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The Impact of Meta-cognitive Teaching Math on Math Problem Solving Ability among High School First Grade Students

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ABSTRACT ─ The aim of this study is evaluate the effect of meta-cognitive teaching math on math problem solving ability among first high school first grade students. This research is a quasi-experimental and the participants of this study was the available sample of researcher included 52 students from seventh grade male students of a public exemplary school in Karaj, 26 of them in the control group and 26 patients in the intervention group participated. To compare the scores before the Implementation of study, participants in both groups responded to the issues of self-designed pre-test. After pre-test the researcher taught mathematical cognitive issues during seven sessions in the experimental group, while teaching mathematics was done in traditional methods in the control group. After seven sessions, both intervention and control groups responded to the self-designed post-test. The findings were studied by using qualitative analysis methods. The results showed that meta-cognitive teaching mathematics in solving mathematical problems has led to empowerment of students in the intervention group and this type of teaching in their attitude to mathematics and mathematical problem solving has a positive effect.
KEY WORDS: meta-cognition, teaching, math, problem-solving ability.

Introduction

What is meta-cognition? The first part of this word is "meta" that in Oxford Dictionary reads: Meta notes to change the situation or case. It also means above and beyond. The second component of this term is Cognition. Siefert (1991) believes that cognition refers to processes that help people learn, think and recall (Zare´ and Ahmadabadi, 1390). Meta-cognitive is one's knowledge about their cognitive processes. Meta-cognition is a complex structure and has a very wide meaning that many experts have acknowledged the complexity of it. Baker and Brown have identified two component of knowledge (knowledge) and inhibition (regulation) for meta-cognition that the first component referred to knowledge of skills, Cognitive strategies and resources for the effective performance of the tasks and the second component is the ability to use self-regulation mechanisms and to ensure the successful performance of task(Zare´ et al., 1391). Sonfild (1992) exposes that the meta-cognitive, is a term that has wide applications and it refers to the knowledge to understand and adjust to the person's thinking process by themselves (Zare´ and Ahmadabadi, 1390). According to Gouia (1992) when math teachers have found that Non-cognitive aspects of a matter is importance of cognitive function, Meta-cognition in the sense of knowledge and cognitive control has drawn a lot of attention from mathematics education research community. So the interest in the study of meta-cognition in solving mathematical problems among math educators is increasing (Ayoubian and Gouia, 1379). This article examines the impact of meta-cognitive teaching math on math problem solving ability among high school first grade students.

Problem Statement

Mathematics learning ability includes areas which meta-cognitive abilities have many applications on it. Akturk and Sahino (2011) believe that teaching how to use meta-cognitive strategies to students increase their academic achievement and their learning efficiency. Students with advanced cognitive skills are those who aware of what they have learned and do not know; always monitor their learning; express their opinions about their intake; update their knowledge; develop and complete the new learning strategies constantly; are aware of their strengths and weaknesses; and always trying to improve their skills(Zare´ et al., 1391). Undoubtedly, nowadays all students are not capable of solving the problem and experience has shown that many of them have trouble in problem solving and find the appropriate means, in order to solve it, is difficult for many students. But the point of view Polya (1962), seek the necessity of conscious search to appropriate means to achieve a specific purpose that at the outset, are inaccessible and problem solving means finding the means (Khodayari, 1392). According to Gouia (1992), within each group of questions related to problem solving, the most basic questions is about understanding the issues when someone solves the problem, in fact, what is he/she doing. Sonfild (1992) in the process of problem solving in the classroom had installed the poster in her class, which was included, the following practical question:

A) What do you do in fact?
B) Why do you do this?
C) How does this job help you solve the problem?

One of the challenges of math teachers and parents of students, are improve student performance in problem solving. To acknowledge the majority of math teachers, there is usually a fear in the hearts of students to get involved in solving math problems and they see a math problem, are concerned. What is the reason of this fear and worry in fact? What factors are effective in strength it? Why do some students look toward math negatively? And vice versa, why do some of them love math and its problems and always get good marks in exams? It seems that teacher' roles as regulator, facilitator and a role model for cognitive behavior at each stage of education play and they can be effective on math problem solving ability of students by meta-cognitive teaching math. Undoubtedly, teaching method of math teacher has a huge impact on student's problem-solving performance. Various methods are used in teaching math, including traditional methods and modern methods. Meta-cognitive teaching math in terms of researcher is the teaching where the teacher tries to improve meta-cognitive dimension of students in mathematics that the students can achieve a Regular logical thinking and they can find the different solutions for their problems. The researcher is trying to assess the effects of this type of teaching in this study. In other words, what the researcher is concerned with understands the impact of meta-cognitive teaching math on math problem solving ability among first high school first grade students of a public exemplary boyish school in Karaj.

Review of literature

The following are a few related researches about teaching in the field of meta-cognitive on mathematical problem solving include:

In the study that have done by Zare´ and Mohammad Ahmad Abadi (1390) about the effect of meta-cognitive instruction in mathematical problem solving of students, the conclusion was that meta-cognitive training can improve the performance of students in solving mathematical problems. The study showed that students who were trained to be aware of their strengths and weaknesses and to know which categories of lessons are easy and which are difficult for them and what they are interested, they were better than other in problem solving. In the study of Foulad Chang (1376) about impact of cognitive training on math achievement of students in second grade of Junior High School, Came to the conclusion that in terms of cooperation with, reasoning, thinking and analysis can be hoped that the students' ideas rather than memorizing formulas, understand mathematics and learn how to learn. Collaborative learning environment for the opportunity to discuss and argue about solutions and asking for help from others, leads students to development of meta-cognitive skills. The best findings of Foulad Chang research about meta-cognitive teaching were that the poor students benefited on cognitive teaching more than strong students. Anca Moga (2012) investigated the effect of meta-cognitive teaching on students' math performance in his Ph.D. thesis. Anca Moga believes that the main problem in the inability of students in problem-solving, is not a lack of skills, But it is the inability to choose the appropriate method and this failure stems from the fact that Kind of students problems is different in problem solving. In a study related to the present research, Jacobse and Harskamp(2009), by the using meta-cognitive teaching to enhance students' mathematical problem solving skills, point out important points. They report that students in primary schools often have difficult experience with problem-solving. In this regard, several scientists have suggested meta-cognitive skills teaching set the direction of solving the problem by providing clues and patterns and indirect support questions in different ways, including with the help of computer programs and based on application-driven learning environment can help students in the direction of solving the problem. To solve the problem, navigator training is preferred rather mere teaching. In this type of teaching, students fixate their stream of consciousness and thinking strategies in relation to the problem solving.

Research Questions

This research is a step towards clarifying the effect of the way the great scholars like Sonfild and Polya have emphasized on using it. Undoubtedly mathematics teaching method is very effective role in student achievement. In order to clarify the role of meta-cognitive teaching on student performance, the main question under study conducted:

"What is the effect of teaching math on high school first grade students and especially their math problem solving ability?"

Research Method

This study was a quasi-experimental study that analysis of data in the context of a pre-test and post-test for two groups is qualitative that in the course of the implementation of quasi-experimental design, statistical analysis and content analysis help to understand and explain the qualitative questions.

Statistical population and sampling

Participants in this study were the seventh grade boy students of a public exemplary school in city of Karaj. Due to the fact that due to administrative issues, the use of meta-cognitive teaching was not possible in different schools, for this study, Researcher was selected the school where he was engaged to education in it, to be able to be manipulated in the educational structure. In this school there were four seventh grades. The number of students in these classes is 30 people that a total of 120 seventh-grade students who in terms of age, the age of the participants were about 13 years. This shows that the groups were homogeneous and the variable age as an intervening variable was controlled. It should be noted that students in the sixth grade, to enter into these types of schools are selected through entrance exams. To synchronize groups, intervention and control, researcher chose 26

people from each class which included 26 participants in the control group and 26 were in the intervention group. Eliminated students were present in these classes but their performance in the pre-test and post-test study was not investigated.

Research Instrument

In this study, as regards for the seventh new math book, there was not a standardized test to measure changes in student mathematics achievement, For this reason, researcher with his expertise and experience and as well as consultations with experts in the field of math and science education, Supervisors and advisers, proposed two tests and one questionnaire to measure students in mathematical problem solving.

Procedure of Research

Since the researcher tries to examine the effect of meta-cognitive teaching mathematical on problem solving students' behavior, he deal with problem solving ability of them. In this study, the doer of meta-cognitive teaching was the researcher of the study that to do this, followed these steps in the method of teaching. The duration of this study was for one semester (second semester in the 93-94 school year), which started from Day 1393 and lasted to Ordibehesht 1394. In order to assess the effects of meta-cognitive teaching, teaching method was done based on meta-cognitive teaching in the intervention group during the seven sessions, While way of teaching math were in traditional method in the control group.

Pre-Test

Before the start of seven session's cognitive teaching math gave a test to students that was pre-test and its questions was teacher-design and it included five math problems. This test was done without **foreknowledge** to students from both groups it means intervention and control at the same time. Before the starting seven sessions said, at first researcher tried to give students a questionnaire that involved their mind with some "meta-cognitive components". So that the questionnaire was developed and delivered to students in the intervention group and they were asked to take home the questionnaires and Try to actually answer questions. For this reason they have authority to write or do not write its name. To give more information to readers of this study, a summary of activities in seven sessions of cognitive teaching is provided in the following.

Seven session's meta-cognitive teaching math

First Session

In this session gathered questionnaires and the researcher tried to ask students face to face and verbal questions to understand their "meta-cognition" and ask meta-cognitive question. He tried to explain to students that speak the truth and do not lie from the embarrassment or other thing and they understand the belief system, their ability to understand mathematics, diversifying their strategies, their restraint in solving math questions and understand their worldview than his math and in general to strengthen their mathematical cognitive dimensions.

Second Session

In this session was tried that students hear the thought other students during problem solving. That's why it was written a question on whiteboard and one of them went to the board. He was asked to think aloud while solving. In addition, the three basic questions of Sonfild (1992) wrote on the smart board that was in view of the students, so they are realized their cognitive dimension by seeing it:

A) What do you do in fact?
B) Why do you do this?
C) How does this job help you solve the problem?

Students are asked to comment about the students' problem solving performance of the student who was solving the problem**.**

One purpose of this session was that students hear thought the other students during problem solving and to see the strategies that he uses and strengthen their self-regulation, in addition, to see his courage problem solving and generally they become familiar with other students cognitive dimension during problem solving and therefore are aware of their cognitive and increase their cognitive abilities further.

Third Session

This session involves the formation of cooperative groups in the school chapel. The environment of school chapel was big, beautiful and carpeted that students expressed satisfaction and happiness about transfer the classroom to there and to work together was very good. Students before going to the chapel were grouped into three-handed by investigators. One group was twosome. It was explained to them that you will be given a problem, try to solve the problem alone. It supposed if someone was to solve the problem as soon as possible and other members of the group were unable to solve it, He guide them towards solutions by questions such as Sonfild questions. In this session it tried to be solved some of the questions that had been raised in the pre-test.

Fourth Session

In the session students also went to the chapel and group work was carried out again. During the session several problems were solved. In some cases, the researcher stated tips to make progress in student problem solving. In second problem solving, after the time that the students were engaged while working together to solve it, Researcher solve a problem for them and tried to use the

symbolic method strategy (Use the symbols to solve the problem) Where English letters used in it, solve the problem for them. After seeing the solution of researcher by students, they liked his solution and it was attractive to them. They had attempted to solve this question in different ways, but by seeing this strategy, which use English letters making it easier to solve the problem were wondered and they had been believed the value of use of symbolic More than ever.

Fifth Session

In this session, the students who were prepared files tried to run them. The purpose of this session in terms of researcher was affect students' beliefs about mathematics and broadens their Mathematical worldview and they are become familiar with mathematical applications more than past in the world and life, So with this view, strengthen this aspect of their "cognitive dimension" about math and increase their motivation to learn math and they see more positive than in the past, about math and learning. Some of the students had prepared material in class to present them. The title of some materials that was presented by the students in the class was: "Ten ways to succeed in math", "Application of Mathematics in Medicine", "application of mathematics to astronomy" and "Application of Mathematics in life".

Sixth Session

In the Session was an attempt to provide a famous four-step problem-solving of George Polya, firstly the four stages to be explained to the students. The purpose of this session was the students monitor their thinking in problem solving, strengthen their meta-cognitive skills and become more capable in problem solving. So the researcher tried to explain the importance of these four stages. He developed all stages step by step so that they take these steps in the process of problem solving. After explaining this process, the researcher started writing a math problem on the board and tried to solve this problem for students by using four-step problem-solving of George Polya. During the session, several mathematical problems were solved with the help of four-step problem-solving of George Polya in which students were involved in solving this problem.

Seventh Session

The meeting is also to increase students' cognitive skills and increase the power and ability to problem-solving, cooperative groups formed twosome and students went to the chapel again to solve their problem in cooperative groups. One of the students also wanted to solve individually that the researcher agreed with his request. He was strong in math. When he solved the first two problems quickly, he was asked to inspect other groups and to help those who need guidance. He eagerly accepted. The students were advised that solve the problem individually and then if any one of them could not solve it, another student of another group conduct him with questions and directions for the appropriate strategy. The goal was to increase "self-regulation" of students during problem solving. In this session it was tried the weak students are grouped with strong students. The remarkable tip was that the students wanted the meeting to be held in next class time. In addition it should be noted that to synchronize, it was attempt that the problem that can be solved in the experimental group, in control group also normally be resolved. At the end, a post test was done from students without prior notice, at a time on both groups to eliminate confounding variables.

Post-Test

After running seven session's meta-cognitive teaching math in the intervention group and traditional teaching in the control group, a post test was done in both groups without foreknowledge. It should be noted that before this test, similar to the first three questions had been solved in the two groups and these three questions for them were a practice rather than a problem. But like the problem4 and 5 was not solved in classes. However, in the opinion of the investigator, it may be that the problem 4 has been observed by students in special schools entrance exam tests or Reinforcement classes. But the problem or question 5 was from Thames test 1.

Data Analysis

In analyzing the data, the researcher for accurate and deeper assess of problem solving in both groups, analyzed the papers of pretest, posttest, questionnaires, interviews and observations during the course of his research in qualitative way.

Answering the Research Questions

In order to respond to research question that was "What is the effect of teaching math on high school first grade students and especially their math problem solving ability?" It seemed that meta-cognitive teaching mathematical problem solving has a good effect on their attitudes toward math and problem solving by it. Knowing the difference between good and incapable problem solvers, helps to better understand meta-cognition and the implications of teach problem solving. It seems that a good problem solver have significant differences with a bad problem solver. Therefore, to scrutinize the performance of the students' problem solving in both groups, Investigator paid to review the findings and research data to assess the teaching meta-cognitive effects on problem solving and possibly other things. After analyzing qualitative data, observations, interviews during study and compare the performance of two groups, good results were obtained that mentioned in below and it was don while the analysis and final conclusions.

Table 1. The results of pre-test papers emend of control group

Percent of perfect answer	Perfect answer	Incomplete answer	Empty answers	Number of problem
69%	18	8	0	1
30%	8	18	0	2
57%	15	11	0	3
26%	7	18	1	4
0%	0	26	0	5
----	48	81	1	total

Table 2. The results of pre-test papers emend of intervention group

Percent of perfect answer	Perfect answer	Incomplete answer	Empty answers	Number of problem
50%	13	11	2	1
26%	7	19	0	2
65%	17	9	0	3
26%	7	19	0	4
3%	1	25	0	5
----	45	83	2	total

Table 3. The results of post-test papers emend of control group

Percent of perfect answer	Perfect answer	Incomplete answer	Empty answers	Number of problem
96%	25	1	0	1
69%	18	8	0	2
88%	23	3	0	3
38%	10	13	3	4
30%	8	17	1	5
----	42	42	4	total

Table 4. The results of post-test papers emend of intervention group

Percent of perfect answer	Perfect answer	Incomplete answer	Empty answers	Number of problem
96%	25	1	0	1
57%	15	11	0	2
92%	24	2	0	3
38%	10	12	4	4
42%	11	14	1	5
----	85	40	5	total

As has been shown in table 3 and 4, participants have the same performance in the first and fourth questions in the intervention and control groups. But the condition is different about questions 5. While the control group only 30% had a complete response to this problem, it is observed that the number of complete response in the intervention groups is 42%.

Table 5.The ratio of complete responses to total answers

The ratio of complete responses to total answers of pre-test of control group	36%
The ratio of complete responses to total answers of pre-test of intervention group	34%
The ratio of complete responses of last two questions to total answers of post-test of control group	34%
The ratio of complete responses of last two questions to total answers of post-test of intervention group	40%
The ratio of complete responses of question five to total answers of post-test of control group	30%
The ratio of complete responses of question five to total answers of post-test of intervention group	42%

In general, it cannot be known any math question as a problem. More precisely, we must distinguish between exercise and problem. Exercises are familiar questions that a solution specified for each of them and people can solve them by using these methods. While based on National Council of Teachers of Mathematics standards (NCTM, 2000) problem-solving means

grappling with the task that the solution is not known initially (Hessam, 1389). According to Table 5 it can be seen that the ratio of full answers to total answers in pre-test of intervention group is less than this in control group, but in the last two questions in post-test that Similarly, it was previously unresolved in both groups, the ratio of full answers to total answers of the students in the intervention group was higher than the control group. If the performance of two groups is considered about only question five, it can be seen that the performance of intervention group is much better than the control group. Due to the small number of meta-teaching sessions, it can say that this improved performance, increased significantly.

Diversification of Strategies of Two Groups in Question 4 And 5 of Post-Test

In order to further scrutinize the results of the test, the number and type of strategy used in the question four and five of post-test, the strategies of two groups of students were tested which results has come in tables 6 and 7 below.

Table 7-Diversification of Strategies in Question 4 of Two Groups of Post-Test

Control Group	Intervention Group	Name of Strategy
1	0	**Draw the Shape**
0	0	**Remove Undesirable States**
0	0	**Find Pattern**
0	0	**Modeling**
11	17	**Symbolic Method**
0	0	**Become to Easier Problem**
3	1	**Use the Problem Following**
7	4	**Guess and Check**
2	2	**Other**

According to Table 3, 4 and 6 can be seen that although complete responses were similar in both groups, but the students in the intervention group, for solve question 4, have used strategy symbolic method (using English letters) rather than control group and this method is very good strategy for solving this problem, While both groups in the pre-test, had used of this method for equal number (Each of them for 6 times). As well as the number of using guess and check strategy in the control group is almost double the intervention group, while the two groups in the pre-test papers, had not used this strategy at all. It should be noted that in an inquiry which is carried out by researcher on the most laborious problem or question, in each group, 15 persons were considered the question 4 as most troublesome question. This result means that the intervention group had been able to choose the right strategy. It is worth mentioning that a researcher in the experimental group, during the meta-mathematical teaching, had warned the great importance of this strategy to students and many students also expressed their great satisfaction from use this strategy to solve problems.

Table 8-Diversification of Strategies in Question 5 of Two Groups of Post-Test

Control Group	Intervention Group	Name of Strategy
3	9	**Draw the Shape**
0	1	**Remove Undesirable States**
0	3	**Find Pattern**
1	0	**Modeling**
0	0	**Symbolic Method**
0	0	**Become to Easier Problem**
8	6	**Use the Problem Following**
5	1	**Guess and Check**
9	3	**Other**

By comparing Tables 7 and Tables 3 and 4 can be seen that students in the intervention group, have used draw the shape strategy in solving question 5 more than the students in control groups. To resolve this question, other strategies have been used in the control group. While only three persons of the intervention group had used various strategies. It should be noted that the two groups in the pre-test papers had not used the strategy of drawing shapes. It was also observed that the number of using guess and check method in the control group were 5 cases, and while only one case was in the intervention group and as mentioned above, both groups did not use guess and check strategy in the pre-test at all. This means that the intervention group had a greater effort to find the answer without guess and check strategy. As regards in this problem, the number of complete responses in the intervention group was more than that in the control group, so, it seems, emphasis that the researcher had to use eight strategies listed in the table, has a positive effect on choice of strategy and thus make that the intervention group have more complete answers.

A Results of comparison of the questionnaire answers and the researcher interviewed with a number of students in the intervention group

In order to tripartite making of the information, at the end of the research, researcher was conducted semi-structured interviews with several participants in the intervention group. For further data analysis and compare the results of interviews and experimental observations of researcher and student's responses to the questionnaire, for example, two questions of questionnaire were selected and the student's responses were categorized and the following results were obtained(It should be noted that all students did not give back the questionnaires to the researcher and it may be the number of non-intervention questionnaires of four students is also available in collected questionnaire).

What type of math questions do you like to solve? Problematic or non-problematic questions?

Table 9: The answer to question 3 of the questionnaire

Both of Them	Problematic	Non-Problematic
3	8	14

Write first feeling that comes to you when you faced with a mathematical problem, with a word or sentence.

Other	Negative Feeling	Positive Feeling
3	10	10

Given that in interviews and in the questionnaire, whether in an interview or questionnaire, students expressed themselves and it was emphasis to them that tell the truth regardless of all considerations, it looks that has changed at the students' feelings toward math by compare text interviews and tables 8 and 9. In an interview were random with 8 of them, all of them believed that has modified their courage to solve the problem and it has increased. As can be seen in Table 9 before 7 session's meta-cognitive teaching math, half of them had positive feelings, but the researcher from the analysis of the interviews was recorded as an audio file, came to the conclusion that increased positive emotions in all 8 people interviewed.

Comparison between pre-test and post-test papers of two students at random

In order to more compare between the sheets of two groups, for instance, pre-test and post-test papers, and answer sheets of one student in the intervention group were compared with one student in control group randomly. It should be noted that in terms of mathematical abilities, these two students were almost at the same level before the start of a seven-session cognitive teaching. It was observed that the overall score are almost equal and the score of all questions of pre-test papers of two students are almost the same. But difference is 6 score in the post-test score. Even though similar examples of questions 2 and 3 were resolved in the control group, the student of control group in Post-test had failed to reach the correct answer in these two questions. As regards the post-test was done without previous notice to both groups, this difference can be significant and can be indicate the student´s empowerment in intervention group for problem solving.

Conclusion

Among the various aspects of mathematical performance, problem-solving has particular importance. The vast majority of mathematicians and teachers believe that the most important factor in learning math is problem-solving ability. Many researchers including Lucangeli and Cornoldi (1997) in this regard that the review of cognition process and Knowledge of them could be improved mathematics learning disabilities (Zare´ et al., 1391). Generally as regards to analysis of the present research and interviews and observations were taken during the study period, it appears that meta-cognitive teaching math is created changes in students among them that they are as follows:

1. Math meta-cognitive teaching causes the change of students' attitudes toward math and math class and changes the worldview of them toward math so that they are motivated to more attend in math classes.
2. They love the classroom place shifting and the classroom environment in which students sit on the carpet instead of sitting on hard benches and it causes of their interested in math class.
3. The formation of problem solving cooperative groups with meta-cognitive teaching approach makes the more self-discipline and self-control of students in math problem solving.
4. Using of this method of teaching in problem solving increases the dare of students to get involved with math problems and strengthen the "I can" among them.
5. Math meta-cognitive teaching causes that the students understand more about their own cognitive processes and they review and scrutinize their mathematical abilities. As a result by better management than before could make use of their abilities in problem solving.
6. The four-steps of problem-solving of great scholar of mathematics education, George Polya, is a light and great way for students to solve math problems and learning the fourth stage it means " revert back" is very interesting and useful for them.

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