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Investigating Effective Problem-Solving Techniques for Mathematics Used by Primary Students in Private Sector Schools of Islamabad

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Abstract

Problem-solving occupies a significant place in the field of mathematics and math education. The main objective of the current study was to examine the effective problem-solving techniques used by the students in mathematics at primary level in private sector schools of Islamabad. This research was quantitative in nature. A cross-sectional survey design and survey questionnaire was used. The six-point rating scale was used to collect responses from the students. The validity of questionnaire was ensured by Subject Matter Experts (SMEs) whereas, the reliability of tools was checked through Cronbach's alpha using SPSS. In order to conduct the current research, data was collected from the (n = 400) students of 16 campuses of Roots Millennium School. Students were selected through cluster random sampling technique. It was found through descriptive analysis that the students use metacognitive problem solving techniques more frequently as compared to heuristic techniques at primary level. Moreover, it was also investigated that the higher and lower achievers used different strategies under heuristic and metacognitive problem solving techniques. Higher achievers used more than one strategy sometimes related to heuristic techniques and sometimes used both. The results revealed that the male students preferred heuristic visualization of word problem strategy more frequently than female students.

Keywords: descriptive analysis, heuristic techniques, metacognitive techniques, Problem solving, visualization

Introduction

Problem solving is a skill in mathematics which enables the students to meet the challenges in new mathematics and in real life problems. Therefore, it is essential to provide students with the skills they need to deal with such problems. Mathematical problems cover many different areas of Math

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(Lewis et al., 2009). A framework may be applied to help identify the information needed to solve the problem and to check the answer. Problem solving technique is a permanent skill for the learners to solve real life problems.

Problem-solving plays a significant role in the field of mathematics and math education. Firstly, it is important to observe the most effective method to teach problem-solving, because according to the pure mathematics viewpoint, problem-solving encourages conceptual understanding (Lambdin, 2003). The primary goal to teach mathematics is to develop understanding among students. However, it may not be taught directly, as it is an internal and unobservable phenomenon. It occurs when students' minds assimilate new information with the previous understandings. Teaching problem-solving is a powerful way to promote this kind of thinking (Lambdin, 2003). Secondly, from an applied mathematics perspective, learning more effective ways to teach problem-solving helps students to learn different applications of mathematics. It also makes the mathematics learning process more interesting (Santos-Trigo, 2014). This may help to increase students' skills and motivation to learn mathematics (Xu et al., 2016). For such students practicing and questioning techniques of problem solving could be used to overcome this inability (Wilson et al., 1993). The value of skills and processes instruction needs to be judged by the degree to which the skills and processes actually increase flexible and independent thinking.

Polya believed that problem solving is the main subject of mathematics and when he wrote about students' expectations, he used the term "teaching students to think" (1981). "Thinking" is the subject of real research and solving mathematical problems. Unfortunately, the thoughts of many well-planned students turn into the solution of mathematical problems "what to think." Therefore, a math teacher has a good chance. When the students face confusion in their daily work, it violates their interests, interferes with their intellectual development, and abuses their abilities. However, if students are curious to put their own questions, to stimulate them, and solve problems, it may also provide a way to think independently (Polya, 1981).

A strategy is a method that provides some solution to a problem and gives information on it. Learners use strategies which enable them to learn effectively. "Strategies are groupings of actions, mental or physical, designed to solve a problem" (Biddlecomb & Carr, 2010). There are many

strategies that students may use to find the correct answer They need to know these strategies and utilize them. “In order to learn mathematics, students should have the opportunity to discover a way to reach the solution of the problem by themselves” (Cotic & Zuljan, 2009). They must learn to use these strategies appropriately for problem solving. With the background knowledge of mathematical problem-solving strategies, students are better able to solve any problem that may arise (Klingler, 2012).

According to Montague (2005), students could learn the strategies and become successful problem solvers to make their mathematical problem-solving less complex.

It has been observed that most of the private schools focus more on the coverage of their content instead of developing critical thinking skills and logical reasoning in students. Resultantly, the children are not able to use their skills in solving word problems and are not able to relate these problems to their daily life. They are far from the understanding of the content of mathematics. Therefore, they need to focus more on the understanding of the concepts of problem solving by using different techniques which would help them to enhance their 21st century skills.

Private sector schools were chosen to conduct the current research. These schools focus more on learning 21st century skills as compared to public schools as critical thinking is one of the basic parts of 21st century skills. The ultimate goal of these private schools is to enable the students to think critically and analyze the problem. The students not only become capable to solve the mathematical problems, however, also find solutions for real life problems.

Objectives

1. To examine the problem-solving techniques in mathematics used by the students at primary level in private sector schools of Islamabad.
2. To examine the effect of background factors on the use of different problem-solving techniques used by students at primary level.

Research Questions

1. Which heuristic problem-solving strategies are used by primary students in the subject of mathematics?

2. Which metacognitive problem-solving strategies are used by primary students in the subject of mathematics?

Research Hypotheses

H_o1: There is no significant difference among general interest of students and their preference towards using problem solving techniques for mathematics at primary level.

H_o2: There is no significant difference among gender of students and their preference towards using problem solving techniques for mathematics at primary level.

H_o3: There is no significant difference among parent support of students and their preference towards using problem solving techniques for mathematics at primary level.

Literature Review

Mathematics is considered as one of those subjects which are highly intellectual in nature and involve cognitive processes (Hong & Aqui, 2004). It helps the students to sharpen their minds, reasoning abilities, and grooms their personalities (Atteh et al., 2014).

In the study of mathematics, problem solving plays an essential role. The basic aim of teaching and learning mathematics is to enable the students to deal with wide range of complex mathematical problems. There is a strong bond between mathematics and problem solving. It is not because problem solving is a part of curriculum; however, it is also an approach to think and to develop a skill of self-regulate learning in the students (Rodrigues, 2015). Problem solving may be easy for those who know about the techniques and strategies behind different word problems (Magno, 2011). If problem solving is taught in an effective manner, one can easily develop the skills of problem solving (Polya, 1981).

A problem may be considered as a situation for which some solution is required. A student could reach at the correct solution of the problem through exercise. It enables the learners to identify the problem and to specify the correct path to solve it (Posamentier & Krulik, 1998). Problem solving ability not only helps to solve mathematical problems, however different day-to- day problems that an individual may come across in different occasions (Bhat, 2014).

The approach to solve word problems differs from one learner to another. This is because each learner belongs to a different background and different experiences. Sometimes it depends upon the practice of problem solving at home or the reinforcement of the taught concept in the school at home on the same day (Posamentier & Krulik, 1998). Numerous mind-boggling factors including natural, mental, and ecological factors are uncovered to add to gender differences in mathematical critical thinking in some particular territories. One of the articles recommended that the combined influence of all affective variables may account for the gender differences in mathematical problem-solving patterns (Zhu, 2007).

Mathematical problems have a higher complexity level of thinking than mathematical exercises from a workbook or textbook. A mathematical problem is "the original condition presenting the problem through its appropriate data to a goal which must be reached by the problem solver. It also refers to the path from the original situation to the end solution to be found by the problem solver" (Frobisher & Orton, 1996). Mathematical problems may be solved, however they may not always be immediately obvious. Students need to learn that because they may not get the answer from a one-step procedure that they try to solve for the answer. Students with such mindsets face difficulty with problem solving in the present era classroom setting (Klingler, 2012).

The National Research Council (1989) found that it is not the memorization of mathematical skills that is important, however it is the self-assurance that one knows how to find and use mathematical tools in problem solving. Students build this confidence through the process of creating, constructing, and discovering mathematics. When this process becomes part of a students' everyday routine, they become more proficient and capable to develop, carry out, and execute their plan. Helping students to become better problem solvers is not only the fundamental part of mathematics learning, but it also makes them proficient across other content areas and grade levels. This skill is an ongoing process that students need to develop at their own pace. The hope of teaching through problem solving is to have students continue to use problem solving skills throughout their life (Klingler, 2012).

A research conducted by Ali et al. (2010) stated that the students of grade 8 in Pakistan exhibit the strategies used in problem solving which may affect their achievement in mathematics. The findings revealed that the

achievement of students having same educational background may be increased through problem solving strategies. These strategies enhance thinking and reasoning power of the learners. It helps to create motivation and enthusiasm in students towards mathematics (Dannawi, 2013).

Problem solving may be presented in the form of three themes in order to create a plan to understand the problem and to find its solution. In the first theme, problem solving may be viewed as a context in which alternative objectives are achieved. In these objectives it behaves as motivation, exercise, critical, and analytical power. In the second theme, problem solving may be viewed as a skill that enables the learners to solve real life problems. Whereas, in the third theme it may be viewed as an art (Stanic & Kilpatric, 1988). Polya (1981) aligned the third theme of problem solving and reshaped the concept in 20th century. He gave an idea to solve word problems through different strategies (Xu et al., 2016).

There are two techniques to solve word problems of mathematics. One is heuristic and the other is metacognitive technique. In 1980s the center of attention was metacognition to solve word problems of mathematics. According to some researchers metacognition comprises three main parts. Firstly, it is based on the knowledge about one's own reasoning. Secondly, it follows the determination one's activities through a critical thinking task. Thirdly, it is based on conviction and instincts (Schoenfeld, 2013). The development and utilization of wide scope of knowledge-based functions are covered by the process of cognition. Instead of knowledge, metacognition also helps to enhance memories, experiences, learning, and reasoning power (Pena-Ayala & Cardenas, 2015).

The strategies under metacognitive technique are based on self-talk and self-monitoring. Apart from mathematical knowledge, the factor that affects the performance of a student's knowledge is the lack of understanding regarding the use of strategies under metacognitive technique (Tok, 2013; Yimer, 2004). Teachers need to be professionally trained enough to instruct so that they may improve the learner's skills of self-direction to solve mathematical problems. Therefore, the process of problem solving of mathematics and its effectiveness may be enhanced when the students are able to determine or evaluate their own performance (Schoenfeld, 1987).

Methodology

The current research was quantitative in nature. A cross-sectional survey design was used to conduct the study. Survey questionnaire and background proforma were used to investigate the effective problem-solving technique used by the primary students. The data was collected from the primary students of private sector schools of Islamabad.

Population

The population of research comprised primary level students in the private sector schools of Islamabad. There are total 35 campuses of Roots Millennium School in 20 cities and 16 campuses located in Islamabad. Total population of grade 5 in these 16 campuses was 403 in which total number of boys were 213 and total number of girls were 190.

Sampling

In the current research, sample was drawn from 16 campuses of Roots Millennium Schools (RMS) of Islamabad. The data was collected from the (n = 403) students (213 boys and 190 girls) of 16 campuses of Roots Millennium School. Students were selected through cluster random sampling technique.

Instrumentation

The following tools were used in the current research:

1. Mathematics Problem Solving Survey Questionnaire
2. Background Proforma

Mathematics Problem Solving Survey Questionnaire

Self-constructed "Mathematics Problem Solving Survey Questionnaire" was used to collect the responses of students on effective problem-solving techniques. The questionnaire was developed under six strategies of both heuristic and metacognitive techniques. There were total 30 items in the questionnaire. Six-point rating scale was used to collect responses on questionnaire items. Following are the main constructs of self-developed tool.

Table 1
Mathematics Problem Solving Survey Questionnaire and its Main Constructs

Constructs
1.Heuristic Heuristic is a technique used for problems-solving in mathematics. Heuristic technique speeds up the process of problem solving to find the solution. There are many strategies used to solve word problems of mathematics under this heuristic technique (Polya, 1981).
2.Metacognitive Metacognitive technique is related to the knowledge of learning through the process of think about thinking (Flavell, 1979). This technique enables the learners to observe their understanding and to regulate their learning along with the process of problem solving (Greeno, 1982).

Reliability and Validity of the Tool

Piloting was performed to determine the appropriateness of tool items for the respondents. A survey was conducted through the questionnaire which was piloted from a private school of Islamabad. The validity of questionnaire was ensured by Subject Matter Experts (SMEs). Reliability of questionnaire was checked through Cronbach's alpha using SPSS. It provided help to measure the internal consistency of all the items in a questionnaire. Three items were excluded from the questionnaire in this process.

Table 2
Cronbach's Alpha Reliability of Questionnaire

Subscale	k	Cronbach alpha	Sample item
1.Heuristic Technique	22	.874	I prefer to make a model to show information while solving mathematical problems.
2.Metacognitive Technique	5	.641	I prefer to infer additional information that was not directly given while solving mathematical problems.

Subscale	k	Cronbach alpha	Sample item
Problem-Solving Techniques	27	.875	I prefer to re-read the problem for better understanding while solving mathematical problems.

Data Collection

In the current research, the questionnaire and background proforma were used as tools to collect the data. The questionnaire measured the preferred use of two problem solving techniques. Close ended items were developed in questionnaire. School principals were contacted and informed consent was taken before data collection. Students were explained the items of questionnaire and were asked to fill in the presence of the researchers.

Data Analysis and Results

Descriptive analysis was conducted to examine the use of heuristic and metacognitive problem-solving strategies used by primary students in mathematics. In order to examine the mean score differences across background factors, inferential statistics was used.

Heuristic and Metacognitive Problem-Solving Strategies used by Primary Students in the Subject of Mathematics

Table 3

Mean Scores of Heuristic and Metacognitive problem-solving strategies used by primary students in Mathematics

Subscales of Problem Solving Techniques	*M*	*SD*	Skewness	Kurtosis
Heuristics: Act it out (AO) *n* =2	8.41	1.780	-.858	.291
Heuristics: Work backwards (WB) *n* =3	13.112	2.409	-.780	.996
Heuristics: Before-after concept (BAC) *n* =2	9.717	1.273	.037	-.835
Heuristics: Make a model or picture (MAP) *n* =3	13.742	3.542	-1.323	.837
Heuristics: Make an organized list (OL) *n* =2	9.205	2.642	-1.010	-.188

Subscales of Problem Solving Techniques	*M*	*SD*	Skewness	Kurtosis
Heuristics: Guess and check (GC) *n* =4	19.180	2.957	-.955	1.884
Heuristics: Look for a pattern (LP) *n* =3	14.390	2.237	-.814	-.004
Heuristics: Visualization of word problem (VP) *n* =3	15.682	1.928	-.477	-.859
Metacognitive: Self talk (ST) *n* =2	10.275	1.066	-.965	1.406
Metacognitive: Making a checklist (MC) *n* =3	15.270	1.3196	.006	-.603

The values of skewness and kurtosis were under the normal range which showed the normal distribution of data and hence it was appropriate for inferential analysis. Furthermore, it may be observed from the mean values that the metacognitive techniques were more preferred by the students at primary level. The standard deviation values were also less than the values for subscales of heuristics problem solving techniques. Therefore, it was reported that the students preferably used metacognitive problem solving techniques in mathematics at primary level.

Gender of Students and their Preference towards using Problem Solving Techniques for Mathematics

Table 4

Mean Score Comparison of Subscales by Gender

Subscale	Gender	*N*	*M*	*SD*	*t* (398)	*p*
AO	Male	211	8.34	1.756	-.815	.415
	Female	189	8.49	1.809		
WB	Male	211	12.97	2.505	-1.237	.217
	Female	189	13.27	2.294		
BAC	Male	211	9.70	1.196	-.266	.790
	Female	189	9.74	1.358		
MOP	Male	211	13.81	3.736	.377	.707
	Female	189	13.67	3.321		

Subscale	Gender	*N*	*M*	*SD*	*t* (398)	*p*
OL	Male	211	9.09	2.569	-.957	.339
	Female	189	9.34	2.721		
GC	Male	211	19.09	2.486	-.608	.543
	Female	189	19.28	3.413		
LP	Male	211	14.52	2.187	1.196	.232
	Female	189	14.25	2.289		
VP	Male	211	15.99	1.839	3.419	.001
	Female	189	15.34	1.974		
ST	Male	211	10.27	1.147	-.002	.998
	Female	189	10.28	.972		
MC	Male	211	15.31	1.249	.685	.494
	Female	189	15.22	1.397		

Independent sample t-test was used to find the mean difference between male and female preference towards using heuristic and metacognitive problem-solving techniques at primary level. There was a significant difference (p = .001) in scores for males and females in using heuristic visualization of a word problem strategy. This shows that males (M = 15.99) preferred the visualization of word problem strategy under heuristic techniques than females (M = 15.34).

General Interest of Students and their Preference towards using Problem Solving Techniques for Mathematics

Table 5

Mean Scores of Problem Solving Strategies and Student's General Interest in Mathematics

	Subscale	*N (400)*	*M*	*SD*
AO	Low	63	8.63	1.324
	Medium	232	7.82	1.735
	High	105	9.57	1.505

	Subscale	*N (400)*	*M*	*SD*
WB	Low	63	12.59	1.291
	Medium	232	12.88	2.398
	High	105	13.93	2.747
BAC	Low	63	8.29	.633
	Medium	232	9.89	1.183
	High	105	10.20	1.155
MOP	Low	63	14.49	.504
	Medium	232	13.28	4.062
	High	105	14.32	3.188
OL	Low	63	10.32	.643
	Medium	232	8.90	3.005
	High	105	9.22	2.349
GC	Low	63	20.57	3.514
	Medium	232	18.77	3.172
	High	105	19.25	1.518
LP	Low	63	14.22	.870
	Medium	232	14.36	2.381
	High	105	14.55	2.473
VP	Low	63	14.70	2.763
	Medium	232	15.79	1.454
	High	105	16.03	2.073
ST	Low	63	10.37	1.112
	Medium	232	10.41	1.032
	High	105	9.93	1.049
MC	Low	63	15.59	1.399

Subscale	*N (400)*	*M*	*SD*
Medium	232	15.22	1.332
High	105	15.19	1.225

Table 5 presents the descriptive analysis of problem solving strategies with respect to the three different rates of student's general interest in mathematics. It is notable that the mean score values of problem solving strategies for heuristic act it out, work backwards, before after concept, and visualization of word problem increased as the rate of student's general interest in mathematics increase. The mean score values of problem solving strategies for heuristic made an organized list, make a model or picture, guess and check and metacognitive self talk shows a minimum effect with students general interest in mathematics.

Table 6

Mean Scores Comparison of Problem Solving Strategies and Student's General Interest in Mathematics

Problem Solving Strategies		*SS*	*df.*	*MS*	*F*	*p*
AO	Between Groups	224.688	2	112.344	42.882	.000
	Within Groups	1040.072	397	2.620		
WB	Between Groups	100.277	2	50.138	8.984	.000
	Within Groups	2215.661	397	5.581		
BAC	Between Groups	160.334	2	80.167	65.386	.000
	Within Groups	486.743	397	1.226		
MOP	Between Groups	121.396	2	60.698	4.933	.008
	Within Groups	4885.081	397	12.305		
OL	Between Groups	100.060	2	50.030	7.397	.001
	Within Groups	2685.130	397	6.764		
GC	Between Groups	161.157	2	80.579	9.607	.000
	Within Groups	3329.883	397	8.388		

Problem Solving Strategies		*SS*	*df.*	*MS*	*F*	*p*
LP	Between Groups	4.723	2	2.361	.471	.625
	Within Groups	1992.437	397	5.019		
VP	Between Groups	76.424	2	38.212	10.772	.000
	Within Groups	1408.253	397	3.547		
ST	Between Groups	16.700	2	8.350	7.585	.001
	Within Groups	437.050	397	1.101		
MC	Between Groups	7.591	2	3.795	2.192	.113
	Within Groups	687.249	397	1.731		

Note. SS= Sum of Squares, MS=Mean Square

One-way Analysis of Variance (ANOVA) was performed to compare the mean score differences of using problem solving strategies with student's general interest in mathematics. There was significant difference in the student's general interest in mathematics on the subscale of heuristics techniques. While for metacognitive techniques, difference was found on the subscale of ST. Furthermore, in order to identify the particular groups with significant mean score difference, post-hoc analysis is given below.

Table 7

Post- hoc Test of Difference of Problem-Solving Strategies and Student's General Interest in Mathematics

Problem Solving Strategy	(I) What is the rate of student's general interest in Mathematics?	(J) What is the rate of student's general interest in Mathematics?	Mean Difference (I-J)	*p*
AO	Low	Medium	.812*	.000
	High	Low	.937*	.000
		Medium	1.748*	.000
WB	High	Low	1.346*	.000
		Medium	1.050*	.000
	Medium	Low	1.602*	.000

Problem Solving Strategy	(I) What is the rate of student's general interest in Mathematics?	(J) What is the rate of student's general interest in Mathematics?	Mean Difference (I-J)	*p*
BAC	High	Low	1.914*	.000
		Medium	.312*	.017
MOP	Low	Medium	1.216*	.015
	High	Medium	1.048*	.011
OL	Low	Medium	1.421*	.000
		High	1.098*	.008
GC	Low	Medium	1.800*	.000
		High	1.324*	.004
VP	Medium	Low	1.095*	.000
	High	Low	1.330*	.000
ST	Low	High	.432*	.010
	Medium	High	.472*	.000

* The mean difference is significant at the .05 level.

Furthermore, a post-hoc test (LSD) was conducted to find the significant difference between groups. It showed a significant difference between using heuristic and metacognitive problem solving techniques on the basis of student's general interest in mathematics. It was concluded that the students with low interest in mathematics were more likely to use heuristic problem solving techniques, (that is, OL, MOP, GC, AO) and metacognitive strategy (ST) as compared to the students with medium or high interest. Moreover, the students with medium interest were more likely found to be using WB, VP, and ST strategies for problem solving in mathematics. It was also concluded that the students with high interest in mathematics preferred to use heuristics problem solving techniques, that is, AO, WB, BAC, and VP.

Parent Support of Students and their Preference towards using Problem Solving Techniques for Mathematics

Table 8

Mean Scores of Problem Solving Strategies and Parent Support in Mathematics

Problem Solving strategy	Parent support	*N (400)*	*M*	*SD*
AO	With parental assistance/family member	141	7.82	2.559
	With tutor's assistance	86	8.55	.835
	By self	173	8.82	1.103
WB	With parental assistance/family member	141	12.33	2.915
	With tutor's assistance	86	12.95	2.233
	By self	173	13.83	1.750
BAC	With parental assistance/family member	141	9.13	1.178
	With tutor's assistance	86	9.65	1.421
	By self	173	10.23	1.046
MOP	With parental assistance/family member	141	11.34	3.751
	With tutor's assistance	86	14.87	1.353
	By self	173	15.14	3.070
OL	With parental assistance/family member	141	7.50	3.159
	With tutor's assistance	86	10.06	.709
	By self	173	10.17	2.038
GC	With parental assistance/family member	141	17.94	4.101
	With tutor's assistance	86	19.84	1.884
	By self	173	19.87	1.701
LP	With parental assistance/family member	141	13.40	2.915
	With tutor's assistance	86	15.22	1.575
	By self	173	14.79	1.469

Problem Solving strategy	Parent support	*N (400)*	*M*	*SD*
VP	With parental assistance/family member	141	15.42	2.078
	With tutor's assistance	86	16.00	2.012
	By self	173	15.74	1.734
ST	With parental assistance/family member	141	10.25	1.043
	With tutor's assistance	86	10.29	1.105
	By self	173	10.29	1.072
MC	With parental assistance/family member	141	15.33	1.376
	With tutor's assistance	86	15.41	1.305
	By self	173	15.16	1.278

Note. *N*= Total number of students, *M* = Mean score *SD* = Standard deviation

Table 8 presents the descriptive analysis of problem solving strategies with respect to the three different categories of support in mathematics. It is notable that the mean score values of problem solving strategies for heuristic act it out, work backwards, before after concept, make an organized list, make a model or picture, guess, and check increased as the rate of students solving word problems by themselves in mathematics increase. The mean score values of problem solving strategies for heuristic look for pattern and visualization of word problem increased as the rate of students solving word problems with tutor's assistance in mathematics increase.

Table 9

Mean Scores Comparison of Problem Solving Strategies and Parent Support in Mathematics

Problem Solving Strategies		*SS*	*df.*	*MS*	*F*	*p*
AO	Between Groups	79.434	2	39.717	13.302	.000
	Within Groups	1185.326	397	2.986		
WB	Between Groups	175.993	2	87.996	16.325	.000
	Within Groups	2139.945	397	5.390		

BAC	Between Groups	92.895	2	46.447	33.274	.000
	Within Groups	554.183	397	1.396		
MOP	Between Groups	1260.554	2	630.277	66.798	.000
	Within Groups	3745.923	397	9.436		
OL	Between Groups	631.094	2	315.547	58.155	.000
	Within Groups	2154.096	397	5.426		
GC	Between Groups	336.951	2	168.476	21.206	.000
	Within Groups	3154.089	397	7.945		
LP	Between Groups	225.512	2	112.756	25.267	.000
	Within Groups	1771.648	397	4.463		
VP	Between Groups	19.071	2	9.535	2.583	.077
	Within Groups	1465.607	397	3.692		
ST	Between Groups	.156	2	.078	.068	.934
	Within Groups	453.594	397	1.143		
MC	Between Groups	4.305	2	2.153	1.238	.291
	Within Groups	690.535	397	1.739		

Note. SS= Sum of Squares, MS=Mean Square

Act it out (AO), Work backwards (WB), Before-after concept, (BAC) Make a model or picture (MOP), Make an organized list (OL), Guess and check (GC), Look for a pattern (LP), Visualization of word problem (VP), Self-talk (ST), Make a checklist (MC)

One-way Analysis of Variance (ANOVA) was performed to compare the mean score differences of using problem solving strategies with three categories of support in mathematics. The results revealed that there was a significant difference in heuristic problem solving techniques (Act it out (AO), work backwards(WB) , make a model or picture (MOP), make an organized list used by students, and the kind of support they reported in doing mathematics, before after concept, guess and check and look for pattern strategy. Furthermore, there was no significant association of parent support in mathematics towards using heuristic visualization of word problem strategy, metacognitive self-talk strategy, and metacognitive make a checklist strategy.

Table 10

Post- hoc Test of Difference of Problem Solving Strategies and Parent Support in Mathematics

Problem Solving Strategy	(I) How does a student complete his/her Mathematics homework?	(J) How does a student complete his/her Mathematics homework?	Mean Difference (I-J)	*p*
AO	With tutor's assistance	With parental/family assistance	.724	.002
	By self	With parental/family assistance	.998	.000
WB	With tutor's assistance	With parental/family assistance	.620	.052
	By self	With parental/family assistance	1.493	.000
BAC	With tutor's assistance	With parental/family assistance	.516	.002
	By self	With parental/family assistance	1.091	.000
MOP	With tutor's assistance	With parental/family assistance	3.532	.000
	By self	With parental/family assistance	3.798	.000
OL	With tutor's assistance	With parental/family assistance	2.555	.000
	By self	With parental/family assistance	2.664	.000
GC	With tutor's assistance	With parental/family assistance	1.901	.000
	By self	With parental/family assistance	1.931	.000
LP	With tutor's assistance	With parental/family assistance	1.82	.000
	By self	With parental/family assistance	.435	.120

Furthermore, a post-hoc test (LSD) was conducted to report the particular groups which showed a significant difference between using

heuristics problem solving strategies in mathematics on the basis of doing homework with support mechanism. In the heuristic problem solving strategies, it was investigated that the students more likely used heuristic techniques while doing mathematics with tutor's assistance or by themselves as compared to those doing mathematics with parental support.

Furthermore, a post-hoc test (LSD) was applied to report the particular groups. It showed that there was no significant difference between using heuristic before after concept strategy, metacognitive self-talk strategy, metacognitive make a checklist strategy, and practice time in mathematics ($p > .05$).

Discussion and Conclusion

Polya discussed heuristics to solve word problems of mathematics in his book "How to solve it" in 1957 and described four broad strategies under heuristic technique to find the solution of mathematics problems. Heuristic technique may be used by the teacher or sometimes by the students themselves. There are different strategies under heuristic technique that may help students to identify and solve the word problem (Gersten et al., 2009). The problem-solving heuristics utilized by the students make an organized list, look for a pattern, look for a clue, make a model or picture, make an equation, restating the problem, guess and check, use of formulas, trial and error, using basic operations, and using techniques to create formula. The students sometimes solving problem by using only one strategy, while some other time they use more than one strategy to find the solution (Krulick & Rudnick, 1996).

Metacognitive Problem-Solving Strategies used by Primary Students

Some researchers have shown that the metacognitive technique provides students with high level of cognitive skills (Wong, 2008). The strategies under metacognitive technique emphasize to plan about the findings and monitoring regarding what you have found (Kuhn, 2000). Discoveries demonstrated that each student showed his/her own aspect towards problem solving. Metacognition and cognitive skills are related with each other. Therefore, it may not be known what is going on in some one's mind without thinking skill (Barbacena & Sy, 2015).

Heuristic Problem-Solving Strategies effectively used by Primary Level

Sometimes heuristics are taught by teachers and sometimes students come across them on their own. It is important to note that heuristics are general strategies that a student may use on their own to help identify and solve a math problem (Gersten et al., 2009).The most basic heuristic is considered to be Gues and Check . Heuristics are best used with students who understand the mathematic concept; however, have trouble remembering the steps to complete a problem (Burns, 2011).

Metacognitive Problem-Solving Strategies Effectively used by Primary Level High and Low Achievers

Intelligent learners are capable to reflect easily on their problem solving skills by knowing number of strategies to solve the problems and using those strategies in an effective manner. If a student has higher metacognition, he/she may solve the mathematical problem in the best and accurate way. The above average students were able to use the strategies of metacognitive technique; however, the rate of use of metacognition was low among average and below average learners. The use of metacognitive strategies affects the performance of the students in mathematics in a positive manner (Wong, 2008). Metacognition and thinking skills are related to each other and we cannot find out what is going on some one's mind without thinking skill (Barbacena & Sy, 2015).

Recommendations

On the basis of findings following recommendations have been given for stakeholders:

- The current study may help the mathematical curriculum developers to add such contents in the curriculum related to problem solving which may help them to enhance the learning of heuristic strategies.
- It is projected that the implementation of 21st century learning skills stimulates logical, reflective, meta-cognitive, creative, and critical thinking. These skills impact the learning and problem solving of mathematics. In this way, the student's engagements in problem solving of mathematics may be improved along with the development of many soft skills. These skills include communication, flexibility, integrity, courtesy, positive attitude, team work, interpersonal skills, responsibility, and work ethics. The evidences collected through

problem solving of mathematics may also evaluate their higher order abilities.

- There is a lack of research studies that focuses on the effective techniques used to solve word problems of mathematics at primary level. These practical insights may help the researchers to gather and extrapolate further theoretical understandings. The present study attempted to bridge this gap in the literature by adhering to quantitative methods.
- In order to investigate the differences in mathematical problem-solving patterns, it may be more helpful for researchers to focus on individual differences rather than to assume that girls are an inferior group while boys are a superior group. Consideration of these points may be helpful while designing future investigations.
- School might benefit from positive partnership with parents by involving decision making process which affects students' pass in mathematics.

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