Global Educational Studies Review
GESR

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Effect of Problem Solving Teaching Method in Mathematics on the Performance of 7th Grade Students

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Abstract: *The study aimed to analyze the effect of problem-solving teaching methods in mathematics on the achievements of elementary level students. The major objective of the study was to; i. To compare the mathematics academic achievements and ability of problem-solving among 7th class students taught through traditional and problem-solving teaching methods. 7th class students of Govt. Secondary School 47 NB Sargodha were divided into two groups and randomly assigned as control and experimental groups. Two tests were validated through peer review, expert opinion and pilot testing; one "Problem Solving Ability Test in mathematics" (PSATM) and "Achievement Test in mathematics" (ATM) for 7th grade were used as pre-test and post-test. The experiment was conducted for a period of six weeks. The t-test and ANOVA were applied for data analysis. The major conclusion was that the participants treated with a new method of problem-solving teaching showed better results than the participants taught by traditional teaching methods in the achievement test and problem-solving ability test. It is recommended that elementary level mathematics teachers teach the students by using problem-solving teaching methods in their lesson plans for the development of problem-solving ability among learners.*

Introduction

Humans are better creatures of the world due to their cognitive or thinking abilities. To create, analyze and take decisions in different circumstances he can use his thinking abilities (Ahneal, 2011). Judging, logical thinking, reasoning and problem solving are attributes of mental or thinking abilities (Solso, 2001). According to Robertson (2005) in our routine life, we face many kinds of problems. To enable the children to deal tactfully or skilfully with unwanted circumstances of academic and daily life is the main aim of education (Ahmad et al., 2014).

To achieve any goal everybody faces hurdles and difficulties. Through educational practices, people can try to control these hurdles and problems. Quality education plays an important role in solving problems and enjoying facilities in the recent science and technology era. A learner faces problems in his studies, especially in mathematics. Keeping in mind this reality, the methods of teaching in educational institutions should be problem-solving oriented. The student's potential can be polished by adopting problem-solving

instructions to handle future life situations. Special attention to problem-solving as a teaching method in instructional practices is not given and it is not properly focused on in the inspection process. For learners problem solving is important not only to solve their academic problems but also to tackle their everyday life troubles. According to the demands of modern life and advanced learning theories and for improvement of the teaching-learning process curriculum is revised. It will enable the learners to use their abilities, especially problem-solving ability to solve various kinds of daily life problems (Kirkley, 2003). To fulfil international standards there is an important need to redesign the curriculum for academic excellence (Anneal, 2011). After completing a prescribed course of studies it is actually the performance of the learner which is called academic achievement. After analysis of recent research, the conclusion is that "to manipulate the previous knowledge problem-solving teaching method plays an important role and on the basis of manipulation to overcome the problems" (Ali, Hukamdad, Akhter, Khan, 2010). So, the Problem-solving teaching method may be examined as an instructional method in the institutions of Pakistan. Therefore, the 7th-grade students were selected for this study because In the Pakistani education system learners of this level have higher-order thinking abilities and may have the ability to find out the solution, if they are instructed by problem-solving teaching method.

Statement of the Problem

A common ability to deal with problematic situations can be developed by problem-solving teaching methods and it is also encouraging dynamic learning in mathematics as well as science subjects. In mathematics education, the problem-solving teaching method is the method of understanding a situation and conditions; then mathematical concepts are applied to solve it. So, numerous collaborative phases of testing are involved. Hence the study was an attempt to; find out the effect of the problem-solving teaching

method on 7th-grade students' mathematics achievements and problem-solving ability.

Objectives of Study

The research work's objectives are given below:

1. To compare the mathematics achievements of students taught by traditional and problem-solving teaching methods at the elementary level.
2. To analyse the elementary level students' ability of problem-solving, taught by traditional problem-solving teaching methods in the subject of mathematics.

Hypotheses

To examine the mathematics achievement and ability of problem-solving, the hypotheses tested are given below:

H_{01}: There is no significant difference between mean scores of mathematics achievement of the participants taught by traditional as well as a problem-solving teaching method in the pre-test.

H_{02}: There is no significant difference between mean scores of mathematics achievement of the participants taught by traditional as well as a problem-solving teaching method in post-test.

H_{03}: There is no significant difference between the mean problem-solving ability scores of the participants in a pre-test in mathematics taught by traditional as well as a problem-solving teaching method.

H_{04}: There is no significant difference between the mean problem-solving ability scores of the participants in post-test in mathematics taught by traditional as well as a problem-solving teaching method.

Review of Related Literature

According to English language learners (2019), the source of difficulty worry or something that is hard to deal with is called a

problem. An inquiry starting from given conditions to investigate a fact or result is called a problem (Oxford dictionary, 2019). Whereas Woolfolk (2004) described that a problem is the first stage, to attain a goal or requisite output and it provides a way for reaching the desired goal. Ferguson-Hessler & Broekkamp (2001) discussed two sorts of problems i.e. open-ended and closed-ended problems. The problems with more than one correct solution are called open-ended problems. Ill- structured or ill-defined problems are examples of open-ended problems. It may be simple or complex (Dörner, & Funke, 2017). Real-life problems are considered rather than textbook problems. It may be called complex problems. Closed-ended problems can be solved with a limited set of possible solutions (Edmund, 2006). Two more kinds of problems are described by Krug (2004):

Well-Planned or Structured Problems

A problem having a clear cut answer that can be solved by an algorithm is called a well-structured problem (Wallace, 2007). In most textbooks, problems stated in mathematics and science books are well structured that require a correct answer (Abdillah, Mastuti, & Rahman, 2018). Well-structured problems have correctly defined statements, a partial set of operations or a set of rules which may have a clear goal or solution to the problem (Ormerod, 2003).

Ill-Organized or Un- Structured Problems

Ill structured problems, sometimes called disordered problems, have more than one solution and cannot be solved mathematically e.g. writing scripts for movies or dramas or building a future career sketch (Adams, 2007). An ill-structured problem does not yield an exact solution (Abdillah, Mastuti, & Rahman, 2018).

Problem Solving Teaching Method

The capability of solving a problem can build up by problem-solving methods and mathematics may be provided as the subject matter for developing this ability (Yayuk, & Husamah (2020). He further described that problem solving is a lifelike skill and simulation is necessary to acquire it. According to the nature of the problems, it is needed to solve for the achievements of most wanted goals (Woolfolk, 2004). According to Lesh and Zawojewski (2007) outside class settings suggest expanding problem-solving approaches and looking into the learners' thoughts they introduce the build "model elicit actions" and in the improvement of problem-solving experience view as a way to connect them. Now, the study on the modern 21st learners expands and as a part of a learning society that promotes and values modelling edifice activities frequently purifies problem-solving competencies.

Problem Centered Teaching and Learning Approach

According to Gurat (2018), the problem-centred teaching approach is referred to problem-solving for arithmetic. They described that knowledge is acquired through problem-solving learning whereas learners are well-known with the problem. Students are in the dynamic role of problem solvers by being confronted with diverse errands that have no voluntarily famous process or algorithm. The teachers hold influential non-routine arithmetical problems to learners for solving and they are to defend and clarify their solutions (Greene, 2008).

Problem Solving Method as a Part of Instruction

Kirkley (2003) describes that students generally teachers make a content inventory, for example, proportion, square root, percentage etc. In mathematics to pertain problem-solving as an instruction method, it is required to know the answers to such questions similar to what is math. What sort of tricks should be incorporated into the arithmetic program of study? Which category of strategies and techniques can be useful for

teaching math? He also supported that problem solving must be paying attention to school arithmetic according to him problem-solving is a skill for mathematical troubles and situations. Consequently, a mathematical problem-solving instruction strategy should be useful to improve the proficiency in mathematics of students.

Research Design

The nature of this research was experimental and pre-test post-test control group design was opted to examine the effect of independent variables (teaching method) on dependent variables (achievement and problem-solving ability). Further, selected stages of the dependent variable of achievement (high, average and low) were also studied.

Population

According to the nature of variables, there were two categories of population:

Target Population

All the 7th-grade students from high/higher secondary schools of tehsil Sargodha were the target population for this research work.

Accessible Population

All the 7th-grade students from Govt. Secondary School 47 NB Sargodha were the accessible population for this research work.

Sampling

Achievements levels of 7th-grade students were considered ranging from 33% marks to 80% marks & above. In the selection of representative sample fishbowl technique of random sampling was used step by step.

i. Seventy-two 7th class students were listed in descending order according to obtained scores in December test, 2019.

ii. Three levels of achievement i.e. low, average and high achiever students of 7th grade were categorized according to the criteria described by Board of

Intermediate and Secondary Education (BISE) Sargodha, 80% and above = A+ grade, 79% to 70% marks = A grade, 69% to 60% marks = B grade, 59% to 50% marks = C grade, 49% to 40% marks = D grade, 39% to 33% marks = E grade and students declared fail less than 33% marks.

For this research work, the students who had achieved A+ and A grades were put in the category of high achievers, B & C grade achievers were put in the average achiever's category, D & E grade achievers were considered low achievers.

1. From the 72 total students for all categories of low, average and high achievers, selecting 36 students randomly in one group, two groups were formulated. In each group, taking 12 in each category of low, average and high achievers.

Using the technique of random sampling one group including 36 students was taken as an experimental and 2nd group including 36 students was taken as a control group.

Instruments of the Study

Two research tools were developed one was an achievement test in mathematics and the other was a problem-solving ability test for this research work. To develop achievement tests in mathematics 7th-grade Maths elementary textbook published by Punjab Textbook Board was followed. Due to the short time the topics; square root, direct and inverse variation and financial arithmetic were selected for this experiment.

According to cognitive domain's levels like knowledge, understanding and application, the distribution of items was 20% from the topic of square root, 30% from the topic of direct and inverse variation and 50% from the topic of financial arithmetic.

Problem-solving ability test in mathematics was another instrument. In which items of mathematics and problematic situations regarding the topics i.e. square root, direct and inverse variation and financial

arithmetic, were included. According to PISA (2016), multiple-choice items were used to evaluate the majority of the cognitive processes. Every problem has a well-defined stem using mathematical concepts, with 4 options to select the correct answer.

Validation of Research Instruments

In two ways validation was carried out.

a. Both instruments (test of problem-solving ability in mathematics "PSATM" and mathematics achievement test "ATM") were gone through by five subject specialists in mathematics for content and face validity.

b. Pilot testing was carried out on one hundred 7TH grade students of four government schools who were not in the actual sample. After calculating the difficulty and discrimination index, finally, 50 items for the achievement test were chosen. The final test's reliability was 0.822 and the item's discrimination and difficulty index range was 0.20 to 0.70 as recommended by Nitko and Brook hart (2007).

c. The overall reliability of the problem-solving ability test was 0.83. Finally, 15 items were finalized for the problem-solving ability test in mathematics. Item wise difficulty index and discrimination power of the problem-solving ability test were within the range of 0.33 to 0.67 and the overall reliability of the problem-solving ability test was 0.83.

The Procedure of the Experiment

From 25th January to 10th March 2030 experiment of the study was continued for a period of six weeks. The experiment group was treated with a problem-solving teaching method by the researcher himself because it was difficult to train a teacher to teach by using a problem-solving teaching method. The Control group was treated with the traditional method by an educator whose qualification was M.Sc. and B.Ed.

i. For each group pre-tests were administered (test of problem-solving ability and mathematics achievement test) before beginning the experiment. Pre-tests scores were not disclosed to the students.

ii. The experimental group was treated with a problem-solving teaching method according to developed lesson plans whereas the control group was taught with routine teaching.

iii. After six weeks of teaching post-tests, i.e. mathematics achievement and ability of problem-solving were conducted on both control and experimental groups.

iv. After the experiment, the control group was also exposed to problem-solving teaching methods to avoid discrimination among students.

Data Analysis and Results

Data were analyzed through t-test, ANOVA and effect size was also calculated.

Groups	N	Mean	SD	df	T	P-value
Experimental group	35	22.83	12.58	34	12.409	.066
Control group	37	22.54	12.55	36		

Table 1. Comparing Pre-test Scores in Achievement Test

Table 1 represents that in the pre-test of mathematics no difference in mean scores of both control and experiment groups was found as indicated by t-value= 12.409, df

=36 and p-value =.066>0.05. Therefore, the null- hypothesis was no significant difference was accepted. Thus, in the pre-test of mathematics achievement, the performance of

students of the treatment group and control group was equivalent.

Table 2. Comparing Post-test Scores in Achievement Test

Groups	N	Mean	SD	Df	t	p-value	Effect size
Treatment group	35	34.66	9.8	34	20.84	.000	1.05
Control group	37	24.54	9.5	36			

Table 2 represents that in the post-test of mathematics achievement, the null hypothesis of no significant difference was rejected because the t-value (20.84), df (36) were significant at a p-value of 0.000<0.05. Students of the experimental group treated with a problem-solving teaching method with a greater mean score (mean score = 34.66) showed better results than students of the control group (mean score= 24.24) taught by the traditional teaching method. The Cohen's d effect size = 1.05 showed that the difference in achievement was large.

Table 3. Comparing High Achievers' Scores in Achievement test

Groups	N	Mean	SD	df	t	p-value	Effect size
Treatment group	23	40.48	3.69	22	52.59	.000	0.19
Control group	5	39.60	5.13	4			

Table 3 represents that in the achievement test a significant difference was found in mean scores of high achievers of both control and experiment groups because the value of t (52.59) with df=22 at a p-value of 0.000<0.05 was significant. High achievers of the group treated by problem-solving teaching method with a greater mean score (mean score = 40.48) showed better results than high achievers of the control group (mean score= 39.60) taught by the traditional teaching method. The Cohen's d effect size = 0.19 showed that the difference in achievement was trivial.

Groups	N	Mean	SD	Df	t	p-value	Effect size
Treatment group	4	31.750	4.5	3	25.59	.000	0.18
Control group	14	28.072	4.2	13			

Table 4. Comparing Average Achievers' Scores in Achievement Test

Table 4 represents that a significant difference in mean achievement scores of average achievers of both experiment and control groups was found because the value of t (25.59) with df=13 at p-value 0.000<0.05 was significant. Average achievers of the group treated by problem-solving teaching method with a greater mean score (mean score = 31.750) showed better results than average achievers of the control group (mean score= 28.072) taught by the traditional teaching method. The Cohen's d effect size = 0.18 showed that the difference in achievement was trivial.

Table 5. Comparing Low Achievers' Scores in Achievement Test

Groups	N	Mean	SD	Df	t	p-value	Effect size
Treatment group	8	19.136	5.9	7	12.285	.000	0.36
Control group	18	17.00	5.8	17			

Table 5 represents that a significant difference in mean achievement scores of low achievers of both experiment and control groups was found because the value of t (12.285) with df=17 at p-value 0.000<0.05 was significant. Low achievers of the group treated by the problem-solving teaching method with greater mean scores (mean score = 19.136) showed better results than low achievers of the control group (mean score= 17.00) taught by the traditional teaching method. The Cohen's d effect size = 0.36 showed that the difference in achievement was small.

Table 6. One Way ANOVA for Comparison of High, Average & low Achievers' Scores in Achievement Test within Experimental Group

	Mean	S.D	F-value	df	p-value
High Achievers	40.00	3.88			
Moderate	27.20	2.77	46.007	71	.000
Low Achievers	4.01	10.86			
Total	72	6.6250			

Table 6 depicts that value of f=46.007 at p-value 0.000<0.005 was significant. It reflects that in the achievement test, a significant difference in mean scores among the participants of three categories i.e. high, average & low within the treatment group was found.

Table 6-A. Post HOC Test for High, average & Low Achievers

Achievement stage	Achievement stage	Mean Difference	Std. Error	Sig.
High achievers	Low	23.18*	3.34747	.000
	Moderates	12.80*	6.03474	.038
Moderates	Low	35.98*	5.17816	.000

Table 6-A reflects that a significant difference between mean scores of participants' achievement levels was found. It also shows that on the basis of mean difference with a p-value of 0.000<0.05, in the achievement test high achievers did considerably better than the low (mean score difference 23.18) and moderate achievers (mean difference 12.8) of the treatment group. Similarly, moderates achievers of the treatment group also did better than low achievers (mean difference of 35.98).

Analysis of Results of Problem Solving Ability Test in Mathematics

Table 7. Comparing Pre-test's Scores in the Test of Problem Solving Ability

Groups	N	Mean	SD	df	T	p-value
Treatment group	35	6.83	2.59	34	16.49	.055
Control group	37	7.24	2.67	36		

Table 7 represents that the difference in mean scores pre-test of the problem-solving ability of students of the treatment group and control group was not significant as indicated by a value of t = 16.49, with df =36 at p-value = .055>0.05. Thus, pre-test of problem-solving

ability in mathematics' the performance of the treatment group and control group was approximately equal.

Table 8. Comparing Post-test Scores in the Test of Problem Solving Ability

Groups	N	Mean	SD	Df	t	p-value	Effect size d
Treatment group	35	11.35	2.14	34			
					31.34	.000	1.35
Control group	37	8.135	2.59	36			

Table 8 shows that a significant difference in mean scores of students of both experiment and control groups in post-test of problem-solving ability was found as indicated by a value of t=20.84 with df=36 at p-value 0.000<0.05. Students of the group treated with the problem-solving teaching method with greater (mean score of 11.35) showed a better ability of problem-solving than students of the group treated through the traditional teaching method (mean score= 8.135). Cohen's d effect size = 1.35 shows that difference in problem-solving ability was large.

Table 9. Comparing High Achievers' Scores in Test of Problem Solving Ability

Group	N	Mean	SD	df	t	p-value	Effect size d
Treatment group	23	12.65	1.228	22			
					49.381	.000	1.55
Control group	8	11.13	.641	7			

Table 9 represents there the difference in mean scores on the test of problem-solving ability, high achiever students of both experiment and control groups were significant as indicated by a value of t=49.381 with df=22 at p-value 0.000<0.05. High achievers of the group treated with the problem-solving teaching method with greater mean gain score (mean score = 12.65) showed a better ability of problem-solving as compared to students of the group (mean score= 11.13) treated through the traditional teaching method. The difference in the ability of problem-solving was large because the Cohen's d effect size = 1.55.

Table 10. Comparing Average Achievers' Scores in Test of Problem Solving Ability

Groups	N	Mean	SD	df	t	p-value	Effect size d
Treatment group	11	9.00	.927	10			
					47.196	.000	0.15
Control group	17	8.88	.633	16			

Table 10 represents that in the problem-solving ability test the difference between mean scores of average achievers of both experimental & control groups was significant because the t-value (47.196) with df (16) at a p-value of 0.000<0.05 was significant. Average achievers of the group treated by the problem-solving teaching method with a greater mean gain score (mean score = 9.00) showed a better ability of problem-solving

than the group (mean score= 8.88) taught through the traditional teaching method. The difference in problem-solving ability was trivial because the Cohen's d effect size = 0.15.

Table 11. Comparing Low Achievers' Scores in Test of Problem Solving Ability

Groups	N	Mean	SD	df	T	p-value	Effect size d
Treatment group	12	8.84	.927	11	10.180	.000	2.36
Control group	12	5.083	1.729	11			

Table 11 represents that in the ability test of problem-solving the difference in mean scores of low achievers of both experiment and control was found significant because the value of t=10.180 with df=11 at p-value 0.000<0.05 was significant. Low achievers of the group treated by problem-solving teaching method with greater (mean score = 8.84) showed better performance than low achievers of the group (mean score= 5.083) taught by traditional teaching method. The difference in problem-solving ability is larger because Cohen's effect size d = 2.36.

Table 12. One way ANOVA for Comparison of High, Average & Low Achievers' Scores in Ability Test of Problem Solving within Experimental Group

	Mean	S.D	F-value	Df	p-value
High Achievers	78.67	6.11	27.51	71	.000
Average	60.67	4.05			
Low Achievers	15.91	17.74			
Total	20.39	22.81			

Table 12 shows that the value of f=27.51 at a p-value of 0.000<0.005 was significant. It reflects that the problem-solving ability of low, average and high achievers of both experiment & control groups have a significant difference in mean scores on the problem-solving ability test.

Table 12-A. Post HOC Test for High, Average & Low Achievers

Achievement level	Achievement	Mean Difference	Std. Error	Sig.
High achievers	Low	62.75[*]	10.1864	.000
Moderates	Low	44.75[*]	10.1864	.000

Table 12-A represents the positive mean scores' difference in the ability of problem-solving, of participants was significant. It shows that the problem-solving ability test of high achievers (with a positive mean difference = 62.5) performed considerably better than low achievers. While low achievers of the experimental group showed less performance than moderate achievers (mean difference 44.75).

Conclusions

Conclusions are drawn as under:

1. Problem-solving teaching method proved more effective for 7th class students' mathematics achievement

because the experimental group treated with the new teaching method of problem-solving performed better than students of the control group who were taught through the traditional teaching method.

2. At the elementary level problem-solving teaching method in mathematics also proved more useful for mathematics achievements of high, average and low achievers because the experimental group's achievements are higher than the control group.

3. In the mathematics achievement test, within the experimental group, high achievers acquired better achievement than average and low achievers and average achievers also obtained better achievement than low achievers.

4. The problem-solving teaching method in mathematics proved more effective for achieving the ability of problem-solving as the students of the group treated with the problem-solving teaching method did better in the problem-solving ability test than students of the group taught by routine teaching.

5. At the elementary level in mathematics, the problem-solving teaching method proved more effective for the problem-solving ability of low average and high achievers because the experimental group's performance was better as compared to the low average and high achievers of the control group.

6. High achievers within the experimental group have better problem-solving ability than average and low achievers in mathematics.

Discussion

In Govt. schools of Pakistan, the effect of problem-solving teaching methods on achievements and ability of problem-solving among 7th-grade learners were studied.

The major conclusion was that the problem-solving teaching method in 7th class mathematics proved more effective for

mathematics achievements because the experimental group treated with the new teaching method of problem-solving, gave better results than students of the group educated through routine teaching method in the test mathematics achievement. This conclusion is in line with the findings of Ali, Hukamdad, Akhter, & Khan (2010) who concluded that the "use of problem-solving method enhanced the achievement of the students in mathematics"; the possible reason may be due to the problem-solving method, a student can apply basic concepts in the required situation as well as in subject matter. While the results that in mathematics, learners of all levels i.e. low average and high achievers of the treatment group showed better achievements than the performance of participants treated by conventional teaching is similar to the findings of Behlol, Akbar, & Sehrish (2018) that "The achievement level of high and low achievers students taught through PSA was significantly better than the performance of high and low achievers taught through traditional methods of teaching". Further, the result of this study that in the ability test of problem-solving, the students of the group treated with a new teaching method of problem-solving did better than students of the group taught by routine teaching is matched with the results found by Cheng, She, & Huang (2018) that "Students' scientific knowledge, reasoning and problem solving all are successfully improved after receiving six weeks scientific problem solving". It was valuable for average and low achievers because it helped both average and low achievers to participate in classwork and use their minds to learn thinking which enhanced their thinking abilities and developed problem-solving abilities.

Recommendations

Recommendations are drawn on the basis of data analysis and conclusions as under

1. Problem-solving teaching methods can also improve the academic achievements of learners because students can understand and solve

problems rationally. By using this method, learners can get enhanced scores. Thus, adopting it for in-service teachers training by QAED (Quaid-e-Azam Academic for educational development) may adopt for mathematics teachers.

2. Problem-solving teaching methods may be emphasized during the training of pre-service teachers. Thus, by having the expertise in this instructional method prospective math teachers may be more effective in their instructions.

3. It is also recommended for mathematics teachers, to teach the students by using problem-solving teaching methods in their lesson plans for the development of problem-solving ability among learners.

4. Assessment systems like NTS, PPSC, FPSC and BISE's teams of paper developers can include items related to the problem–solving approach in the mathematics of the paper which may be helpful for participants in their practical life.

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