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# The effect of teaching the cognitive and meta-cognitive strategies (self-instruction procedure) on verbal math problem-solving performance of primary school students with verbal problem- solving difficulties

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## Abstract

This study investigates the effects of teaching the cognitive and meta-cognitive strategies (self-instruction procedure) on verbal math problem-solving (VMPS) performance of primary school students with VMPS difficulties. The experimental design using pre-test, post-test with control group is applied. The students were selected random ally of primary school and examined with VMPS test (pre-test). 60 of the students with VMPS difficulties are purpose fully matched in experimental and control groups (30 girls and 30 boys). During treatment experimental students received strategies instruction of 16 weeks of 45 min in 2 months during the school hours. The VMPS performances in each group are measured with post-test . The results of repeated measures analysis shows that teaching of cognitive and meta-cognitive strategies (self-instructional procedure) significantly improved performance of experimental group in both genders ( $F=44.86$ ,  $P<0.0001$ ). Also no signified differences between boys and girls in either applying the strategies or effectiveness of teaching ( $F=1.22$ ,  $P>0.05$ ).

*Keywords:* cognitive and meta-cognitive strategies, self-instruction, verbal math problem- solving performance;

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## 1. Introduction

The importance of mathematics is of increasing value in today s society. In fact, to be non-mathematical students become passive spectator rather than an active participant in the modern world. Mathematics learning is now viewed from a socio cultural perspective in which the context for learning and the relationship between social interactions and cognitive development are considered important factors (Montague, 1995).

According to the National Council of Teachers of Mathematics, “problem solving is very important of mathematics learning. In everyday life and in the workplace, being able to solve problems can lead to great advantages” (NCTM, 2000).

Problem solving as a complex mental process therefore all students in schools for elementary general education with any age and ability level have difficulties with Problem solving, especially about students who have cognitive disabilities. Teachers expressed weaknesses on student in problem solving, therefore suggest that problem solving as the important parameter applied in changing the mathematics curriculum planning (NCTM, 1998).

Students in addition mastery of the basic operations also must acquire problem-solving skills in Moreover, in difficulties be explained by such child characteristics as intellectual functioning, motivation, problem-solving skills,

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memory skills, strategy acquisition and application, and vocabulary. Another important cause of math difficulties may be a poor fit between the learning characteristics of individual students and the instruction (Carnine, 1997).

All students with mathematics difficulties require special attention. These students have special educational needs. There are new forms of instruction, therefore, ask students to construct their own knowledge under guidance of the teacher. Teaching mathematical problem solving is a challenge for teachers. Many of whom rely almost exclusively on mathematics textbooks to guide instructions. Most textbooks are not very helpful when it comes to teaching students how to solve math problems.

Successful problem solving is also dependent upon the interaction and influence of cognition and meta-cognition, and affect. It is presumed that meta-cognition is central to problem solving because it manages and coordinates the other components (Mayer, 1998, p. 51). Many studies indicate that cognitive, meta-cognitive strategies and motivational beliefs are important for effective VMPS. The purpose of this study is to investigate the effects of teaching cognitive and meta-cognitive strategies (procedures self instruction) on VMPS performance of primary school students with problem solving difficulties. The study assesses how participation in cognitive and meta-cognitive strategy instruction facilitates the student's knowledge, use, and control of mathematical problem solving strategies. Finally, is there a difference between performance of boys and girls in strategy use?

### *1.1 Mathematical Problem Solving*

Mathematical problem solving is a complex cognitive activity involving a number of processes and strategies. Montague (2006) defined mathematical problem solving as a process involving two stages: problem representation and problem execution. Both of them are necessary for problem solving successfully. Successful problem solving is not possible without first representing the problem appropriately. Appropriate problem representation indicates that the problem solver has understood the problem and serves to guide the student toward the solution plan. Students who have difficulty representing math problems will have difficulty solving them. Mathematical problem solving also requires self-regulation strategies. Mayer (2003) divided mathematical problem solving into four cognitive phases: translating, integrating, planning and execution.

### *1.2 Cognitive and Meta - cognitive Strategies Instruction*

The theoretical foundation of cognitive strategies instruction considers both behavioural and cognitive theory; that is, information processing and developmental theory (Montague, 2008).

Cognitive, meta-cognitive and self-regulated skills are necessary for mathematical problem solving. Cognitive processes and strategies needed for successful mathematical problem solving are: comprehension strategy hypothesizing or setting a goal and making a plan to solve the problem, estimating or predicting the outcome computing or doing the arithmetic, and checking to make sure the plan was appropriate and the answer is correct (Montague, 2003).

Meta-cognition has to do with knowledge and awareness of one's cognitive strengths and weaknesses as well as self-regulation, which guides an individual in the coordination of that awareness while engaged in cognitive activities (Wong, 1999). In other words, cognitive strategies are used to monitor by meta-cognitive strategies. VMPS also requires self-regulation strategies. Self-regulation, the ability to regulate one's cognitive activities, underlies the executive processes and functions associated with meta-cognition (Flavell, 1976). Self-regulation strategies, such as self-instruction (tell themselves what to do), self-questioning (ask themselves questions), self-monitoring (check themselves as they solve the problem), self-evaluation, and self-reinforcement, that help to students and facilitate problem solving process (Montague, 2008). Students with problem solving difficulties are poor in effectiveness implement of cognitive, meta-cognitive and self-regulated strategies. Therefore these students need explicit instruction in selecting strategies appropriate to the task, applying the strategies in the context of the

task, and monitoring their execution. They have difficulty abandoning and replacing ineffective strategies, adapting strategies to other similar tasks, and generalizing strategies to other situations and settings (Montague, 2008). Instruction aims to develop strategic learners who have an effective and efficient repertoire of strategies and are motivated, self-directed, and self-regulating strategies, such as self-instruction.

### *1.3 Self- instruction procedure*

Self-instruction refers to a variety of self-regulation strategies that , students can use to manage themselves as learners and direct their own behavior with specific prompting or solution-oriented questions (Steadly&et.al, 2008). Learning is essentially broken down into elements that contribute to success: setting goals; keeping on task; checking your work as you go; remembering to use a specific strategy; monitoring your own progress; being alert to confusion or distraction and taking corrective action; checking your answer to make sure it makes sense and that the math calculations were correctly done (Steadly&et.al, 2008, P.5). In this way, they develop both meta-cognitive awareness and the self-regulation skills that manage the learning process.

### *1.4 Gender differences in mathematical problem solving*

Gender differences in mathematical problem solving have been given increased attention by researchers in the last few decades. A review of studies reveals that the situation of gender differences in mathematical problem solving is very complex. The factors that contributed to gender differences in mathematical problem solving, and then moved to biological, psychological, environmental perspectives, in order to find gender specific patterns of mathematical problems solving and possible explanations of their existence( Zhen Zhu ,2007). Results from studies in literature on gender differences in mathematical problem solving are not equal. Some found that relationship between gender and the mathematics performance was very weak (caplan and caplan, 2005). Some research studies have reported gender differences in strategy use among elementary school students (Carr and Jessup, 1997; Carr and Davis, 2001; Zhen Zhu, 2007) and some showed that males generally outperformed females on mathematical tasks (for example, Helpem, 2000).

## **2. Methods**

### *2.1 Participation*

The statistical population is selected from primary school children of grade 4 in save city among which 1000 students (500 boys and 500 girls) were selected through random sampling. They're examined with VMPS test (pre-test form A). 204 students, whose scores ranged between the average and one standard deviation less than average, are chosen as having difficulties in VMPS. The subjects of this study were 60 fourth grade students (30 boys and 30 girls) that having difficulties inVMPS. The subjects with average intelligence (IQ range between95 to 115), average age (age range between 9 years and 6 months to 10 years and 6 months) average math performance (math range from 11 to 20) were selected. They matched with this control variables (intelligence, age and math performance) in two experimental group (15 girls and 15 boys), and control group (15 girls and 15 boys).

### *2.2 Research design*

Research design is experimental design with randomized block design. Moderator variable sex in two blocks (boys and girls) and independent variables in each block is examined separately. The experimental design used the analysis of students' mathematical achievement test data.

Table .1. Experimental design with randomized block design

Gender (a)	Experimental Intervention (b)	Repeat test	
		Pre-test (c1)	Post-Test (c2)
Boy (a1)	Experimental group (b1)	G11	G11
	Control group (b2)	G12	G12
Girl (a2)	Experimental group (b1)	G21	G21
	Control group (b2)	G22	G22

### 2.3 Instrument

The main instruments used in this study were:

- VMPS tests in this study, made by researcher. Both pre-test and post- test which chosen of was conducted in form A and form B. Each test included 10 verbal mathematical problem of elementary fourth grade text book of mathematics content was taken so that two scores and total problem score is 20. Psychometric properties of tests, test validity and content validity by using expert training and evaluation, and reliability coefficients obtained using the composed test (two half), 96% were calculated.
- Cattell Intelligence Test (Form A) which is non-verbal form with the fourth sub test was comprised of group form with a time limit has been done.

### 3. Procedure

In the experimental design, Students were assigned to two groups: Experimental group had received cognitive and meta-cognitive strategies training with self-instruction Procedure; and control group that does not receive strategy instruction. In baseline stage both experimental group and control group took a pre-test consisting of 10 word problems that had selected of their textbook. In treatment stage experimental group received teaching the cognitive and meta-cognitive strategies (self-instructional procedure) that combine both cognitive and meta-cognitive elements in 16 weeks of 45 minutes during two months of school hours. Establishing intimate and friendly relationship with the students, the researcher gave them a word problem in the first session .then she asked them to read it carefully and solve it individually. The answer and the applied strategies in the process of problem-solving were analyzed separately by her. In this way the students get awareness of their baseline. The researcher then elaborates more on the importance of application of those strategies during the process of problem solving. Then they signed a contract written and presented by the researcher to take the responsibility to participate. The instructional process consisted of two parts: first, the cognitive and second, and the meta-cognitive (self-instruction technique) teaching. In the cognitive part of this multi-strategy intervention, the student learns an explicit series of steps to analyze and solve a math problem. These steps include:

1. Reading the problem
2. Underlining the important information
3. Drawing the problem
4. Creating a plan to solve the problem
5. Predicting / estimating the answer
6. Computing the answer
7. Checking the answer

The meta-cognitive component of the intervention is say strategy. 'The student self-instructs by stating, or 'saying', the purpose of the step ('Say'). In this model, students can use to manage themselves as learners and direct their own behaviour. To teach students to "talk to them" while learning new information, solving a math problem, or completing a task. The first stage is cognitive modelling. "Modelling process" is thinking aloud while demonstrating an activity. Investigator says everything which is thinking about and doing. Students have the opportunity to observe and hear how to solve mathematical problems. Both correct and incorrect problem-solving behaviours were modelled. Modelling of correct behaviours helped students understand how good problem solvers use the processes and strategies appropriately. Modelling of incorrect behaviours allowed students to learn how to use self regulation strategies to monitor their performance and to correct errors. The second stage is explicit instructor direct: As soon as the students learned the routine modelling, they exchanged places with investigator and became models for their peers. The self-statements that students used to talk themselves through the problem-

solving process were actually prompting students to use a range of strategies and to recognize that certain strategies need to be deployed at certain times. Because learning is a very personal experience, it's important that teachers and students work together to generate self-statements that are not only appropriate to the math tasks at hand but also to individual students. Instruction also needed to include frequent opportunities to practice their use, with feedback until students had internalized the process. Then investigator led the group as they recited all the processes and the SAY strategy. The third stage is the explicit self-direct: in this stage the students solved a problem while thinking aloud and verbalizing the processes and strategies individually. The researcher did not guide them directly. Then investigator assessed the problem solvers and they get feedback from her. The fourth stage is the reductive self-direct: the subjects were asked to state the instructions to them while trying to solve a word problem. The last stage is the implicit self-instruction: during this step the subjects were asked not to use guiding card except the emergent cases. During the whole stages the researcher controlled, monitored and assessed the subjects using persuasive statements and words and gave them her feedback. This let the students to generalize and maintain the strategy in other cases than the instructional one. After practicing all the stages the investigator asked the students to apply the strategy to complete the cognitive processes of one another. Two weeks later, the instructor examined both groups – the control as well as the experimental group with a post-test. The results were then compared and evaluate.

**4. Results**

In order to analyze The effect of teaching the cognitive and meta-cognitive strategies (self-instruction procedure) on verbal math problem-solving performance of primary school students with verbal problem- solving difficulties , the researcher compared the mean of the performance beaten the two groups - the experimental and the control group. the comparison in both pre-test and post-test of problem solving indicated that the performance of the two groups increased in post-test in proportion to pre-test.the mean of the experimental group increased up to 4.33 while in control group as 2.3 . This happens while there was no signified difference between the two in the pre-test (Table2, Figure1).

Table .2. Mean of pre-test and post test scores of problem solving in the experimental and control group

Groups	Pre-test					Post-test				
	N	Min score	Max score	Mean	Standard Deviation	N	Min score	Max score	Mean	Standard Deviation
Experimental	28	5	9	6.75	1.28	28	2	20	11.08	4.51
Control	30	5	9	6.83	1.28	30	3.5	17	9.13	3.44

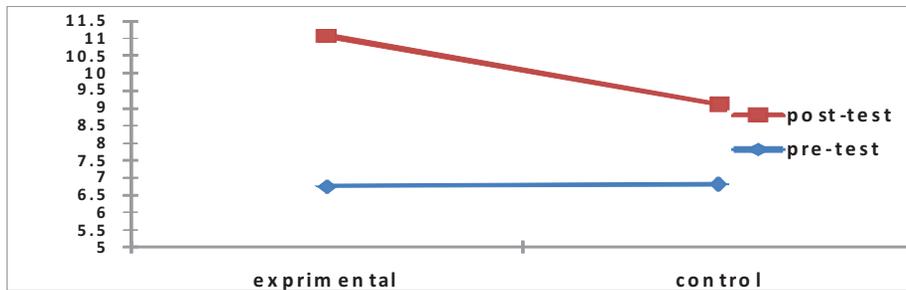


Figure. 1. The linear figure of Mean of pre-test and post test scores of problem solving in the experimental and control group

In order to analyze the gender differences in verbal mathematical problem solving as well as the rate of effectiveness of teaching the cognitive and meta-cognitive strategies (self-instruction procedure), the mean of performance of girls in experimental group in post-test was compared to that of the boys (Table 3). The comparison showered that the performance had increased in both groups. The mean increased up to 4.25 in girls and 4.43 in boys (Figure2).

Table 3. Mean pre-test and post test scores of problem solving of girls and boys

Gender	Pre-test					Post-test				
	N	Min score	Max score	Mean	Standard Devotion	N	Min score	Max score	Mean	Standard Devotion
Girls	14	5	9	6.89	1.37	14	2	20	11.14	4.82
Boys	15	5	8.5	6.73	1.22	14	4	18	11.03	4.83

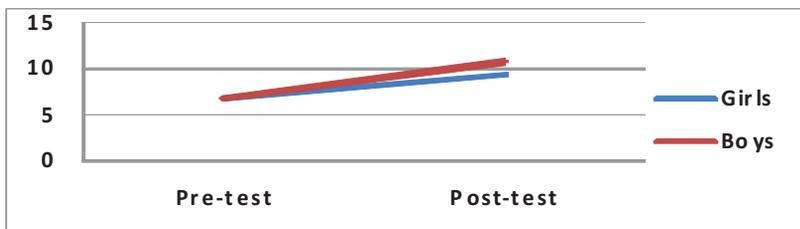


Figure. 2. The linear figure of Mean of pre-test and post test scores of girls and boys

Repeated measure analysis is used in order to analyze the significance of the observed differences between the means the simplest designs are the repeated measure design ,pre-test- post-test design in which the subjects are measured once before and once after the tests. In such designs the total changes include between and within the groups. The changes within the group are partly attributed to the act of experiment and partly to the errors (Howell, 1995).in the present research measure analysis with two factors between groups – group and gender, and a factor within the group-test is applied by the researcher. The findings are shown in table 3.the findings suggest that the effect of the test and the interaction of the group with the test has the significance level of  $p < 0.0001$ .they also indicate that the performance of the subjects in post-tests is better than the pre-tests regardless of the effects of the group and the gender in such a way that the mean of the performance of the subjects in post-test has risen from 6.8 to 10.07 and there is an increase in the score to 3.27 (figure 4). Moreover, the effect of the group and the interactive effect of gender with it is not signified. The main effect of the test is signified, but the interactive effect of the gender with tests as well as the effect of the gender with the group and the test are not signified however, the interactive effect of group with test is signified(figure 3).

Table 3. Summary of measurement analysis with two between subjects factor (group and sex) and a within subjects factor (test)

	Change sources	Free degree	Square sum	Square average	Fin	Sig
Between groups	Groups	1	25.38	25.38	2.52	0.118
	Gender	1	12.31	12.31	1.22	0.274
	Groups& gender	1	20.84	20.84	2.07	0.156
	Error	54	846.28	10.7	-	-
	Total	59	602.25	-	-	-
Within groups	Test	1	319.25	319.23	44.86	0
	Groups & Test	1	30.1	30.1	4.23	0.045
	Test & gender	1	13.98	13.98	1.96	0.167
	Groups & Test & gender	1	10.62	10.62	1.49	0.227
	Error	54	384.21	7.11	-	-
	Total	58	758.14	-	-	-
	Entry	117	1360.6	-	-	-

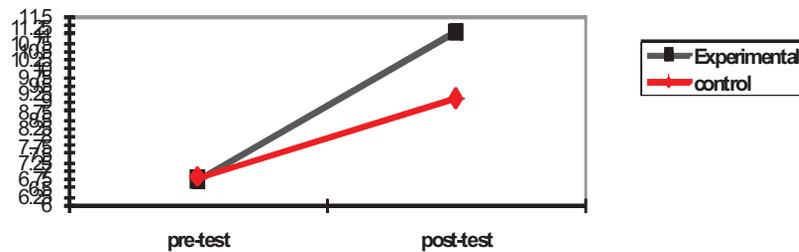


Figure 3. Interpretation group and test of problem solving

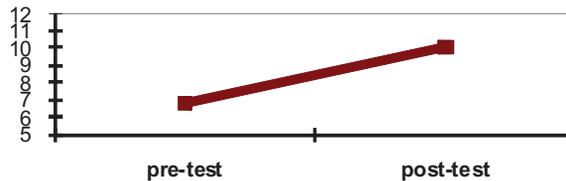


Figure 4. Compare pre-test and post test scores of problem solving performance

## 5. Conclusion

Results of the present investigation are meaningful in terms of each of the two research objectives: First, strategies instruction was efficacious in improving the mathematical word problem solving of students with problem solving difficulty. Also Important and significant gains were evidenced in the students' knowledge, use, and control of math word problem-solving strategies, such that their awareness of these domains approximated that of average-achieving students. Second, it studies the gender differences concerning the application of the instructional strategies verbal mathematical problem-solving., math problem solving program makes mathematical problem solving easy to teach. Students are provided with the processes and strategies that make math problem solving easy to learn, and they become successful and efficient problem solvers. Also the finding indicated that self- instruction, a self-regulation strategy, as a component of instructional models, is effective generally for mathematics problem solving. Application of strategy instruction significantly improved word problem-solving performance of students with difficulties. All students with mathematics difficulties require special attention .These students have special educational needs. There are new forms of instruction, therefore, ask students to construct their own knowledge under guidance of the teacher. These students need explicit instruction in selecting strategies appropriate to the task, applying the strategies in the context of the task, and monitoring their execution. They have difficulty abandoning and replacing ineffective strategies, adapting strategies to other similar tasks, and generalizing strategies to other situations and settings. They also gain a better attitude toward problem solving when they were successful. Researcher reported that low achievers trained in learning to monitor and control their own cognitive processes for solving mathematics problems do better than untrained (Teong, 2003).

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Problem Solving Strategies - Examples and Worked Solutions of Math Problem Solving Strategies, Verbal Model (or Logical Reasoning), Algebraic Model, Block Model (or Singapore Math), Guess and Check Model and Find a Pattern Model, with video lessons, examples and step-by-step solutions. Using the guess and check problem solving strategy to help solve math word problems. Example: Jamie spent \$40 for an outfit. She paid for the items using \$10, \$5 and \$1 bills. If she gave the clerk 10 bills in all, how many of each bill did she use? Show Video Lesson. Problem Solving : Make A Table And Look For A Pattern. Identify - What is the question? Plan - What strategy will I use to solve the problem? Problem solving is "cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver" (p. 287) [1]. As an important component of mathematical problem solving, Word problem solving (WPS) "involves knowledge about semantic construction and mathematical relations as well as knowledge of basic numerical skills and strategies" (p. 1) [2]. For example, a word problem often presents a story (e.g. "Xiaoming bought five pencils, and Xiaohong took three of them." Learning how to solve word problems has long been difficult for students and has gained attention in the field of mathematical development [3]. As a component of metacognitive knowledge, self-image concerns personal strengths and limitations relative to the abilities of others. Verbal self-instruction training probably leads to promote math problem-solving performance of intellectually disabled boy students. Key words: Boy Students, Intellectually Disabled, Math Problem-solving, Verbal Self-Instruction. Submitted :16 September 2015. Accepted: 6 November 2015. Instruction of meta-cognitive strategies has positive effect on problem-solving of student with dyscalculia (20). Paying attention to researches which have. Keywords mathematics, word problem solving, cognitive strategy instruction, mathematics difficulties, learning disability. Difficulties in solving word problems can be a "major impediment for [students'] future success in any math-related discipline" (Gersten, Chard, et al., 2009, p. 26). Table 1 provides word problem types and descriptions, typical of primary-level instruction (Riley & Greeno, 1988; Van de Walle, Karp, & Bay-Williams, 2012). The following is an illustration, as an example, of how word problems might be presented in first grade. In this case, a join word problem type is presented. This article presents an overview of two studies that examined the relationship between metacognition and mathematical problem solving in 165 children with average intelligence in Grade 3 in order to help teachers and therapists gain a better understanding of contributors to successful mathematical performance. Principal components analysis on metacognition revealed that three metacognitive components (global metacognition, off-line metacognition, and attribution to effort) explained 66% to 67% of the common variance. The findings from these