polya problem solving model (M= 38.93, SD= 18.99). The difference in the performance mean scores for the two experimental subgroups (male and female) was (MD=10.50).

Research Question Three: What effect does Polya PSM have on the performance mean scores of low achieving and high achieving students taught simple linear equation in one variable?

Table 3: Mean and standard deviation of low and high achieving students taught simple linear equation in one variable using Polya PSM

Achievers	N	Mean	SD	Mean Difference
Low	62	35..27	13.15	15.77
High	38	51..04	16.91	

Table 3 above showed mean and standard deviation of low achieving and high achieving students taught simple linear equation in one variable. The table showed that the low achieving students taught simple linear equation in one variable using Polya PSM performed lower (M= 35.27, SD= 13.15) than their high achieving counterparts who were taught with the same PSM (M= 51.04, SD= 16.91). The difference in the performance mean scores for the two experimental subgroups (low and high achievers) was (MD=15.77).

H_{O1}: There is no significant difference between the performance mean scores of students taught simple linear equation in one variable using Polya problem solving model and those taught with Wood PSM..

Table 4: Independent t-test of students taught simple linear equation in one variable using Polya PSM and those taught with Woods PSM.

Group	N	Mean	SD	df	t_{cal}	t_{crit}	Min	Max	Decision
EG	100	52.64	10.60				28	88	
				198	6.12	1.96			*
CG	100	39.52	18.49				8	84	

EG = Experimental Group, CG = Control group, *Significant

Table 4 above showed that there was a significant difference between the performance mean scores of students taught simple linear equation in one variable using Polya problem solving model and those taught using Woods PSM (t_{cal} = 6.12>$t_{Crit.}$= 1.96 at 198 df). Hence, the null hypothesis one which stated that there was no significant difference between the performance mean scores of students taught simple linear equation in one variable using Polya problem solving model and those taught with Woods PSM was rejected and the alternative hypothesis retained at 0.05 level of significant.

H_{O2}: There is no significant difference between the performance mean scores of the male and female students taught simple linear equation in one variable using Polya problem solving model.

Table 5: Independent t-test of the male and female students taught simple linear equation in one variable using Polya PSM

EG	N	Mean	SD	df	t_{cal}	t_{crit}	Min	Max	Decision
Male	59	49.42	12.62				28	88	
				98	3.32	1.96			*
Female	41	38.93	18.99				8	84	

*Significant, EG = Experimental Group

Table 5 above showed that there was a significant difference between the performance mean scores of the male and female students in the experimental group taught simple linear equation in one variable using Polya problem solving model (t_{cal} = 3.32 >$t_{Crit.}$= 1.96 at 98 df).Hence, the null hypothesis two which stated that there is no significant difference between the performance mean scores of the male and female students taught simple linear equation in one variable using Polya problem solving model was rejected and the alternative hypothesis retained at 0.05 level of significant.

H$_{O3}$: There is no significant difference between the performance mean scores of low achieving and high achieving students taught simple linear equation in one variable using Polya PSM.

Table 6: Independent t-test of low and high achieving students taught simple linear equation in one variable using Polya PSM

EG	N	Mean	SD	df	t$_{cal}$	t$_{crit}$	Min	Max	Decision
Low	62	35.27	13.15				8	68	
High	38	51.04	16.91	98	1.31	1.96	88	24	**

**Significant, EG = Experimental Group

Table 6 above showed that there was no significant difference between the performance mean scores of the low and high achieving students in the experimental group taught simple linear equation in one variable using Polya problem solving model (t$_{cal}$ = 1.31< t$_{Crit.}$= 1.96 at 98 df).Hence, the null hypothesis three which stated that there is no significant difference between the performance mean scores of the low and high achieving students taught simple linear equation in one variable using Polya problem solving model was retained at 0.05 level of significant.

Discussion of Findings

The result of table 1 showed that students who were taught simple linear equation in one variable using Polya PSM in the experimental group performed better than the students who were taught using Woods PSM in the control group. This was revealed in the performance mean scores of the experimental group which was 52.64 while that of the control group was 39.52 with a mean difference of 13.12 in favour of experimental group. This was also confirmed by the test of hypothesis one on table 4 which revealed that t$_{cal}$ > t$_{crit}$ which showed that the Polya problem solving model had positive effect on students performance in simple linear equation in one variable. Hence the null hypothesis one of no significance difference in the mean performance scores of students taught simple linear equation in one variable using Polya PSM and students taught using Woods PSM was rejected.

However, the result of table 2 showed that the male students that were taught simple linear equation in one variable using Polya PSM performed better than their female counterparts that were taught using the same method. This was revealed in the performance mean score of the male students which was 49.42 while that of female students was 38.93 with a mean difference of 10.50. This was also confirmed by the result of table 5 which showed that   t$_{cal}$ > t$_{crit}$, which showed that Polya problem solving model had positive effect on the male students performance in simple linear equation in one variable. Hence the null hypothesis of no significance difference between the performance mean scores of male and female students taught simple linear equation in one variable was rejected.

The result of the study was in line with the findings of Atteh et al. (2018) which revealed that the use of Polya PSM in teaching and learning of linear equations improved students understanding of the principles of solving linear equations in one variable. This is also in consonance with the earlier findings of Mehmood (2014) who found that teaching via problem solving method based on revised Bloom's taxonomy had a higher positive effect on students performance than the conventional method. Findings of Nneji (2013) also showed that students taught algebra with Polya George PSM achieved higher and retained more than those taught with expository method. Meanwhile, the results of this study showed that the male students performed

higher than the female students taught using Polya problem solving model. However, the findings of Nneji (2013) deviated from this.

Conclusion

The study concluded that Polya PSM was more effective than the Wood PSM in the solving of simple linear equation in one variable amongst students based on method, gender and

Recommendations

1. Polya problem solving model should be adopted by all teachers when teaching simple linear equation in one variable.
2. Secondary school Mathematics teachers in general should be trained on the use of Polya problem solving model for teaching and learning of Mathematics.
3. Other PSM can be employed by Mathematics to cater for the needs and interest of the low achieving students.

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