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Investigation of the Impact of Metacognitive Education on Mathematics Educational Performance

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ABSTRACT: This research aims to measure the effect of educating met cognitive skills and mathematical educational performance of elementary school fifth graders of public school in city of Kerman. It was conducted by quasi-experimental method. Statistical population consisted of four 20-student classes from elementary school's fifth grade, which were selected by multistage cluster sampling. Then, first, research-made mathematical tests and met cognitive questionnaires, which were found to be acceptable in reliability and validity calculations, were given as pre-test to all subjects in sample groups. In test group, met cognitive skills were taught to students by trained teachers for the period of three months, and during this period, control group were left in normal condition without receiving met cognitive teaching. Then, mathematical test and met cognitive skills test were again given as pretest to the four samples. The results of final administration of questionnaires were analyzed using quantitative and qualitative methods such as covariance descriptive statistics and multivariable variance. The results suggest that teaching met cognitive skills improves mathematical performance. There is a significant difference between performance of test. group and that of control group in pretest of variables of preparation, evaluation and ordering skills. So, teaching met cognitive skills has had an effect on improvement of met cognitive skills, and all above said skills also have had an impact on improvement of mathematical educational performance. Therefore, the following functional recommendations are suggested: holding met cognitive skills training courses for teachers, launching research teams with subject of met cognition, conducting research on age groups

***Keywords*:** Meta cognitive skills, mathematics educational performance, ordering, preparation, evaluation.

INTRODUCTION

In today's world which is information explosion era, production of new information and outdating former information takes place so rapidly that books contents become outdated before being published (Mayers, translated by Abili, 1995). We live in an era in which methods and styles play decisive roles. Today's teachers must have open minds and views. They should be ready to test different educational approaches and accept new information on learning and learners. Future teachers should change their traditional viewpoints and methods. As Carl Rogers says, they should be learning facilitators and as Ckller says, they should do educational engineering. The term "metacognition" means being aware of one's learning or way of learning. Thinking and studying skills are samples of metacognitive skills. Slavin (1950; translated by SeyyedMohammadi, 2008) believes that students can be taught skills in order to be able to evaluate their understanding and realize how much time do they need for studying a particular subject and select a useful plan for dealing with learning and problem-solving. Education is aimed to improve learning abilities of students but learning is not restricted to a particular person of group an almost all activities we do across our lives are originated from our learning experiences. We learn different academic and non-academic subjects like math, literature, science, art, theology and social education. Moreover, we also learn different emotions. Preparation of a complete list of what humans learn all over their lives is almost impossible. However, two

types of skills, i.e. cognitive and metacognitive skills have been emphasized. Downing (2008) believes that metacognition also includes recognizing thinking analysis, inferring results from analysis and the way of putting what is learned into action. To solve problems effectively, students need to evaluate their minds performances. In other words, they need to understand cognitive assignments like memorizing, learning and problem-solving. Mathematics, besides an academic subject, is a way of thinking which forms based upon understanding a problem, explanation of basic problem concepts, organization and classification of necessary information and explanation of problem-solving method. In the traditional mathematics education, this area of knowledge was considered purely as a collection of realities and procedures and learners had to learn it by memorizing. However, targets like concept understanding, establishment of relationship between understanding and reasoning and utilization of exploration process in problem-solving process in order to strengthen and develop conceptual knowledge and skills are emphasized in new approaches to mathematics education. The theoretical bases of these educational approaches are cognitive theory in learning and "metacognition" psychology (Peterson, 1996; as quoted from Kadivar and KamaliZaresh, 2005).

2.Important role of metacognitive skills in education

Kadivar (2000) refers to Slavin (1994) who believes that educational psychologists emphasized on teaching special learning skills to students within the past few decades and also refers to Lefranquis (1997) who believes that learning how to learn is one of the important targets of learning and teaching process. He contends that: the relationship between metacognition and attribution styles and motivational results should also be considered by teachers who believe in cognitive viewpoint. Undoubtedly, if students are taught their failures are dependent on not studying well and adopting wrong learning methods and are not dependent on factors like chance, low talent and assignments difficulty and meanwhile they are provided with proper methods, they can achieve academic success by trying hard and being responsible for failures (Kadivar, 2000).

3.Metacognition and mathematics educational performance

There is some evidence which shows that persuading individuals to do metacognitive process results in improvement in their performances. For instance, Dominoski (1990) believes that if we manage to make individuals do executive processes like "revision", "planning", "checking" and "attention to problem features and make them do metacognitive process and solve problems on their own, their problem-solving performance will be improved and learning transfer will be observed. Learners' cognition and understanding of metacognitive processes and strategies has a considerable influence on academic progress and learning improvement in learners (Seif, 2000). Metacognitive strategies are important factors in educational performance process (Goud and Brafi, 1995). Considering the common meaning of metacognition "thinking about thinking", two important aspects of metacognition include:
1. Reflexive thinking, which refers to "what we know", 2. Self-regulation, which means "how we learn". Coordination and agreement between these two aspects results in effective learning and improvement in educational performance of learners (Mokhtari and Richard, 1998). Students' ability to do cognitive assignments has a close relationship with their ability in metacognition (Aghazadeh and Ahadiyan, 1998). Teachers should be aware of the influence of metacognitive experiences on students' successful learning (Afkildz, 2008). Mathematics education and students' progress in this major has always been a main academic challenge. Solutions like adjusting books and training teachers have been useful but it seems necessary to adopt new teaching methods and providing new strategies like metacognitive education. It is important to pay attention to metacognitive skills and processes in the present era which involves virtualization of education and learning and widespread learning resources and it is necessary to educate students so that they are able to plan, guide and control their learning process and participate in learning in a self-led process. Mathematics, besides an academic subject, is a way of thinking which forms based upon understanding a problem, explanation of basic problem concepts, organization and classification of necessary information and explanation of problem-solving method. Considering the above discussion, the present research tries to investigate the influence of metacognitive education on mathematics educational performance in primary schools students. The following hypotheses were proposed:

- Teaching metacognitive strategies is effective in increasing primary school students' educational performance.
- Teaching metacognitive strategies is effective in increasing metacognitive skills.

There is a difference between educational performance of experiment and control groups after teaching metacognitive strategies.

MATERIALS AND METHODS

Research methodology was quasi-experimental because it is aimed to investigate the influence of teaching metacognitive skills on mathematics educational performance in students of fifth grade in primary schools. Statistical population included all female and male students who studied in grade five in Kerman City public primary schools during 2011-2012 academic years. 80 of these students were selected as respondents. Multistage cluster sampling method was used for picking sample members. First, 4 schools out of Kerman public primary schools were selected at random (two boys schools and two girls schools). In the next stage, one class from each school was selected (totally 4 grade five classes). Then, two classes (one boy's class and one girl's class) were labeled as experiment group and 2 classes (one boys class and one girls class) were labeled as control group. Each class was made up of smart, average and weak students.

- Experiment group: 40 students in grade five, including 20 boys and 20 girls
- Control group: 40 students in grade five, including 20 boys and 20 girls

5.Measurement instruments

5.1 Mathematics test

One of the instruments of this paper was a teacher-made math test which was implemented for control and experiment groups in the beginning and end of the educational program as pretest and posttest. This test had 15 questions. The questions were classified into three groups based on their contents. The first group included 7 questions which were exactly extracted from book text and could be answered only by referring to memory. The second group included 5 questions which required students' inference in addition to memorizing. The third group included 3 questions which were related to students' metacognitive thinking in some manner. The questions were evaluated by several math teachers and experts and the test content validity was verified.Metacognition test also had a Chronbach's alpha equal to 92%.

5.2 Metacognition test

One of the tests which was implemented before and after survey on both control and experiment groups was metacognition test. This questionnaire contained 27 questions and was designed by AbolfazlKarami (2002). It is a translation of ISQ questionnaire. This questionnaire measures preparation, regulation and evaluation of metacognitive skills dimensions.

RESULTS AND DISCUSSION

Results

Since the main goal of this research was to compare performance of experiment and control group members in terms of educational performance variables after implementation of independent variable (teaching metacognitive strategies), covariance analysis was used for testing the hypotheses.

First hypothesis: Teaching metacognitive strategies is effective in increasing primary school students' educational performance.

Table 1. results of impacts tests on respondents (dependent variable: educational performance)

Source of variations		df	Sum of squares	F	P
groups	4/68	1	4/68	0/367	0/54
pretest	203/99	1	203/99	15/97	0/000
Groups*pretest	32/94	1	32/94	2/58	0/113
Error	919/2	72	12/76		

As it can be seen in table 1, the probability of verifying H0 for comparison of experiment and control groups' performance in educational performance test is greater than 0.05 (sig=0.113). Therefore, it can be concluded that regression slopes homogeneity hypothesis is verified.

Table 2. results of impacts tests on respondents (dependent variable: educational performance)

Source of variations	Sum of squares	df	Mean of squares	F	P	Eta square
posttest	178/31	1	178/31	13/67	0/000	0/158
groups	289/95	1	289/95	22/23	0/000	0/233
error	952/15	77	13/04			

As it can be seen in table 2, the probability of verifying H0 for comparison of control and experiment group's performance in posttest of academic performance variable has a significant influence on both groups' respondents. Therefore, it can be concluded that there is a significant difference between performances of the two groups in educational performance variable posttest. The final column of this table (eta squared) indicates determination coefficient. It can be concluded that about 23.3% (0.233) of educational performance variance is predicted by the independent variable (=teaching metacognitive strategies). Finally, it can be concluded that teaching metacognitive strategies can improve academic performance. Therefore, there is enough evidence for supporting the first hypothesis.

Second hypothesis: Teaching metacognitive strategies is effective in increasing metacognitive skills. In order to investigate the impact of teaching metacognitive strategies on increasing the application of metacognitive skills, first we should have used MANCOVA statistical method but because Wilkz Lambda index was not significant (value=0.979, $F_{(3, 61)}$=0.432, p>0.05), we were not allowed to use MANCOVA. Therefore, first we conducted multivariate regression on posttest and then we conducted a MANCOVA analysis on remaining points (error). Results showed that Wilkz Lambda index is significant (value=0.251, $F_{(3, 74)}$=73.72, p<0.01). Results of analyzing difference between control and experiment groups in each sub-constructs (planning, evaluation, regulation) revealed that F value is significant in all three cases. The results are summarized in table 3.

Table 3. Results of multivariate variance analysis test for metacognitive strategies dimensions

Source of variations	dimensions	Sum of squares	df	Mean of squares	F	P	Eta square
groups	planning	18722/146	1	18722/146	197/163	0/000	0/722
	evaluation	20473/555	1	20473/555	219/647	0/000	0/743
	regulation	1034/023	1	1034/023	119/889	0/000	0/612
error	planning	7216/778	76	94/958			
	evaluation	7084/053	76	93/211			
	regulation	655/49	76	8/625			

As it can be seen in table 3, there is a significant difference between experiment and control groups performance in posttest for planning, evaluation and regulation variables. The final column of this table (eta squared) indicates determination coefficient. It can be seen that about 72.2% (0.722) of the variance of planning dimension can be predicted by the independent variable (teaching metacognitive strategies). Similarly, 74.3% of evaluation dimension and 61.2% of regulation dimension can be predicted by the independent variable i.e. metacognition strategies. Therefore, there is enough evidence for supporting the second hypothesis.

Third hypothesis: There is a difference between educational performance of experiment and control groups after teaching metacognitive strategies.

Table 4. results of impacts tests on respondents and gender (dependent variable: educational performance)

Source of variations	Sum of squares	df	Mean of squares	F	P
groups	46/58	1	46/58	5/58	0/021
gender	2/45	1	2/45	0/28	0/58
pretest	153/06	1	153/06	18/34	0/000
Groups*gender	6/59	1	6/59	0/79	0/37
Groups*posttest	0/713	1	0/713	0/085	0/77
Gender*posttest	57/83	1	57/83	6/93	0//01
Groups*posttest*gender	0/77	1	0/77	0/092	0/76
error	567/49	68	12/76		

As it can be seen in table 4, the probability of verifying H0 for comparison of experiment and control groups' performances in terms of gender is greater than 0.05 in academic performance posttest (sig=0.76). Therefore, it can be concluded that regression slopes homogeneity hypothesis is verified.

Table 5. results of impacts test on respondents in terms of gender (dependent variable: educational performance)

Source of variations	Sum of squares	df	Mean of squares	F	P	Eta square
posttest	210/2	1	210/2	23/63	0/000	0/25
groups	303/07	1	303/07	34/07	0/000	0/32
gender	245/58	1	245/58	27/6	0/000	0/28
Groups*gender	69/77	1	69/77	7/84	0/007	0/09
error	952/15	71	8/89			

As it can be seen in table 5, the probability of verifying H0 for comparison of experiment and control groups' performances in terms of gender in educational performance variable posttest, has a significant impact on interaction between female and male respondents in experiment and control groups. Therefore, it can be concluded that there is a significant difference between the two groups' members' performances in educational performance variable posttest in terms of gender and experiment group's girls had a better performance than boys. The final column of this table (eta squared) indicates determination coefficient. It can be seen that about 9% (0.09) of the variance of educational performance is determined by interaction between independent variable (=metacognition strategies teaching) and gender. Finally, as evidence reveals, it can be concluded that teaching metacognitive skills can improve educational performance. Therefore, there is enough evidence for supporting the first hypothesis.

7.Conclusion and discussion

Metacognitive skills are very valuable for achieving success in learning and problem-solving and educational progress. A student's ability to solve mathematical problems is facilitated by metacognitive interventions by teachers. Succeeding to solve a mathematical problem does not purely depend on having enough knowledge about problem-solving but also depends on the level of metacognitive knowledge. Considering the first hypothesis,teaching metacognitive skills improves primary school students' educational performance. We found that the probability of verifying H0 for comparison of control and experiment groups' performance in educational performance pretest is greater than 0.05. Therefore, it can be concluded that regression slopes homogeneity hypothesis is verified. Considering the scattering graph, there is some kind of linear relationship between the two variables. Further, regression lines slopes are almost parallel. Moreover, R squared values reveal the degree and intensity of relationship between dependent variable scores and posttest scores. Considering the results of impacts tests on respondents (dependent variable: educational performance) the probability of verifying H0 for comparison of experiment and control group performances in posttest of educational performance variable, has a significant impact on the two groups respondents. Therefore, it can be concluded that there is a significant difference between the two groups' members' performance in educational performance variable posttest. Considering the evidence, it can be said that teaching metacognition skills can increase educational performance. Result of this hypothesis test conforms to the results of former studies. These studies include: Kar and Joor investigated the impacts of metacognition skill on mathematics educational performance in 71 students in 1995. Alexander (1994) found also similar results. Further, Mourach (1995) conducted a similar study in which 32 children received a series of metacognitive teachings in order to be prepared both for going to school and improving their mathematics. Results showed that metacognition had a considerable influence on children academic performance. In the second hypothesis, first we should have used MANCOVA statistical method in order to investigate the influence of teaching metacognitive skills on improvement of application of metacognitive skills. However, because Wilkz Lambda index was not significant (Value=0.979, $F(3.61)=0.432$, $p>0.05$), we were not allowed to use MANCOVA. Therefore, we conducted multivariate regression on the posttest and then we conducted MANCOVA analysis on the remaining scores (error). Results showed that Wilkz Lambda index is significant (value=0.251, $F(3/74)=73.72$, $p>0.01$). results of investigation of the difference between experiment and control groups in each of the sub-constructs of metacognitive skills (preparation, evaluation and regulation) showed that in all three sub-constructs, F value is significant. Considering the results of multivariate variance analysis test results for metacognitive skills, it can be said that there is a significant difference between experiment and control groups' performances in preparation, evaluation and regulation variables posttests. It can be seen that about 72.2% (0.722) of the variance of preparation skills is explained by the independent variable i.e. teaching metacognitive skills. Similarly, 74.3% (0.743) of evaluation skills variable and 61.2% (0.612) of regulation variable is predicted by the independent variable. Laken GoliTelarini (1998) also conducted a similar research titled: the influence of metacognitive skills and planning, evaluation and regulation dimensions on math learning in students who study at grades 3 to 8. His results showed that students progressed considerably in metacognitive skills like planning, evaluation and regulation. Kapa and Movarch (1996) gave teaching on metacognitive knowledge dimensions like preparation, evaluation and regulation to students of grade 5 in primary schools. He concluded that students who received the lessons improved in mathematical problem-solving and achieved higher marks. For the case of the third hypothesis, there was some kind of linear relationship between posttest and pretest scores (dependent variable: educational performance). Further, regression lines slopes were also almost parallel. Moreover, R squared value indicates the degree of relationship between dependent variable scores and posttest scores. In the table of impacts tests on respondents in terms of gender (dependent variable: educational performance), it was observed that the probability of verifying H0 for comparison of control and experiment groups' performance in terms of gender in educational performance variable posttest, interaction between boy and girl tests in control and experiment groups has a significant impact. Therefore, it can be concluded that there is significant difference between

the two groups'members' performance in educational performance variable posttest in terms of gender and experiment group's girls had a better performance than boys.

8. Summation

Results showed that metacognitive skills teaching program has a significant influence on educational performance in mathematics. As it was said, students who discussed in small 4-5 membered groups and evaluated solutions and compared each assignment with former problems and also revised their learning metacognitive processes got better grades in mathematics than students of the control group who did not receive any kind of metacognition skills education. Delklas and Harington (1991) believe that when a learner reviews progress process especially when learning is difficult improves learning. Increase in experiment group students' math marks was not obtained due to spending more time on study and their educational and class hours was unchanged. These results conform to that of previous studies. As it was said before, teaching mathematics using metacognitive skills can help students with performing more actively in mathematics learning and understanding mathematical problems well. Flowel (1985) believes that many students have metacognitive defects. In other words, they have a basic knowledge of particular subject and major but they do not know how to use that knowledge. Results of the present research showed that cooperation, reasoning, thinking and analysis can help understand mathematics rather than memorize it and learn how to learn. A cooperative learning environment provides an opportunity for discussion and reasoning on solutions and asking for help from others. Therefore, it grows metacognition in students.

Recommendations:

1. The main result of the research was that teaching metacognitive skills improves mathematics understanding. Therefore, it is recommended to hold metacognition skills training classes for free for teachers and make managers to persuade teachers to teach metacognitive skills.

Managers are advised to form research groups in schools for working on metacognition skills in order to familiarize teachers with metacognition teaching.

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