Vol. II, Issue 3, Oct – December 2021 *International Research Journal of Education and Innovation*
ISSN No: (ONLINE): 2710-043 ISSN No: ISSN (PRINT): 2710-0448
www.irjei.com DOI: https://doi.org/10.53575/irjei.v2.03(21)11.119-128

Enhancing Mathematical Word Problem Solving Skills: Using Bar Model Visualization Technique

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Received on: 20-10-2021 Accepted on: 21-11-2021

Abstract

The study purpose is to investigate the effect of Bar Model Visualization Technique on the word problem solving skills of elementary level students in mathematics. Following were the objectives of the study (i) to investigate the effect of Bar Model Visualization Technique on addition word problems-solving skills; (ii) to investigate the effect of Bar Model Visualization Technique on subtraction word problems solving skills; (iii) to investigate the effect of Bar Model Visualization Technique on multiplication word problems solving skills; (iv) to investigate the effect of Bar Model Visualization Technique on division word problems solving skills. The null hypotheses were designed to test the objectives as (i) there is no significant effect of Bar Model Visualization Technique on addition word problem solving skills; (ii) there is no significant effect of Bar Model Visualization Technique on subtraction word problem solving skills; (iii) there is no significant effect of Bar Model Visualization Technique on multiplication word problem solving skills; (iv) there is no significant effect of Bar Model Visualization Technique on division word problem solving skills. The nature of the study was experimental. Pre-test and post-test equivalent group design was used as a tool for data collection in this study. Sample of the study was 40 students (Male & Female) of Government Primary School No.2 Bab-e-Jadeed District Nowshera, Khyber Pakhtunkhwa. The sample students were divided on the basis of pretest scores by applying paired random technique in to experimental group and control group. Data were analyzed by mean, SD and t-test. It was concluded that the concepts of Bar Model Visualization Technique had significant effect on addition word problems and subtraction word problems but it has not significant effect on

multiplication word problems neither division word problems. The results of the study show that Bar Model Visualization Technique had significant effect on Mathematical word problem solving skills and also the learner take interest in the subject. It provides alternative method for teacher to teach mathematics subject.

Keywords: Bar Model Visualization Technique, Mathematical word problem, Elementary level, Problem solving skills.

Introduction

Mathematics is defined as a figurative language that enables its learners to communicate the ideas related to the element of quantity and to think about the record (Lerner & Johns, 2009). Mathematics includes data handling, dealing with numbers, counting, geometry, measurement, and even more difficult activities, which make this subject a complex one (Dowker, 2004).

In Pakistan, the national curriculum for the subject of mathematics declares this subject as a compulsory subject from primary to secondary level. In our country, it is a difficult task for most of the students to learn mathematics. Curriculum of Mathematics, in our country comprises a distinctive kind of knowledge that requires a specific mind frame, positive attitude and continuous struggle on part of the learners (Government of Pakistan, 2006).

According to Skovsmose (2013) the view point of educating learners in mathematics can be taken as narrowly and widely. Assumed the philosophy narrowly in some of the tasks of mathematics is considered as its aim. So it can be said that in this sense of mathematical philosophy i.e narrow sense, the concern of education aims besides the way of its teaching. However, the objectives, goals, aims and purposes, to teach mathematics is not an easy task, individuals or social groups are involved in it, which make it a complex one. According to Ali (2011) these mathematical standards included in the national curriculum are not present in subject of mathematics, which enable the leaners to utilize mathematical knowledge for the dire demand to live in a society surrounded by technology.

Jan and Rodrigues (2012) added that problem solving is one of the critical mechanisms in mathematics at all levels and in all mathematical activities in education. Almost all the learners of mathematics around the globe consider this word problem as a boring task and they feel difficulty in solving such questions. At elementary level Mathematics, Science, English, Urdu are the important subjects and Mathematics is most important subject among them but students find it difficult to solve numbers, algebra and geometry.

The curriculum for the subject of mathematics should be offered in multiple ways in order to make the teaching of mathematics understanding and interesting. These multiple ways may include virtual (dynamic electronic) representation, pictorial (static visual) representation and physical (concrete) representations. Such representations can be used by mathematics educators for manipulative purposes to enhance the abstract contents or symbolic contents to model the concepts of mathematics. He further cited that in the late 1800s, it was used for the first time in mathematics education formally, the learners of mathematics and educators used concrete manipulative in those old days, but in the modern classroom the use of pictorial and virtual manipulative is in practice for teaching of mathematics (Cope, 2015).

Related Researches

Bar Model is particular model that provides itself well to the concept of equality. “In the subject of mathematics, the bar model indicates to a long or short size strip on which different scales are represented at the same time, by the use of bar mode, a quantity of amount can be conveyed through a different quantity or amount”. Three types of bad models are widely in

practice: the first on in them is part-part-whole, the second type of bar model is comparing, and the third type of bar model is multiplication or division (Van den Heuvel-Panhuizen, 2003).

According to Azizah, Rohani and Mokhtar (2010) one of the important aspects of mathematics is word problem solving. It joins day to day and real life problems and applications.

The difficulties felt by the students in problem-solving can be easily tackled by the means of numerous activities and strategies. Of among those strategies is the use of bar model strategy, which is suitable enough for the learners to enhance their way of understanding, related to questions like word problem-solving. Bar model was introduced in Singapore Education. This strategy in teaching of mathematics is one of the visualization ways of learning. Problem-solving skills enable the learners of mathematics to be more independent in solving the problems (Vula & Kurshumlia, 2015).

Bar model strategy enable the learners to be more constructive their own knowledge. Bar Model strategy is a strategy that promotes understanding of the learners regarding problem-solving questions. Piaget's constructivist theory has a close relation with the strategy of bar model, which enable the school leaners to build their personal knowledge by know-how. Bar Model fosters critical thinking in students as it works on visual approach. Learners can extract information regarding any question and relationship between the bar and information given by drawing the rectangular bar (Hofer, 2015).

The visualization happening the minds of the learners can be transported by the means of the bar model more effortlessly, simply, naturally and smoothly as compare to symbols (Fong Ng & Lee, 2009).

Sherman and Bisanz (2009) found that the learners were well able to express their thinking and overcome a much comfortable knowledge of equality, when they were provided a problem without symbolic contexts. Possibly the learners may show more improvement and they may enjoy the problem solving if bar model is used.

Statement of the Problem

Bar Model is an effective technique for students to learn Mathematics. The purpose of this study is to practice this technique for primary level students. The study was aimed at investigating the effect of Bar Model Visualization Technique on the word problem solving skills of elementary level students in the subject of mathematics.

Objectives

The research study aimed at:

- To investigate the effect of Bar Model Visualization Technique on addition word problem solving skills.
- To investigate the effect of Bar Model Visualization Technique on subtraction word problem solving skills.
- To investigate the effect of Bar Model Visualization Technique on multiplication word problem solving skills.
- To investigate the effect of Bar Model Visualization Technique on division word problem solving skills.

Hypotheses

The hypotheses were as:

$H_0 1$. There is no significant effect of Bar Model Visualization Technique on addition word

problem solving skills.
$H_0$2. There is no significant effect of Bar Model Visualization Technique on subtraction word problem solving skills.
$H_0$3. There is no significant effect of Bar Model Visualization Technique on multiplication word problem solving skills.
$H_0$4. There is no significant effect of Bar Model Visualization Technique on division word problem solving skills.
$H_0$5. There is no significant effect of Bar Model Visualization Technique on student's mathematical word problem solving skills.

Method and procedure
Population
Population of the study was comprised of all Government Primary Schools district Nowshera Grade-V students studying Math.

Sample
For the conduction of experiment Government Primary School No.2 Bab-e-jadeed Tehsil Pabbi District Nowshera was selected. Forty students of Grade-V were selected as sample of the study. These forty students were divided in two groups on the basis of pretest by paired random sampling technique. There were 15 male and 5 female students in each group.

Research Design
The research was experimental. The participants were distributed in two groups: experimental and control. The pretest-posttest equivalent group design was used to measure the effectiveness of treatment that involved two equivalent groups, the following was the symbolic representation of research design (Farooq & Tabassum, 2017).

R_E =	O_1	T	O_2
R_C =	O_3		O_4
dR_E =	O_2 - O_1		
dR_c =	O_4 - O_3		
D= d R_E - d R_C			

Where,
R_E = Randomly Selected Experimental Group
R_C = Randomly Selected Control Group
O_1 & O_3 = observation of pre test
O_2 & O_4 = observation of Post-tests
T = Treatment (teaching by experiential learning model)
d = difference between mean scores of Pre-test and Post-test

Research Instrument
Data was collected by the following tool.

Pretest and Posttest
The researcher developed tests (pretest and posttest). Both tests were developed on the basis of the lesson plan objectives as well as study objectives.

Treatment
Teacher developed lesson plans for delivering the lecture. Control group were taught with lecture demonstration method. While experimental group were taught with Bar model visualization technique which include book, chalk/marker, blackboard or whiteboard, flash cards and Bar models (developed from packing foam and drawing on charts).
Three chapters Numbers and Arithmetic Operations, Unitary Method and Fractions were taught to the Grade-V students by two different teachers, one teacher for control and other one for experimental group.

Procedure
The researcher for the research study subjects developed sixteen sets of lesson plans. Duration of the study was six weeks. Each class lasted thirty-five minutes in duration. The subject students were introduced to mathematical words question and teacher converted a problem from words into an internal representation. During this stage actions were also taken to move to an external representation from the internal representation. For instance, a diagram was drawn by the teachers related to the elements of the problem on black/white board and also presented charts and models (made of packing foam/ clipboard). These diagrams were rectangular in shape. Different strategies (operations) were applied in order to achieve the desired numerical solution. Groups were formed and blocks were distributed among them. Different sizes of blocks (models) were used. Students practiced independently to solve words problem questions using bar models.

The Part Whole Method
Part Whole Method is also called as the 'part part whole' method. In this method, bar models are used for representation of the known and unknown quantities as parts of a whole. It helps the learners of mathematics to represent the very common 'missing number' problems. This can be done in two ways.

Data Collection
Pre-test was given to the sample student of the study in order to divide them into two equal groups based on their pre-test scores using paired random sampling technique. Three chapters were taught to the experimental group through experiential learning, whereas the control group was taught using the traditional (lecture demonstration) method. The treatment was continued for a total of six weeks. The post-test was given after the six-week treatment to assess the effectiveness of the treatment. The data was collected by instructors (research assistants) using a test (posttest) which was delivered to the sample learners.

Data Analysis and Findings
To analyze the data mean, standard deviation and T-test were used. The mean scores were used to determine the overall performance of the groups, and the t-test was used to conclude whether there was significant difference in pretest and posttest scores between the experimental and control groups.
$H_0$1. There is no significant effect of Bar Model Visualization Technique on addition word problem solving skills.

Table 1 Significant effect of Bar Model Visualization Technique on addition word problem solving skills

Group	N	Mean	SD	V	df	t-value	Effect
Pre-Experimental	20	6.15	0.875	0.765	19	8.109	Significant
Post-Experimental	20	7.65	0.489	0.239			

Degree of freedom=19, Significance level = 0.05, Table Value =2.093

Table 1 indicates that the calculated t-value was 8.109 which were significant at significance level (0.05) because calculated t-value (8.109) was greater than table (critical) value (2.093); hence the null hypothesis is rejected. On the basis of pre-test and post-test results, mean and SD showed the significant difference between pre-experimental and post-experimental groups. The table value shows that the experiential learning is significantly better than traditional learning. It means that there was significant effect of Bar Model Visualization Technique on student's addition word problem solving skills.

$H_0$2. There is no significant effect of Bar Model Visualization Technique on subtraction word problem solving skills.

Table 2 Significant effect of Bar Model Visualization Technique on subtraction word problem solving skills

Group	N	Mean	SD	V	df	t-value	Effect
Pre-Experimental	20	4.45	1.316	1.734	19	2.269	Significant
Post-Experimental	20	5.25	1.292	1.671			

Degree of freedom=19, Significance level = 0.05, Table Value =2.093

Table 2 indicates that the calculated t-value was 2.269 which were significant at significance level (0.05) because calculated t-value (2.269) was greater than table (critical) value (2.093); hence the null hypothesis is rejected. On the basis of pre-test and post-test results, mean and SD showed the significant difference between pre-experimental and post-experimental groups. The table value shows that the experiential learning is significantly better than traditional learning. It means that there was significant effect of Bar Model Visualization Technique on student's subtraction word problem solving skills.

$H_0$3. There is no significant effect of Bar Model Visualization Technique on multiplication word problem solving skills.

Table 3 Significant effect of Bar Model Visualization Technique on multiplication word problem solving skills

Group	N	Mean	SD	V	df	t-value	Effect
Pre-Experimental	20	2.3	1.301	1.694	19	0.971	Not Significant
Post-Experimental	20	2.6	0.502	0.252			

Degree of freedom=19, Significance level = 0.05, Table Value =2.093

Table 3 indicates that the calculated t-value was 0.971 which were significant at significance level (0.05) because calculated t-value (0.971) was lesser than table (critical) value (2.039); hence the null hypothesis was accepted. On the basis of post-test result, SD shows that both the male and female students of experimental groups were not significantly different after treatment. It means that there was no significance effect of Bar Model Visualization Technique on student's multiplication word problem solving skills.

$H_0$4. There is no significant effect of Bar Model Visualization Technique on division word problem solving skills.

Table 4 Significant effect of Bar Model Visualization Technique on division word problem solving skills

Group	N	Mean	SD	V	df	t-value	Effect
Pre-Experimental	20	3.65	1.308	1.713	19	0.690	Not Significant
Post-Experimental	20	3.4	1.313	1.726			

Degree of freedom=19, Significance level = 0.05, Table Value =2.093

Table 4 indicates that the calculated t-value was 0. 690 which were significant at significance level (0.05) because calculated t-value (0. 690) was lesser than table (critical) value (2.039); hence the null hypothesis was accepted. On the basis of post-test results, mean and SD shows that both the male and female students of experimental groups were not significantly different after treatment. It means that there was no significance effect of Bar Model Visualization Technique on student's division word problem solving skills.

$H_0$5. There is no significant effect of Bar Model Visualization Technique on student's mathematical word problem solving skills.

Table 5 Significant effect of Bar Model Visualization Technique on student's mathematical word problem solving skills

Group	N	Mean	SD	V	df	t-value	Effect
Pre-Experimental	20	22.9	3.14	9.88	19	5.375	Significant

Post-Experimental	20	29.15	5.62	31.60

Degree of freedom=19, Significance level = 0.05, Table Value =2.093

Table 5 indicates that the calculated t-value was 5.375 which were significant at significance level (0.05) because calculated t-value (5.375) was greater than table (critical) value (2.093); hence the null hypothesis was rejected. On the basis of pre-test and post-test results, mean and SD showed the significant difference between pre-experimental and post-experimental groups. The table value shows that the experiential learning is significantly better than traditional learning. It means that there was significant effect of Bar Model Visualization Technique on student's mathematical word problem solving skills.

Discussion

This study was undertaken to analyze the effect of Bar Model Visualization Technique on mathematical word problem solving skills of Grade-V students in mathematics. Following were objectives of the study (1) to investigate the effect of Bar Model Visualization Technique on addition word problem solving skills, (ii) to investigate the effect of Bar Model Visualization Technique on subtraction word problem solving skills (iii) to investigate the effect of Bar Model Visualization Technique on multiplication word problem solving skills (iv) to investigate the effect of Bar Model Visualization Technique on division word problem solving skills. A total of 40 students studying in primary school were taken randomly as the sample of the study. A Pretest Posttest equivalent group design was used in the study. Teacher made test that were developed for collection of data. To analyze the collected data statistical techniques mean, standard deviation and t-test were used. The study was significant for students, teachers, curriculum developers and future researchers.

On the basis of findings of post-test score, the t-value (8.109) rejected null hypothesis and t-value showed that there was a significant difference between the mean scores of pre-experimental and post-experimental groups. Therefore, the mean score (7.65) of post-experimental group was higher than the mean score (6.15) of pre-experimental group. It illustrate that experiential learning of students' achievement is significantly improved than traditional learning and results of the study supported the findings of the studies reported by Arcavi (2003) that experiential learning had significant effect on the increasing students' conceptual knowledge and achievement.

On the basis of findings of post-test score, the t-value (2.269) rejected null hypothesis and t-value showed that there was significant difference between the mean scores of pre-experimental and post-experimental groups. Therefore, the mean score (5.25) of post-experimental group was higher than the mean score (4.45) of pre-experimental group. It illustrate that experiential learning of students' achievement is significantly improved than traditional learning.

On the basis of findings of post-test score, the t-value (0.971) accepted null hypothesis and t-value showed that there was no significant difference between the mean scores of pre-experimental and post-experimental groups. Though, the mean score (2.6) of post-experimental group was higher than the mean score (2.3) of pre-experimental group. It depicts that in post-test results, mean and SD shows that both the female and male students of experimental groups were slightly different after treatment but not significantly. It means that there was no significance difference between the mean score of male students and female students of pre-experimental and post-test experimental groups in multiplication.

On the basis of findings of post-test score, the t-value (0.690) accepted null hypothesis and t-

value showed that there was no significant difference between the mean scores of pre-experimental and post-experimental groups. Though, the mean score (3.4) of post-experimental group was lesser than the mean score (3.65) of pre-experimental group. It depicts that in post-test results, mean and SD shows that both the female and male students of experimental groups were not significant different after treatment. It means that there was no significance difference between the mean score of male students and female students of pre-experimental and post-test experimental groups in division.

On the basis of findings of pre-experimental and post-experimental score, the t-value (5.375) rejected null hypothesis and t-value showed that there was a significant difference between the mean scores of pre-experimental and post-experimental groups. Therefore, the mean score (29.15) of post-experimental group was higher than the mean score (22.9) of pre-experimental group. On the basis of pre-test and post-test results, mean and SD showed the significant difference between pre-experimental and post-experimental groups. The table value shows that the experiential learning is significantly better than traditional learning. It means that there was significant effect of Bar Model Visualization Technique on student's mathematical word problem solving skills. Osman et al. (2018) urged that it improves pupils' understanding regarding problem-solving and help to visualize and resolve problems.

Conclusions

- The results of the study show that Bar Model Visualization Technique had significant effect on addition word problem solving skills.
- The results of the study show that Bar Model Visualization Technique had significant effect on subtraction word problem solving skills.
- The results of the study also show that Bar Model Visualization Technique had no significant effect on multiplication and division word problem solving skills.
- It was concluded that the current traditional methods of teaching were neither according to the needs of our society nor according to the needs of the learners.
- It was also concluded that with visualization technique the learners had better understanding of word problem question and they participate in the activities.

Recommendations

- It was concluded from the results that the traditional way of teaching has no effect on Mathematical word problem solving skills and the learner cannot take interest in the subject. Hence it is recommended that teachers should stop traditional methods to teach mathematics and government should arranged teacher training with visualization technique.
- It is recommended that government should introduce the Bar Model Visualization Technique in the textbook of Mathematics.
- It is recommended that teachers should use visualization technique in Mathematics as well as in Science for better understanding of problem and teacher should motivate the learner to participate in the activities.
- It was concluded that the concepts of Bar Model Visualization Technique have significant effect on addition word problems and subtraction word problems but it has not significant effect on multiplication word problems neither division word problems. However, it is recommended that the Bar Model Visualization Technique should not just use for addition and subtraction but for all basic operation like multiplication, division and fraction.

Acknowledgements

The authors would like to thank all of the participants for their contributions.

References

1. Ali, T. (2011). Exploring students' learning difficulties in secondary mathematics classroom in Gilgit-Baltistan and teachers' effort to help students overcome these difficulties. *Bulletin of Education and Research, 3*3(1), 47 https://ecommons.aku.edu/pakistan_ied_pdck/81/
2. Arcavi, A. (2003). The role of visual representations in the learning of mathematics. *Educational studies in mathematics*, *52*(3), 215-241 https://link.springer.com/article/10.1023/A:1024312321077
3. Azizah, A., Rohani, A. T., & Mokhtar, N. (2010).Visual representations in mathematical word problem solving among form four students in Malacca. *Procedia-Social and Behavioral Sciences*, *8*, 356-361 https://www.sciencedirect.com/science/article/pii/S1877042810021555
4. Cope, L. (2015). Math manipulatives: making the abstract tangible. *Delta Journal of Education, 5*(1), 10 19 https://eric.ed.gov/?id=EJ1097429
5. Dowker, A. (2004). *Mathematical difficulties psychology and intervention*. London: Routledge. https://books.google.com.pk/books?hl=en&lr=&id=VB-5BU0G2L0C&oi=fnd&pg=PP1&dq=Dowker,+A.+(2004).+Mathematical+difficulties+psychology+and+intervention.+London:+Routledge.&ots
6. Farooq, R. A. & Tabassum, R. (2017). *Understanding research in education.* Revised Edition. Majeed Books, Rawalpindi: Pakistan https://www.qurtuba.edu.pk/thedialogue/The%20Dialogue/12_4/Dialogue_October_December2017_433-440.pdf
7. Fong Ng, S., & Lee, K. (2009).The model method: Singapore children's tool for representing and solving algebraic word problems. *Journal for Research in Mathematics Education, 4*0(3), p282-313 https://pubs.nctm.org/view/journals/jrme/40/3/article-p282.xml
8. Government of Pakistan. (2006)**.** *National curriculum for Grade I-XII*. Islamabad: Ministry of Education.
9. https://itacec.org/document/nep09/NCERT%20Pakistan%20paper%20BRI.pdf
10. Hofer, C. (2015). The introduction of the Singapore bar model in year 1 problem solving: a personal reflection. *The STeP Journal: Student Teacher Perspectives*, *2*(2), 107-117 http://insight.cumbria.ac.uk/id/eprint/4149/
11. Jan, S., & Rodrigues, S. (2012). Students' difficulties in comprehending mathematical word problems in English language learning contexts. *International Researchers, 1*(3), 152-160 https://link.springer.com/article/10.1007/s10758-014-9238-0
12. Lerner, A.W., & Johns, B.H. (2009). *Learning disabilities and related disabilities: strategies for success*. United States: Cengage Learning. https://oarklibrary.com/file/2/89eaf73f-f472-4c45-9ee8-de6362288cbb/39231afb-c5df-4235-8595-64bbfbac016f.pdf
13. Osman, S., Che Yang, C. N. A., Abu, M. S., Ismail, N., Jambari, H., & Kumar, J. A. (2018). Enhancing Students' Mathematical Problem-Solving Skills through Bar Model Visualisation Technique. *International Electronic Journal of Mathematics Education, 13*(3), 273-279. https://doi.org/10.12973/iejme/3919
14. Sherman, J., & Bisanz, J. (2009). Equivalence in symbolic and no symbolic contexts: Benefits for solving problems with manipulatives. *Journal of Educational Psychology. 1*01(1), 88-100 https://psycnet.apa.org/journals/edu/101/1/88.html?uid=2009-01936-016
15. Skovsmose, O. (2013). *Towards a philosophy of critical mathematics education* Vol. 15. Springer Science & Business Media https://books.google.com.pk/books?hl=en&lr=&id=WJ3dBgAAQBAJ&oi=fnd&pg=PT8&dq=Skovsmose,+O.+(2013).+Towards+a+philosophy+of+critical+mathematics+education+Vol.+15.+Springer+Science+%26+Business+Media&ots=fY7pJZWywz&sig=q_qdkwcnQPJNE-Nwad7l7vIPFbo&redir_esc=y#v=onepage&q&f=false
16. Van den Heuvel-Panhuizen, M. (2003). The didactical use of models in realistic mathematics education: An example from a longitudinal trajectory on percentage. *Educational Studies in Mathematics, 5*4(1), 9-35 https://www.jstor.org/stable/3483213
17. Vula, E., & Kurshumlia, R. (2015). Mathematics word problem solving through collaborative action research. *Journal of Teacher Action Research*, *1*(2), 34-46 http://www.practicalteacherresearch.com/uploads/5/6/2/4/56249715/vula_34-46.pdf