The Use of Bar Models in Solving Mathematical Problems: Its Effect on Academic Performance

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Abstract – *This study sought to evaluate the effects of bar models in solving mathematical problems on the academic performance of the freshmen students of STI College Tagbilaran for school year 2013-2014. The randomized Solomon four-group design was employed in the study. The study targeted the four sections of freshmen students taking up Bachelor of Science in Information (BSIT) and Associate in Computer Technology (ACT). Two sections from BSIT compromised as the experimental group with a total of forty students and two sections from ACT served as the controlled group with a total of forty- three students. Teacher-made test was the main research instrument utilized in the study. Study revealed that the use of bar model as an approach in solving mathematical problems is effective in improving the performance of the students. Furthermore, bar model is more effective than the conventional approach. Exposure on the types of test presented helped also the students to gain insights in the increase of their scores in the post-test.*

Keywords – academic *performance, bar models, solving mathematical problems*

INTRODUCTION

In our modern world, it cannot be refuted that solving mathematical problem is considered as an important part of Mathematics education. The ability to solve mathematical problem is the ultimate goal of mathematics. It has become clear that an individual's ability to solve mathematical problem enhances his or her ability to function in the context of everyday situation and work settings [1].

The Department of Education said that almost two-thirds of the high schools fared poorly on the National Achievement Test (NAT) in the school year 2010-2011 with some 67.10 percent of schools getting below average NAT scores. Only around one-third of the high schools scored between 51 percent and 75 percent while only 1.13 percent of schools were rated superior with a mean score between 76 to 100 percent among its takers [2].

Studies and researchers showed that Philippines belongs to the low performing nations in terms of academic achievement in two subjects namely English and Mathematics [3]. Among the thirty-eight (38) countries who participated in the International Mathematics and Science Study (TIMSS) conducted in 2000, the Philippines ranked number 36 while in 2003, Philippines ranked 40 out of the 45 participating countries. In addition, in the International Mathematics Olympiad (IMO) 2003 the Philippines ranked number 79 out of 82 countries and in 2007, the Philippines with 21 points ranked number 84 out of 93 participating countries. Internationally, the Philippines belongs to the bottom five of poor achievements in Mathematics and Science [4]. The results call for a change in the approaches of teachers in teaching mathematics especially in solving mathematical problem.

Factors such as low expectations, difficulty in applying mathematical skills in flexible ways to solve novel problems, deficiencies in mathematical concepts, inadequate instruction by teachers who have a poor grasp of mathematics, overemphasis on procedural knowledge, and lack of opportunities to achieve at high levels are known to continue to these poor mathematics achievement [5]. Many teachers lack specific instructional strategies to help these children meet the high standards [6]. Furthermore, finding from the meta-analysis of intervention research in mathematics for low achieving students indicated that few studies focus on specific instructional practices to improve student learning [7].

With test results of the students in the national and international scenarios, it is a vital role of the teachers to find a way on how to address the low performance of the students in mathematics especially in solving mathematical problems. As teachers, they may use an approach that will make solving mathematical problems more interesting and easier to understand since it has been observe that college students were having a hard time in solving simple mathematical problems. Though they were already in a college level but still they complained that the given mathematical problems were too abstract and found it hard to picture the situation indicated by the problem that they were trying to solve. Most of them complained that the inclusion of solving mathematical problems in the curriculum made their life stressful. They think that it will just add burdens, frustrations, stress and struggles in their daily life. With this difficulty and negative beliefs about their overall intellectual capacities their academic performance was also affected. They always got a low score every time they were given activities that involves solving mathematical problems.

To address the said problem mentioned above, mathematics teacher had introduced varied teaching strategies to help solving mathematical problem become easy and appealing. Some of the strategies used were restating a problem, decomposing or recombining a problem, drawing figures, making charts or organized lists, exploring related problems, using logical deduction, using successive approximations, using guess-and-check method, and working background [8]. There is certain strategy that has helped improved the problem-solving performances of the students than training them in any other strategy that is being mentioned above [9]. This strategy refers through the use of Singaporean model method.

Singapore was being noted for its outstanding performance in Mathematics and Science. It was found out that the country used an approach that helped the students understand the problem well. The said approach was the introduction of bar models. Its introduction has helped a lot of students in eliminating their fears and negative attitude towards the subject. With the use of bar models, the students were given the opportunity to have a concrete presentation of the problem. They no longer find the given problem too abstract and hard to understand.

According to the results from the Trends in International Mathematics and Science Study [10], Singapore students continue to place among the best mathematical problem solvers in the world. This small country has improved its students' performance upon the introduction of an approach that was developed by a team of educators which advocated a concrete to pictorial strategy. Through the introduction of bar model approach, it let the students construct a pictorial model to represent quantities and their relationship. The model puts back on the relationship and actions presented in the problem and help students choose both the operations and sequence of steps that are needed to solve a problem. [11].

The use of bar models argues that through the construction of a pictorial model to represent the known and unknown quantities and their relationship in a problem, students gain better understanding and develop their abilities in mathematical thinking and problem solving [12]. In few U.S. schools where Asian-style model is taught, both the students and teachers have found it to be an effective tool for problem solving. [13]. Researchers have concluded that visualization is a powerful problem-solving tool and can be helpful in all kinds of mathematical problems [14].

The Singapore model teaches students to represent quantities with bar of varying lengths and determine which operation to choose in one-step problem [11]. There are three primary models that will help students determine which operation to choose. These are part-whole model, whole-part model and the comparison model. The part-whole model is used when a mathematical problem involves a whole and its parts. If the parts are given, they will be added to find the whole value. If the value of whole is given and one part, subtraction is to be used in order to find the missing part. The second type which is the whole-part model is applicable when the total number of parts, a whole and a part is given. And lastly, the comparison model is utilized when comparing two or more quantities.

The use of bar models can begin with young learners with basic addition, subtraction, multiplication, and division problems. Modeling can be extended to ratio, percent, multi-step and other complex problems in the upper grades. Utilizing modeling on a route basis in early grades can lay important foundation for later work, including the transition to algebra by stressing patterns, generalizations, and how numbers relate to each other [15]. By learning to use simple models to represent key mathematical relationship in a word problem, students can more easily make sense of word problems, recognize both the number relationship in a given problem and connections among types of problems and successfully solve problems with the assurance that their solutions are reasonable [16]. Proficiency in applying bar model will assist the students in solving more complicated mathematical problems as they progress through elementary and high school mathematics.

The study is anchored on Gerome Bruner's three modes of representation [17]. These modes of representation are the way in which information or knowledge are stored and encoded in memory. These are the enactive, iconic, and symbolic. Enactive mode involves encoding action based on information and storing it in our memory. Iconic mode is where information is stored visually in the form of images. It is where learning can be obtained through using models and pictures. This explains why, when we are learning a new subject, it is often helpful to have diagrams or illustrations to accompany verbal information. A study has found out that an increase in visual or non-linguistic representation allows students to better recall knowledge and has a strong impact on student's achievement [19]. Symbolic mode is where information is stored in the form of a code such as language. It is where the learner develops the capacity to think in abstract terms.

By studying the effects of applying bar models in solving mathematical problems, it will bring some changes in the performance of the students towards the subject. It positively results to changes in the instruction of the subject. It will also help the students in visualizing the problem from abstract to concrete and assist them in seeing the relationships of the quantities that are involved in the problem. And most importantly, it will aid the students in understanding mathematical problems more easily and will satisfy their learning through seeing and doing.

OBJECTIVES OF THE STUDY

The primary goal of the study is to evaluate the effects of bar models in solving mathematical problems on the academic performance of the freshmen students of STI College Tagbilaran for school year 2013-2014. Specifically, it sought to answer the following questions: What is the pre-test score of the experimental and control group? Is there is a significant difference in the pre-test of the experimental and control group? Is there a significant mean gain of score from pre-test to post-test of the experimental and control group? And lastly, is there a significant difference in the post-test results of the control and experimental group with and without pre-test?

METHODS

The randomized Solomon four-group design was employed in the study. This design attempts to eliminate the possible effect of a pre-test. The subjects were randomly assigned to four groups, with two of the groups were given pre-test and the remaining two groups were not. The experimental group was exposed to treatment; one pre-tested while the other one is not. From the control group, one is pre-tested while the other one is not. The study targeted the four sections of freshmen students taking up Bachelor of Science in Information (BSIT) and Associate in Computer Technology (ACT). Two sections from BSIT compromised as the experimental group with a total of forty students and two sections from ACT served as the controlled group with a total of forty-three students. A total of twenty students from the control group were given a pre-test and twenty-three students were not. For the experimental group, twenty students were given a pre-test and twenty students were not. All of the four groups were given a post-test.

Teacher-made achievement test was used as the instrument of the study. One set of tests was used for pre-test and post-test. The test was based from the topics covered during the months of experimentation. The researcher took the items from the courseware provided by the school that contains the topics, seat works and quizzes to be executed on the students. Some of the items were taken from the internet. The content of the test covered the topics on the four fundamental operations, ratio, fractions and mathematical problems involving fractions. With the use of the table of specification, the researcher had prepared one set of tests which contained fifty-five items.

The research instrument was validated by using the U-L index method. The acceptable difficulty index ranged from .20-.80 while acceptable discrimination index ranged from .25-.80. Items were accepted if it fell on the acceptable difficulty and discrimination indices. Items were subjected for revision if the items had an acceptable difficulty index but with unacceptable discrimination index and vice versa. Items which did not fall on the accepted limits were rejected. A total of one hundred items were validated using the U-L index method, out from one-hundred, fifty-five items were retained, and forty-five items were subjected for revisions.

The data gathering procedure underwent a series of steps. First, a pre-test was conducted to the experimental and control group. To ensure reliability, the researcher was vigilant enough in monitoring the students while answering to avoid cheating. Right after the examination, the papers were collected and checked by the researcher and the students' scores were recorded for statistical analysis.

Second, the bar models were used as an intervention for the experimental group while the conventional method was applied for the controlled group. The four sections of freshmen students were separated into two groups. The first group was the experimental group which consisted of two sections from BSIT. This group was taught using the bar models as a teaching approach of the teacher to help them solve mathematical problems quickly. Students were encouraged to use pictorial model to represent the known and unknown quantities and their relationship in a problem. The second group which was the controlled group was comprised of the two sections of ACT students. The controlled group was educated using the conventional approach. In this approach, the teacher uses the step-by-step approach in solving mathematical problems. The approach is composed of the following steps: finding the given and unknown, representation, constructing an equation, solution and checking. In every topic introduced by the teacher, an exercise was given to the students. The experimentation lasted for two months since the teacher could only meet her students once a week; therefore, for her study to be reliable, she allocated eight meetings for the administration of the experiment.

Lastly, after discussing all the topics in their Math- plus subject, a post-test was conducted to the two groups. This was done to find put the effects of bar models on the academic performance of the students.

The scores of the students were gathered and used for statistical analysis. The mean test, standard deviation, t-test of dependent and independent means were the statistical treatments used in the study. The mean test was used to find out the kind of distribution the data has, and the standard deviation was used to measure the spreadness of the data of the four sections of freshmen students in their pre-test and post-test scores. In testing the difference between the pre-test and post-test results of the students' mathematics scores, t-test of dependent means was used, and t-test of independent means was used in testing the significant difference of the pre-test and post-test scores of the control and experimental groups.

RESULTS AND DISCUSSION

Table 1. Pre-test Score of Control and Experimental Groups

Score Interval	Description	Control Group		Experimental Group	
		f	%	f	%
52-55	Excellent	0	0	0	0
46-51	Very Good	0	0	0	0
40-45	Good	0	0	1	4.35
34-39	Satisfactory	5	25	1	4.35
28-33	Fair	4	20	5	21.74
Below 28	Fail	11	55	23	69.56
Total		20	100	23	100
Mean		25.25		24.65	
Standard Deviation		7.63		7.42	
Skewness		0.69		0.67	

It can be observed from table 1 that 45 percent of the students from the control group got the passing percentage score of 50 percent, the school's standard passing rate. Those are described from fair to satisfactory while there are 30.44 percent of the students from the experimental group. There are 4.35 percent of the students from the experimental group who obtained a score ranging from 40-45 which described as good while there's none from the control group. The percentage of students from both groups who got a failing score which is below 28 is 62.79 percent.

When it comes to the closeness or spreadness of the scores from the mean, the standard deviations of the two groups showed a very small difference. The mean of the control group which has a value of 25.25 is higher than the mean of the experimental group which has a value of 24.65. The skewness of both experimental and control groups is positive. It means that most of the students scored below the mean.

Table 2. The Difference on the Pre-test of the Control and Experimental Group

Group	$\bar{x}$	SD	t-value	Tabular Value	Decision
Control Pre-test	25.25	7.63	0.36	1.96	Accept H_o
Experimental Pre-test	24.65	7.42			

Based from the above computed values, it can be seen that the means of the control and experimental groups have a slight difference. Their standard deviation is close to each other. There is no significant difference between the pre-test results of the control and experimental group since the computed value which was 0.36 is less than the tabular value of 1.96. It can be concluded that the control and experimental group exposed to pre-test has the same standing with regards to their performance. The two groups are said to be comparable this is due to the fact that most of them scored poorly in their pre-test scores. Most of them got a failing score.

Table 3. Mean Difference on the Pre-test and Post-test Results of the Control and Experimental Group

Group	Pre-test mean	Post- test mean	D	SD	t-value	Tabular Value
Control Group	25.25	29.3	4.05	3.75	4.83**	2.09
Experimental Group	24.65	39.52	14.87	8.50	8.39**	2.07

***Reject Ho*

The post-test mean of the control group is higher than its pre-test mean. There's a mean gain of 4.05. The computed value of 4.83 is greater than the tabular value which was 2.09, hence, there's a significant mean gain in the pre-test and post-test of the control group. Comparing the pre-test and post-test means of the experimental group, the post-test mean has a bigger value which was 39.52 than the pre-test mean which has a value of 24.65. There's a higher mean gain of 14.87. There is a significant mean gain in the pre-test and post-test of the experimental group. It can be deduced that both groups who were exposed to pre-test has a better performance in the post-test since they are already familiar with the items. The teacher was able to let the students understand the lesson. The use of bar models has also a positive effect on the performance of the students since there's a high increase on the post-test mean of the experimental group. With bar models, it has provided them with a powerful image that organizes information and simplifies the problem-solving process. It has helped them organize their thinking about a given problem. As supported in the study of [18] that that an increase in visual or non-linguistic representation allows students to better recall knowledge and has a strong impact on student's achievement.

On the other hand, the conventional approach is also found to be effective in solving mathematical word problems since there's a mean gain increase of 4.05 in the post-test scores of the controlled group.

Table 4. Difference on the Post-test Results of Control and Experimental Groups with and without Pre-test

Group	$\bar{x}$	SD	t-value
Control without pre-test	24.21	11.07	1.47
Experimental without pre-test	28.76	7.35	
Control with pre-test	29.3	8.25	5.77**
Experimental with pre-test	39.52	7.72	

***Reject Ho; Tabular Value: 1.96*

The experimental group without pre-test has a higher mean of 28.76 compared to the control group without pre-test with a mean of 24.21. The standard deviation of the control group without pre-test is more spread than the standard deviation of the experimental group without pre-test. This means that the scores obtained by the students were varied. There's no significant difference between the post-test results of the control and experimental group without pre-test since the computed value which was 1.47 is less than the tabular value which was 1.96. The mean of control group with pre-test which was 29.3 is less than the mean of the experimental group which was 39.52. There's a slight difference in the standard deviation of both groups exposed to pre-test. There's a significant difference between the post test results of the control and experimental group with pre-test since the computed values which was 5.77 is greater than the tabular value which was 1.96 using two-tailed test with alpha at 0.05. It can be noticed that the experimental group who underwent a pre-test and exposed to the use of bar models has increased their performance. Thus, the experimental group exposed to pre-test has already familiarized the items and the use of bar models is found to be effective on the basis of the mean gain earned by each group**.** This is because students had learned to apply bar models in solving mathematical problems. Based from their experiences, bar models has helped them in eliminating their fears and negative attitudes towards the subject. They were given the opportunity to have a concrete representation of the problem. They no longer find the given problem too abstract and hard to understand.

The result is in consonance with the study conducted by Badger wherein it was found out that in few U.S. schools where Asian-style model is taught, both the students and teachers have found it to be an effective tool for problem solving. [14]. Researchers have concluded that visualization is a powerful problem solving tool and can be helpful in all kinds of mathematical problems [15].

CONCLUSION AND RECOMMENDATION

It can be concluded that the use of bar models as an approach in solving mathematical problems is more effective compared to the conventional approach and has brought positive effects in improving the performance of the students. As stated in Gerome Bruner's iconic mode of representation where information is stored visually in the form of images. It is where learning can be obtained through using models and pictures. This explains why, when we are learning a new subject, it is often helpful to have diagrams or illustrations to accompany verbal information. A study has found out that an increase in visual or non-linguistic representation allows students to better recall knowledge and has a strong impact on student's achievement [18].

Exposure on the types of test presented before the experiment helped also the students in to gain insights in the increase of their scores in the post-test. The researcher recommended that teachers are encouraged to apply bar models as an approach in solving mathematical problems. The teachers are also encourage to continue the conventional approach since it was also found to be effective but must also encourage to incorporate an innovative approach that would make solving mathematical problem more interesting and easy to solve.

REFERENCES

[1] Fede, J. L. (2010). The effects of go solve word problems math intervention on applied problem-solving skills of low performing fifth grade students.

[2] Philippine Daily Inquirer,2011

[3] Armachuelo, Rowena et. al. An assessment on the attitudes and elementary competencies towards mathematics of DWC high school freshmen S.Y. 1995-1996.

[4] The Philippines' weekly alternative magazine, 2006.

[5] Schmidt, W. (2002). Missed opportunities: How mathematics education in the US puts our students at a disadvantage and what can be done about it. Policy report No. 7. Education Policy Center, Michigan State University.

[6] Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. Journal for research in mathematics education, 520-540.

[7] Gersten, R., Chard, D., Jayanthi, M., Baker, S., Morphy, P., & Flojo, J. (2009). A meta-analysis of mathematics instructional interventions for students with learning disabilities: A technical report. Los Alamitos, CA: Instructional Research Group.

[8] Limjap, A. A. (2001). Issues on problem solving: Drawing implications for a techno-mathematics curriculum at the collegiate level.

[9] Yancey, A. V., Thompson, C. S., & Yancey, J. S. (1989). Children must learn to draw diagrams. The arithmetic teacher, 36(7), 15-19.

[10] Martin, M. O., Mullis, I. V., Foy, P., & Olson, J. F. (2008). TIMSS 2007 international mathematics report. Findings from IEA's trends in international mathematics and science study at the fourth and eighth grades, 319-323.

[11] Englard, L. (2010). Raise the bar. Teaching children mathematics, 17(3), 156-165.

[12] Kho, T. H., Yeo, S. M., & Lim, J. (2009). The Singapore model method for learning mathematics. EPB Pan Pacific.

[13] Badger, J. Teaching Singapore math: Evaluating measures to effectively teach and implement a new mathematics curriculum in 21 elementary schools.

[14] Van Garderen, D., Scheuermann, A., & Jackson, C. (2012). Examining how students with diverse abilities use diagrams to solve mathematics word problem. Learning disability quarterly, 36(3), 145-160 DOI: 0731948712438558

[15] Ginsburg, A., Leinwand, S., Noell, J., & Pollock, E. (2009). Reassessing US international mathematics performance: New findings from the 2003 TIMSS and PISA. Colección Digital Eudoxus, (22).

[16] Schmidt, W. H. (2012). At the precipice: The story of mathematics education in the United States. Peabody Journal of Education, 87(1), 133-156.

[17] Bruner, J. S., & Olson, D. R. (1973). Learning through experience and learning through media. Prospects, 3(1), 20-38.

[18] Marzano, R. J., Pickering, D., & Pollock, J. E. (2001). Classroom instruction that works: Research-

based strategies for increasing student achievement. Ascd.

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