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THE JOURNAL OF THE MATHEMATICAL
ASSOCIATION OF NIGERIA

VOLUME 39, NUMBER 1
MATHEMATICS EDUCATION SERIES
SEPTEMBER 2014

Sponsored by "E.T.F. Grant 2010"

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COMPARATIVE EFFECTS OF TWO PROBLEM- SOLVING MODELS ON SENIOR SECONDARY SCHOOL STUDENTS' PERFORMANCE IN MATHEMATICS WORD PROBLEMS

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ABSTRACT

The study adopted pre-test, post-test, quasi experimental design. A total of 180 senior secondary two purposively selected from six secondary schools in Ilorin metropolis took part in the study. The instrument used for data gathering in the study was Mathematics Performance Test (MPT) designed by the researchers. The findings of the study showed that there was a significant difference between the performance of the experimental and the control groups. Gender had no significant influence on the performance of the students exposed to the instructional models. Subject combination of students had significant effect on the performance of students exposed to the Polya's problem- solving model with the science students having the highest mean gain score followed by the commercial students while the Art students had the least mean gain score. Mathematics teachers should take time to teach mathematics language in Bearing before teaching the actual concept to enhance better performance of students. Mathematics Teachers and Mathematics textbook authors should endeavor to employ Polya and Bransford and Stein problem solving models among others to enhance meaningful learning in mathematics.

INTRODUCTION

Mathematics is viewed as the science of structure, order, number, space and quantity (Odili, 1990). This definition connotes that all sciences draw their inspirations from Mathematics. Therefore, it can be inferred that mathematics is the language of all sciences. As important as Mathematics is, literature indicates that a considerable number of students lack adequate understanding of mathematical concepts and skills leading to high failure rate in the subject (Wasike, 2006). Mathematics problem-solving, in particular, requires specialized skills which are practical and which involves a unique linkage between mathematics, communication and the environment. Mathematical expressions must be properly and accurately understood in order to reduce the mistakes committed by students while solving mathematics word problems in general and word problems on bearing, in particular. (Ameen, 2007).

Funkhouser (1992) defined problem-solving as a multiple step process where the problem-solver must have had relationship with past experiences (schema) and the problem at hand and then set up a solution. In order words, students need to learn this process if they are to deal successfully with problems in real life situations and those that they may come across in schools. Therefore, models have been advanced for the teaching and learning of problem-solving. Some of the models are those of Polya (1957) Bingham (1958), Simon and Newell (1972) and Bransford and Stein (1984).

The use of problem-solving models enhances the teaching, learning and performance of students in mathematics word problems involving bearing. Therefore the researcher employed two problem-solving models with more emphasis on teaching the technical terms in bearing on the performance of students in mathematics. The first model involved in the study is the Polya problem-solving model comprising four stages: (1) understanding the problem (2) devising a plan that will lead to the solution (3) carry out the plan (4) looking back. The second model involved is the Bransford and Stein problem-solving model which comprises five stages (1) identification of the problem (2) defining and representing the problem (3) exploiting possible strategies (4) acting on those strategies (5) looking back.

The stage II of Polya problem-solving is further broken-down into stages II and III, by Bransford and Stein respectively in his model. The choice of Bransford and Stein problem-solving model as the second model use to find out whether the five stages enhance better performance of students in solving bearing word problems in Mathematics.

Statement of the Problem

One of the goals of Mathematics teaching and learning is to develop the ability to recognize a problem and apply the knowledge of Mathematics to obtain the solution to the problem. Reports from Chief Examiners of the West African Examinations Council (WAEC) and Mathematics Educators have affirmed students' poor performances in Mathematics problems at the Junior and Senior Secondary School levels. Also, the works of Ameen (2007&2013) respectively affirmed that Word problems involving bearing has been identified as a topic students perceived difficult. Thus, the present study focuses on the comparative effects of two problem-solving models on students' performance in mathematics word problems.

Purpose of the Study

The main purpose of the study was to examine the comparative effects of two problem-solving models of Polya and Bransford and Stein on Students' performance in Mathematics Word Problems. Specifically, the study examined the comparative effects of;

- (1) Bransford and Stein (1984) and Polya (1957) instructional models on students' performance in mathematics word problems involving bearing.
- (2) Bransford and Stein (1984) and Polya (1957) instructional models on the performance of male and female students in mathematics word problems involving Bearing.
- (3) Bransford and Stein (1984) and Polya (1957) instructional models on the performance of science, Art and Commercial students in mathematics word problems involving Bearing.

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Research Questions

In this study, answers are provided to the following research questions:

- (i) What are the comparative effects of Bransford and Stein (1984) and Polya (1957) problem-solving models on the performance of students exposed to the treatment and their counterpart in the control group in solving Mathematics Word Problems involving Bearing?
- (ii) Is there any difference between the performance of male and female students taught with Bransford and Stein (1984) model?
- (iii) Is there any difference between the performance of male and female students taught with Polya (1957) model?
- (iv) Will there be any difference between the performance of Science, Arts and Commercial students taught with Bransford and Stein (1984) model?
- (v) Is there any difference between the performance of science, Arts and Commercial students taught with Polya (1957) model?

Research Hypotheses

The following research hypotheses are tested in the study.

1. There is no significant difference in the performance of students taught with Bransford and Stein (1984) and Polya (1957) problem – solving models and their counterpart in the control group.
2. There is no significant difference in the performance of male and female students exposed to Bransford and Stein's (1984) instructional model in Mathematics word problems involving Bearing.
3. There is no significant difference in the performance of male and Female students exposed to Polya (1957) instructional model in Mathematics Word Problems involving Bearing.
4. There is no significant difference in the performance of Science, Arts and Commercial students taught with Bransford and Stein (1984) instructional model in Mathematics Word Problem- involving Bearing.
5. There is no significant difference in the performance of science, Arts and Commercial students taught with Polya (1957) instructional model in Mathematics Word Problem involving Bearing.

Research Methodology

This study employed a quasi-experimental design (non-randomize, non-equivalent, pre-test, post-test control group design). The choice of this design is considered appropriate when the true experimental design is not possible. The Mathematics Performance Test (MPT) which contains six essay items on bearing word problems was adapted from the West African Senior School Certificate Examinations while two instructional packages were prepared by the researchers and used as treatment for the study. The Mathematics Performance Test was administered to senior secondary 2 students drawn from six equivalent co-educational secondary schools in Ilorin metropolis of Kwara State. The Mathematics performance test was used as the pre-test

and post-test. The research instrument had been tested for validity and reliability by the West African Examinations Council since the instrument was a set of past questions from the senior secondary school Certificate Mathematics Examinations past Questions and also revalidated by the expert in the field of mathematics education at the university of Ilorin. The computed reliability value is 0.67.

The instructional packages were lesson plans prepared by the researchers based on the two problem-solving models of Bransford and Stein (1984) and Polya (1957), the conventional method and the teaching of the technical terms in bearing word problems. These instruments are:

- Polya Problem - solving instructional model (PM)
- Bransford and Stein instructional model (BSM) and
- Lesson plan for the teaching of the technical terms in bearing word problems.

Data Analysis and Results

The research questions that have no equivalent hypotheses were answered using descriptive statistics while the hypotheses were tested using Analysis of covariance (ANCOVA). The Scientific Package for Social Sciences (SPSS) programme of version 17.00 was used to analyze the data.

Research Question 1:

What are the comparative effects of Bransford and Stein and Polya problem-solving models on the performance of students exposed to the treatment and their counterparts in the control group in Mathematics Word Problems involving bearing?

Hypothesis 1: There is no significant difference in the performance of students taught with Bransford and Stein (1984) and Polya (1957) problem-solving models and their counterpart in the control group.

The test for significance of the hypothesis is at α - level of 0.05. In Table1, the analysis indicated that the p-value is zero which is less than 0.05. This indicated that there was a significant difference between the three post-test scores of the students taught using the three (3) instructional models. It could be concluded that there was a significant difference in the performance of students taught with Bransford and Stein, Polya and the conventional method. The models have significant effects in view of the improved performance of the students in posttest in mathematics word problems involving bearing. The multiple comparison test of Scheffe post-hoc analysis was carried out to determine the actual source of the difference that existed among the three instructional methods. The direction of the difference was in favour of students exposed polya instructional strategy.

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Table 1:
ANCOVA Computation on effects of two problem-solving models on students' performance in Mathematics Word Problems involving Bearing

Sources	Type III sum of square	Df	Mean square	F	Significant
Corrected Model	1326.4339	2	663.217	23.261	0.000
Intercept	46948.050	1	46948.050	1646.642	0.000
Method	1326.433	2	663.217	23.261	0.000
Error	5046.517	177	28.511		
Total	53321.000	180			
Corrected Total	6372.950	179			

R Square = 0.208 (Adjusted R Squared = 0.199)

Table 2 shows that post-test mean score of Polya, and Bransford and Stein is 2.92 at 0.013 significant level. Since 0.013 is less than 0.05 level of significance, it implies that significant difference in performance of students exist between the two instructional models. Also, respectively between Bransford and Stein and the other methods, Polya and the conventional method showed that there exist a significant difference, this was based on the p-value of 0.13 and 0.001 which was less than $\alpha = 0.05$. Also, the post-test mean scores of 2.92 and 6.63 indicated significant difference between Polya and Bransford and Stein, and the conventional method respectively when compared with the P-value of 0.013 and 0.000 which are less than 0.05 level of significant. lastly, the post-test mean score differences of -3.72 and -6.63 between conventional method and Bransford and Stein, Polya method difference, with suggested P-value of 0.001 and 0.000 level at 0.05 level of significance. In conclusion, the table indicated that students exposed to the Polya model performed significantly better followed by those exposed to the Bransford and Stein model and those exposed to the conventional method had the least performance.

Table 2:
Test for significant difference between the post-test mean scores on exposure to
Bransford and
Stein, Polya and the conventional methods.

Instructional Method	Instructional Method	Post-test mean score difference	Standard error	Significance
Bransford and Stein	Polya	-2.92*	0.975	0.013
	Conventional	3.72*	0.975	0.001
Polya	Bransford and Stein	2.92*	0.975	0.013
	Conventional	6.63*	0.975	0.000
Conventional	Bransford and Stein	-3.72*	0.975	0.001
	Polya	-6.63*	0.975	0.000

Research Question2: Is there any difference between the performance of male and female students taught with Bransford and Steins (1984) Model?

Hypothesis 2: There was no significant difference in the performance of male and female students exposed to Bransford and Steins (1984) instructional model in Mathematics Word Problems Involving Bearing.

R Square = 0.809 (Adjusted R square = 0.802).

From the table 3, the p-value 0.790 was obtained and was greater than $\alpha = 0.05$ therefore, hypothesis two was not rejected. This indicated that there was no significant difference between the performance of male and female students taught with Bransford and Steins' model in the Word Problems involving Bearing Mathematics.

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Table 3:
ANCOVA computation on the effect of gender on Bransford and Stein's instructional model on the performance of student's in Mathematics Word Problems Involving Bearing.

Source	Type III sum of Squares	Df	Mean Square	F	Significance
Corrected Model	987.634*	2	493.817	120.831	0.000
Intercept	4771.629	1	4771.629	1167.561	0.000
Pre-test	986.733	1	986.733	241.442	0.000
Gender	0.291	1	0.291	0.71	0.790
Total	17391.000	60			
Corrected Total	1220.583	59			

R Square=0.809 (Adjusted R Square=0.802)

Research Question 3: Is there any difference between the performance of male and female students taught with Polya (1957) model?

Hypothesis 3: There was no significant difference in the performance of male and female students exposed to Polya (1957) instructional model in Mathematics Word Problems involving Bearing.

From table 4 the p-value of 0.889 was obtained and greater than $\alpha = 0.05$. This implies that hypothesis three was not rejected, meaning that there was no significant difference between the performance of male and female students exposed to the Polya model in solving mathematics Word Problems Involving Bearing.

Table 4:
ANCOVA Computation of gender for Polya (1957) instructional model on
Mathematics Word Problems Involving Bearing

Source	Type III sum of square	Df	Mean square	F	Significance
Connected Model	1646.272	2	823.136	29.305	0.000
Intercept	4519.557	1	4519.557	160.902	0.000
Pre-test	1625.372	1	1625.372	57.865	0.000
Gender	0.551	11	0.551	0.020	0.889
Error	1601.052	57	28.089		
Total	2567.00	60			
Corrected Total	3247.33	59			

R square = 0.507 (Adjusted R squared = 0.490).

R square = 0.810 (Adjusted R square = 0.799).

Research Question 4: Will there be any difference between the performance of science, Art and Commercial students taught with Bransford and Stein's (1984) model.

Hypothesis 4: There was no significant difference in the performance of Science, Art and Commercial students exposed to Bransford and Stein's (1984) instructional model in Mathematics Word Problems involving Bearing.

The p-value of 0.898 was obtained. Therefore, the hypothesis was not rejected. This indicates that there was no significant difference in the performance of the Science, Commercial and Art students using Bransford and Stein problem- solving model.

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ANCOVA computation of student's performance based on the subject combination exposed to Bransford and Steins (1984) instructional model.

Sources	Type III sum of squares	Df	Mean square	F	Significances
Corrected model	988.2141	3	329.414	79.397	0.000
Intercept	3104.352	1	496.608	119.694	0.000
Pre-test (Covariate)	486.600	1	496.608	0.108	0.898
Error	232.342	56	4.149		
Total	17391.000	60			
Corrected Total	120.583	59			

R square = 0.810 (Adjusted R square = 0.799).

Research Question 5: Is there any difference between the performance of Science, Arts and Commercial students taught with Polya (1957) model.

Hypothesis 5: There was no significant difference in the performance of Science Arts and Commercial students exposed to Polya (1957) instructional model in Mathematics Word Problems Involving Bearing.

From the above table, the p-value of 0.000 was obtained. Therefore the hypothesis was rejected. This indicated that there was a significant difference in the performance of the Science, Commercial and Arts using Polya model.

Table 6:
ANCOVA Computation of Students performance based on the subject combination exposed to Polya instructional model

Sources	Type III sum of Square	Df	Mean Square	F	Significant
Corrected model	2140.266 ^a 4707.057	3	710.089	35.598	0.000
Intercept	653.033	1	4707.057	235.971	0.000
Pre-test (Covenanter)	484.546	1	653.033	32.735	0.000
Class	1117.067	2	242.272	12.145	0.000
Error	25674.000	56	19.948		
Total		60			
	3247.333				
Corrected Total		59			

R Squared = 0.656 (Adjusted R squared = 0.638).

SUMMARY OF THE MAJOR FINDINGS

Findings from the study are as follows:

1. Students exposed to Polya problem-solving model performed better in Mathematics Word Problems involving bearing than their counterparts exposed to Bransford and Stein model.
2. Students in the polya group also out performed students in Bransford and Stein, and the conventional groups.
3. Gender of the students exposed to the three models and their counterparts in the conventional group had no influence on their performance in mathematics word problems involving bearing.
4. Students' subject combination had significant effect on the performance of students exposed to Polya instructional model with the science students out performing their counterparts in commercial and Arts.
5. Students' subject combination had no significant effect on the performance of students exposed to Bransford and Stein model.
6. There was no interaction effect between the instructional models based on gender.

DISCUSSION OF THE FINDINGS

The findings of the study showed that Students taught using Polya's problem-solving instructional model performed better in the Bearing post-test administered than their counterparts taught using Bransford and Stein problem-solving model. This shows that the Polya problem-solving model is the most effective method of instruction out of the three instructional models used in the study. This finding was in line with the findings of Galadima (2002) and Suleman (2010)

The experimental group taught using Bransford and Stein model was the next group that performed higher in Bearing post-test administered, while the control group that was taught using the conventional method had the lowest performance. In the administered Bearing pre-test instrument, the sampled students for the study could not interpret the concepts involving language (technical terms) in bearing correctly, which could be responsible for the students' poor performance in the pre-test administered to them. For instance, some of the students scored zero in the pre-test.

In this study, three instructional models were employed to teach bearing word problems in mathematics. Findings showed that the two problem-solving models of Polya, and Bransford and Stein are effective models of teaching than the conventional method. Further, the study revealed that there was significant difference in the performance of male and female students taught using the two problem-solving models of Polya, and Bransford and Stein in Bearing post-test. The finding conform with the findings of Salman (1998), Galadima (2002), Olawoye (2006) and Suleman (2010). Therefore, both males and females benefited from Polya, Bransford and Stein models of problem-solving.

Also, the performance of science, Art and Commercial Students taught using the two problem-solving models of Polya, and Bransford and Stein in the post-test on bearing is significantly different with the Science students performing best followed by Commercial and Arts respectively. Therefore, the students' subject combination had effect on their performance in bearing word problems. This finding is in agreement with the findings of Salman (1998).

CONCLUSION

The findings of the analyzed results showed that problem-solving models of instructions could enhance students' academic performance better in bearing word problems than the control group. It could be concluded that the Polya and Bransford and Stein models of problem-solving with more emphasis on teaching the technical terms improved students' performances in Mathematics Word Problems Involving Bearing. This implies that problem-solving models explored in this study appeared to have improved students to retain the learned materials. Also, gender had no influence on the performance of students taught using the instructional model of Bransford and Stein. The findings also revealed that subject combination (Science, Arts or Commercial) of Students had significant effects on the performance of students taught using polya instructional strategy while it has no effect on the performance of students taught using Bransford and Stein model in words problem involving bearing in mathematics.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made :

1. Polya problem-solving model should be used by mathematics teachers to teach Mathematics Word Problems Involving Bearing in Nigerian Secondary Schools because it enhances students' performance when solving bearing word problems.
2. The Mathematics teachers should take time to teach Mathematics language in Bearing before teaching the actual concept because it enhances better transformation of the word expression into mathematical expression.
3. Teachers should place more emphasis on the use of the instructional models for Arts and Commercial Students when using various problem-solving models to enhance better performance of all students in solving word problem involving bearing.
4. Mathematics Textbook authors should endeavor to employ Polya and Bransford and Stein problem-solving models in their solved examples to enhance understanding, meaningful and correct interpretation of bearing problems in word expression into mathematical expression.
5. Regular workshops, seminars and symposia on use of instructional models in general and polya and Bransford and Stein in particular should be organized by the ministry of education and other stakeholders for secondary school mathematics teachers in order to enhance their methodological skills.

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