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Surveying the Effect of Metacognitive Education on the Mathematics Achievement of 1st Grade High Junior School Female Students in Educational District 5, Tehran City, 2009-10 Educational Year

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Abstract

This research was carried out in order to evaluate the effect of metacognitive training on learning mathematics. A random sample of 30 guidance school students in Tehran were chosen and participants randomly assigned in an experimental and control groups. Mathematics and metacognitive skills questionnaire were administered in two groups. The experimental groups received 12 sessions of metacognitive training but control group get ordinal training. Reliability of questionnaire was conducted by test retest consistency (r = .720). The validity of the questionnaires is evaluated by the content validity (cvr = .780). Two groups pre-post tests were compared using ANCOVA and T-test. The results revealed that metacognitive training increase not only the mean score in Self-regulated Learning, evaluating and planning in mathematics but also in mathematics scores.

Keywords: Thinking Process; Meta-cognitive Behavior; Meta-cognitive Teaching Method; Learning; Scheduling; Self-regulating; Learning Monitoring

1. Main text

1. Introduction

One of the basic objectives in 21st century education is learning how to learn. That is, compiling and developing sets of thinking processes that can be used in problem solving. Knowing about the thinking stream and controlling and conducting it including receiving, processing, maintaining and transferring information are called metacognition. And its main aim is to assist students (learners) to think and train the skill of thinking and transferring data learned in various, numerous situations. Or in other words, utilizing metacognitive training is being aware of what one knows and what s/he does not know (Holt, 1982; cited by Sief, 2000). To achieve this goal, many of the recent investigations have examined the way of using metacognitive theory in education, and essentially the focus of these investigations has been whether “the
instructing the metacognitive processes can facilitate the learning?” Flavell (2000) cited by Azari (2003) defines:” metacognition refers to the knowledge of people about cognitive processes and products and or/what is related to them.” Walfs et al. (1995) cited by Salari Fard (1978); and Karshaki (2002) has drawn a clearer distinction between cognition and metacognition. According to them, metacognition is mental operations done on the mental operations, while cognition is mental cognition on content. To their belief, what have been called metacognition is second-level mental operations. That is when a learner chooses those mental operations that are exerted on a certain issue and intends to conduct them. Sternberg (1983, cited by L’franceva, 2001, p 192) calls metacognitive skills, management skills since these skills intervene both in setting the goals and in controlling, supervising, and evaluating thinking activities. As a manager of a company may set goals and determine guidelines for its company and direct his/her employees and supervise the firm’s affairs, metacognitive skills also play the same role in controlling mental processes Berk (1994). Masters (1981, cited by Flavell, 1998) said that one of the conceptual evolutions dominating cognition during the last decade has been metacognition idea which emphasizes on the individual’s awareness and consideration of metacognitive processes and strategies. Costa (1984, p 106) says: “If you have already become aware of an inner dialogue in your mind and if you have had to evaluated decision and problem solving processes, then you have experienced metacognition. There are different procedures for learning metacognition among which it can refer to the effective one that is equipping learners with the knowledge of strategies and metacognitive processes, and exercise of applying the cognitive and metacognitive strategies as well as evaluating the results (developing metacognitive regulating). One the commonest educational procedures used for metacognition is thinking aloud. Thinking aloud is a strategy in which people express their thoughts while reading a text or doing a learning assignment. Teachers can model thinking processes of the effective readers using this strategy, and students can also analyze strategies needed by their classmates and themselves. Self-monitoring is another component of the metacognitive learning’s. This can be done through self-asking the questions like “Why are we doing this work?”, “How can I do that?” and “What can I do in some way else?”(Young et al., 2002, p 18)

Teaching method in metacognitive one can be used as a proper guideline to teach subjects by mathematic teachers. The effectiveness of teaching cognitive-metacognitive strategies on performance in many investigation has been surveyed (Beshavard, 2000, cited by Karshki 2002). The effectiveness of teaching cognitive-metacognitive strategies on educable mentally retard students’ performance of mathematic problem-solving in Shiraz city has been studied. The gained results of this study indicate that teaching cognitive-metacognitive strategies has led to its better performance of problem-solving and continuity in testees of experimental group. In this research no differences have not been observed between the performance of male and female students. Abdoos (2001), cited by Karshki (2002), surveyed the effectiveness of teaching metacognitive strategies on the pedagogy of creativity of female 3rd Grade High Junior School students of new-educational system. The results showed the positive effectiveness of teaching metacognitive strategies on the pedagogy of creativity. In addition, effectiveness of teaching metacognitive strategies on two components of fluidity and flexibility was positive and caused students’ metacognitive skills improved. Heydari (2001), cited by Karshki (2002), in a study on the role of components of metacognitive knowledge in female 1st-grade high school students’ achievement of Khoram Dareh city, showed that metacognitive knowledge has a correlation with students’ achievement so that the higher is the level of metacognitive knowledge of the students, the higher their achievements increase. Sanati (2000), cited by Azari (2003), in an investigation, studied the relationship between the metacognitive knowledge of metamemory revision, metamemory awareness, the level of information processing and reviewing the predicate with the male 3rd-grade guidance school students’ performance of mathematic problem-solving in Tabriz city. Its results indicated that first; there is a positive relationship between the levels of processing, mental review, metamemory revision and metacognitive knowledge of
unsuccessful students with their performance in verbal mathematic problem-solving. Second, there is a positive relationship between metacognitive knowledge, predictive review, processing levels and metamemory revision of successful students with their performance in verbal mathematic problem-solving. Third, there is a meaningful correlation between processing levels, mental review, metamemory revision and metacognitive knowledge of successful and unsuccessful students with their performance in verbal mathematic problem-solving. The effectiveness of self-learning intervening on the improvement of mathematic performance of students has been reported in many studies (e.g., Keller & Loyd, 1989; Albion et al., 1982; Cameron et al., 1980; Leon, 1983; Thackwary et al., 1985; Holman et al., 1979; Liu et al., 1981; Shonk et al., 1986; Thackwary et al., 1985; Lorans, 1972; Lorenz, 1972, cited by Hughes, 1988; and Ghorchian, 1998).

In addition, Miller & Brewster (1992), cited by Azari (2003) have reported positive applications of self-learning in mathematic skills. Swanson (1993); Ghorchian (1998); Karshki (2002) have emphasized on the effectiveness of self-learning in mathematic skills. Carr & Punzo (1993), cited by Karshki (2002), dealt with the effectiveness of self-monitoring strategy on improvement of mathematic performance of emotionally disturbed students. The results of this study showed that applying the self-monitoring strategy could lead to the above cited students improving their mathematic performance. Along with this fact, Maag et al. (1993), cited by Karshki (2002) measured the effects of self monitoring on the behaviors concerning mathematic assignments, educational creativity and accuracy with use of mathematic assignment. The results showed that self monitoring can lead to students improving educational performance, creativity and accuracy. In a study, Zikola et al. (1981), cited by Seif (2000) reported that teaching self monitoring to grade-5 students with deficits in attentive behaviors and mathematic assignments had developed considerable changes in their mathematic performance (Shapiro & Cole, 1994, cited by Seif, 2000). The aim of the present study is to survey the effect of teaching metacognition on the students’ learning level of mathematics in comparison with the traditional method of teaching mathematics 1st Grade High Junior School, which deals with the following hypotheses:

1- Teaching students through metacognitive method causes their programming in mathematics increased;
2- Teaching students through metacognitive method causes their self regulation in mathematics increased;
3- Teaching students through metacognitive method causes their learning control in mathematics increased; and
4- Teaching students through metacognitive method causes their scores in mathematics increased.

2. Research Method

In this investigation, a pre-test, post-test plan was used with a control group.

2.1. Statistical Society and Sampling Method

Among 1st Grade High Junior School in Educational District 5 in Tehran City, 30 students were randomly selected and placed in experimental (n =15) and control (n = 15) groups. Random arrangement is the unique method by which all additional possible variables can be controlled (Kerlinger, translated by Sharifi and Najafizand, 1995). First, two groups in mathematic knowledge and programming, self-regulating and learning control variables were evaluated. t-test for independent groups showed these variables in both groups have no meaningful difference, which this finding indicates that both group are identical and have no differences. Then the experimental group was taught mathematics through metacognitive method and control group was exposed to the traditional method of teaching mathematics. At the end of the instructional process, both experimental and control groups were measured from the viewpoints of the respected variables under the same certain condition simultaneously so that the effect of the metacognitive teaching (independent variable) on [the students’] mathematic learning (dependent variable) could be cleared.
3. Instruction

In this research, a mathematic test which was compiled based on the taught content in mathematics was used to assess the mathematic knowledge and to assess programming, self-regulating and learning control based on theoretical topics of metacognition, a set of questions were prepared for each of the above variables. Then the questions of each scale were reviewed and modified considering the supervisor’s and advisor’s opinions. Finally, 30 questions; i.e., 10 for each dimension of metacognition, were prepared in the form of Likert 5-choice questions. After initial preparation, a questionnaire made by five experts was evaluated to examine their content validity. The coefficient of concordance among the experts’ opinion was $0.79$ indicating a high validity that showed the questions of each scale of the questionnaire measure its respected content. A re-test was used to examine the reliability of the materials. The questionnaire was repeated after ten days. Pearson’s coefficient of correlation for the scores gained from two observations was $r = 0.72$ which indicates that the questionnaire is properly reliable. To describe the yielded data, descriptive statistics; e.g., frequency, percentage, mean and standard deviation were used. To find an answer for the hypothesis of the research, co-variance analysis test was used to control the effect of pre-test and $t$-test was used to examine the effect of teaching through metacognitive method on the increase of students’ skills in independent groups. SPSS software was used to analyze statistical data.

4. Findings

Descriptive indexes and the results of $t$-test for the comparison of dimensions of metacognition between both groups of 1st-grade female students in guidance school are presented in Table 1.

Table 1: mean and SD and the results of $t$-test for the comparison of dimensions of metacognition between two groups at the beginning of the research.

<table>
<thead>
<tr>
<th>Dimensions of metacognition</th>
<th>metacognition Group</th>
<th>Traditional group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming</td>
<td>Mean: 8.67</td>
<td>SD: 2.13</td>
</tr>
<tr>
<td>Self regulation</td>
<td>Mean: 8.87</td>
<td>SD: 2.2</td>
</tr>
<tr>
<td>Learning control</td>
<td>Mean: 8.66</td>
<td>SD: 2.1</td>
</tr>
</tbody>
</table>

$t$-test results for Comparison between Dimensions of Metacognition (Programming, Self-regulating, and Learning control)

In Table 1, it shows that there was not any significant difference between two groups in programming, self-regulating, and learning control variables because the level of meaningfulness in either group was too small ($>0.05$) to examine the mean differences which indicates that both group were chosen randomly and have no differences with each other.
The first hypothesis was based on this fact that teaching students through metacognitive method causes their programming in mathematics increased. To answer the above hypothesis to control the pre-test, co-variance analysis test was used.

The students taught through metacognitive method predicted the time needed to do their assignments. They collected data about the research they had to do, formed working groups when necessary, and used self-regulative behaviors very much.

Table 2: co-variance analysis for the effect of teaching through metacognitive method on increasing the programming

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sum of Squares</th>
<th>Degree of Freedom</th>
<th>Mean of Squares</th>
<th>f</th>
<th>Level of Meaningfulness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching Method</td>
<td>1475</td>
<td>1</td>
<td>1475</td>
<td>170.8</td>
<td>0.001</td>
</tr>
<tr>
<td>Pre-test</td>
<td>91.5</td>
<td>1</td>
<td>91.5</td>
<td>10.6</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Regarding that $P < 0.01, f = 10.6$ are for pre-test, and then the scores of the students’ pre-test in programming have a significant effect on those of their post-test. This finding supports the decision to use co-variance analysis test to control pre-test. After omitting the effect of programming score in pre-test on that of post-test, the effect of teaching through metacognitive method on increase of students’ programming became meaningful ($P < 0.001, f = 170.8$).

Consequently, teaching students through metacognitive method causes their programming in mathematics increased. After teaching, mean of programming for the metacognitive group and the traditional group was 17.2 and 12.27, respectively.

Hypothesis 2; teaching students through metacognitive method causes their self regulation in mathematics increased

To answer the above hypothesis to control the pre-test, co-variance analysis test was used, too.

The students taught through metacognitive method could intelligently achieve certain goals. In general, metacognitive skills caused the leading of intelligent thinking, recognizing the individual differences in self-assessment and leading of cognitive evolution and learning, executive awareness and abilities using experiences, strategic and structure-based thinking in this group of students. They did not wait for their teacher to help them in solving mathematic problems and they themselves were to begin first. In order to better understand the subject matter, they benefited their observations from natural environment and peripheral indoor and outdoor of the classroom and used them in solving math problems. The students continuously optimized their performance and gained the ability to turn back and examine the process of problem solving through consecutive exercises.

Table 3: co-variance analysis for the effect of teaching through metacognitive method on increase of self-regulation
The score of the self-regulation pre-test of students on their post-test had no meaningful effect ($P < 0.05, f = 3.44$), consequently, to answer the above hypothesis co-variance analysis test was not used. The different score of self-regulation between pre-test and post-test was calculated and after that, $t$-test was used to examine the effect of teaching through metacognitive method on increase of the students’ self-regulation in independent groups.

Table 4: the results of $t$-test to examine the effect of teaching through metacognitive method on increase of the students’ self-regulation

<table>
<thead>
<tr>
<th>Variable</th>
<th>mean difference in traditional group</th>
<th>mean difference in metacognitive group</th>
<th>$t$</th>
<th>degree of freedom</th>
<th>level of meaningfulness</th>
</tr>
</thead>
<tbody>
<tr>
<td>self-regulation</td>
<td>4.4</td>
<td>15.6</td>
<td>8.6</td>
<td>28</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Variance of the difference of score of self-regulation between pre-test with post-test in both groups had no significant differences ($P > 0.05$). $t$-test showed a significant difference between two groups. That is, teaching students through metacognitive method causes their self-regulation in mathematics increased. The mean difference in traditional group and metacognitive group was 4.4 and 15.6, respectively.

Hypothesis 3: Teaching students through metacognitive method causes their learning control in mathematics increased.

To answer to the above hypothesis, co-variance analysis test was used to control the effect of pre-test. As the results of the research show, there is a tangible difference in the dimensions of metacognition in experimental group in comparison with the traditional group. Among metacognitive strategies, programming and self-controlling are used more other metacognitive strategies by students. The students, whom were taught through metacognitive method, if their learning were incomplete, would promote their learning up to a desired and expected level by solving various problems. They would determine their learning level regarding the objectives of the subject matter and compensate for its the short comings.

Table 5: co-variance analysis for the effect of teaching through metacognitive method on increase of learning control

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sum of Squares</th>
<th>Degree of Freedom</th>
<th>Mean of Squares</th>
<th>$f$</th>
<th>Level of Meaningfulness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching Method</td>
<td>1686.5</td>
<td>1</td>
<td>1686.5</td>
<td>220.4</td>
<td>0.001</td>
</tr>
<tr>
<td>Pre-test</td>
<td>57.1</td>
<td>1</td>
<td>57.1</td>
<td>7.4</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Pre-test score of the students in learning control had a significant effect on that of their post-test \((P < 0.01, f = 7.4)\). After removing the effect of learning control score in pre-test from post-test using co-variance analysis, the effect of teaching through metacognitive method on increase of learning control was significant \((P < 0.001, f = 220.4)\). Consequently, teaching through metacognitive method causes students’ learning control increased. After teaching, mean of learning control for traditional and metacognitive groups was 11.1 and 25.87, respectively.

Hypothesis 4: teaching students through metacognitive method causes their scores in mathematics increased.

To answer to the above hypothesis, \(t\)-test was used for independent groups.

To answer to the above hypothesis in order to control the effect of pre-test, co-variance analysis test was used. According to the results yielded from this research, it shows that the students’ pre-test score has a significant influence on the total score of their metacognition post-test. And after removing the effect of the total score of their metacognition in post-test from post-test, the effect of teaching method (traditionally vs. metacognitively) on the increase of total score of students’ metacognition was examined. And it can be concluded that teaching students through metacognitive method can cause their scores in mathematics increased. And the 4\(^{th}\) hypothesis was supported as well as the total mean of metacognition of metacognitively taught group in post-test was more than that of traditionally taught group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>mean difference in traditional group</th>
<th>mean difference in metacognitive group</th>
<th>(t)</th>
<th>degree of freedom</th>
<th>meaningfulness</th>
</tr>
</thead>
<tbody>
<tr>
<td>self-regulation</td>
<td>1.4</td>
<td>5.1</td>
<td>5.018</td>
<td>28</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Increase of math score in both groups has a meaningful difference \((P < 0.01, t = 5.018)\). That is, teaching students through metacognitive method causes their mathematics increased. Mean mathematic score for traditional and metacognitive groups is 15.16 and 19.33, respectively.

5. Discussion & Conclusion

One of the main objectives of education is learning to hoe learn. That is, compiling and developing a set of thinking processes that can be used in problem-solving and learning. The main goal of the present investigation is to increase our knowledge about thinking processes of students in mathematics. The results gained by this study showed that students whom were metacognitively taught use programming in learning mathematics more than those whom were traditionally taught. This finding is consistent with those of earlier researchers like, Demboo (1994), cited by Niaz; Hartman (1998); Ghorchian (1998); and Sanati (2000), cited by Azari (2003), who recognize those students successful in programming strategies, who can predict time required to do their assignments and use self-regulative behaviors very much.

It was indicated, by examining the 2\(^{nd}\) hypothesis, that students taught through metacognitive method have got a greater level of self-regulation in mathematics in comparison with those who are traditionally taught. Mean scores of self-regulation in post-test of students taught through metacognitive method increased significantly. This result is consistent with those of Cole’s (1982) and Paris & Unograde’s resraches (1990), cited by Hussei (2004). In these investigations, it has been emphasized that those who well benefited from metacognitive skills are able to supervise and guide their learning processes.
In the 3rd hypothesis, this result was gained that students who were taught through metacognitive method, in direct contrast to those who are traditionally taught, exert more learning control in learning mathematics. Garner (1994); Bucker & Brown (1984); Anderson & Keratool (2001); Miller & Brewster (1992), cited by Azari (2003), Swanson (1989); Ghorchian (1998); Karshki (2002); Carr & Punzo (1993), cited by Karshki (2002); Maag et al. (1993), cited by Karshki (2002); Zi kola et al. 91981), cited by Seif (2000); and Shapiro & Cole (1994), cited by Seif’ (2000) reported that teaching self-monitoring strategy has caused considerable changes in mathematic performance.

The 4th hypothesis’ results showed that teaching students through metacognitive method, in contrast to traditional method, causes their scores in mathematics increased. Many researchers’ findings are consistent with this gained result; for example, Parsons (1972); Keller & Loyd (1989); Albion et al. (1982); Cameron et al. (1980); Leon (1983); Thackwray et al. (1985); Holman et al.(1979); Leo et al.(1981); Shunk et al.(1986); Thackwray et al. (1985); Loons (1972); Lorenz (1972), cited by Hughes (1988); Heydari & Hamidi and Abdoos (2001); Ghasemi & Salehi (2002); Poor Noruz (1995); Sanati & Bashavard (2000); Chief Kari, Norman, ShimaMura and Mutakalif (1995) in Segool (1994), Gauge Weber Liner (1995), cited by Husseini (2004); Anderson & Keratool (2001); Igen & Kawacheck (2001); and Alexander et al., cited by Rezaee (2004). Various findings indicate that metacognitive skills play various positive roles in facilitating learning different subjects. And students, who select learning aims, also choose an orientation in doing assignment. They show more resistance facing difficulties. They assign successes to the inner and controllable reasons; take risks and embrace educational challenges while use deeply-processing strategies like; self-asking questions, summarizing, and extending. In general, the results yielded by this investigation showed that programming, self-regulation, and learning control in the group taught through metacognitive method have meaningfully considerable growth, compared with the traditionally taught group. And finally, teaching through metacognitive method causes students’ scores in mathematics increased.

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