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The Effect of Metacognitive Strategy Training on Student Mathematical Problem Solving Process and Contemplative Thinking Skills in Primary School Children with Learning Disabilities

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Abstract

The Purpose of this study was to explore the effect of a metacognitive strategy training on mathematical problem solving process and contemplative thinking skills of primary school children with learning disabilities. The participants in this study were Forty grade five students identified with LD. A pre- post design was used to examine the effectiveness of the metacognitive instructional approach of Strategies Program for Effective Learning and Thinking (SPELT) on mathematical problem solving process and contemplative thinking skills of the target children . Findings from this study indicated the effectiveness of the metacognitive instructional approach of Strategies Program for Effective Learning and Thinking (SPELT) on mathematical problem solving process and contemplative thinking skills of the target children. On the basis of the findings, the study advocated for the effectiveness of metacognitive instructional approach of Strategies Program for Effective Learning and Thinking (SPELT) on mathematical problem solving process and contemplative thinking skills of the target children.

Keywords: metacognitive strategy, mathematical problem solving process, contemplative thinking skills, learning disabilities

Introduction

Metacognition (Flavell 1979; Kuhn 2000; Veenman 1993; O'Neil and Abedi 1996 Mourad Ali, 2010; Saada, 2013) refers to two aspects, namely the students' self-awareness of a knowledge base in which information is stored about how, when, and where to use various cognitive strategies and their self-awareness of and access to strategies that direct learning (e.g. monitoring difficulty level, a feeling of knowing). This awareness is developmental and lies on a continuum. Proficient readers use one or more metacognitive strategies to comprehend texts. There are three main aspects of metacognition: metacognitive knowledge, metacognitive monitoring, self regulation and control (Pintrich, Wolters and Baxter 2000). The first group consists of cognitive learning strategies which the learner uses to regulate the process of knowledge acquisition. These include, for example, elaboration strategies such as the building of links to prior knowledge, or memory strategies such as note taking. The second group consists of metacognitive control strategies. Central here are activities like the planning and monitoring of learning activities, the evaluation of learning outcomes and the adaptation to varying task demands and (unexpected) difficulties, for example, an increase in directed efforts. In addition to these two groups, which are dominant in research and crucial for the learning process, a third group of strategies in the model developed by Pintrich and Garcia (1994) is dedicated to resource management. These strategies are concerned with the control of the general conditions associated with learning, for example, time management and management of the learning environment.

The following two key questions students need to ask themselves are crucial in terms of metacognitive awareness and knowledge:

1. What do I want out of this? (What are my motives?)
2. How do I propose going about getting there? (What are my strategies?)

(Biggs & Moore 1993).

Metacognition appears to function as a vital element contributing to successful problem solving by allowing an individual to identify and work strategically (Mourad Ali, 2009). According to O`Malley and Chamot (1990), meta-cognitive strategies are higher order executive skills that may entail planning for, monitoring, or evaluating the success of a learning activity meta-cognitive strategies operate directly on informing information, manipulating it in ways that enhance learning. Similar definitions have been given by other researchers in this field (Yin and Agnes, 2001; Shokrpour and Fotovatian, 2009; Carrell, et al, 1998; Chamot 2005).

Metacognition and problem solving

Many psychologists assert that problem-solving is the highest level of thinking or learning skills. Crucial to problem-solving ability are the learner's cognitive and metacognitive skills. There has been extensive research on cognition and metacognition in mathematics problem-solving with learning disabled students (Borkowski, Estrada, Milstead, & Hale, 1989; Case, Harris, & Graham, 1992; Montague & Bos, 1986; Slife et al., 1985), with elementary and junior high school students (Charles & Lester, 1984; Montague, 1991; Okamoto & Kitao, 1992), and with gifted and learning disabled students (Garofalo, 1993; Montague, 1992,1993).

Failure in problem solving is generally resulted from failing to organize the mathematical operations, to choose the most effective method, to analyze, to understand the point of problem and to monitor and control operations carried out (Victor, 2004). It is a known fact that students with high metacognitive skills perform better in problem solving (Desoete, Roeyers & Buysse, 2001; Schoenfeld, 1985; Lester, 1994). It has been observed that during problem solving process they are more controlled; they try to break the complex problems into simple parts and they ask questions themselves for clarifying their thoughts. Schoenfeld (1985) states that when one encounter with failures in problem solving techniques, control skills (metacognition) will be helpful for applying strategies successfully (Gökhan& Aysegül, 2009)

Metacognition and contemplative thinking skills

Contemplative thinking interacts with most thinking patterns. Moreover, every step of critical thinking, problem-solving method and deduction- as other thinking patterns- generally include contemplative thinking that cannot be dispensed with since it helps recognize different aspects of the situation and disambiguate it. Therefore, it becomes easier to come up with scientific conclusions that help find reasonable solutions for the problems. Based on what we have presented so far, contemplative thinking can, then be defined as mental process that individuals take during encountering a particular problem or addressing a certain subject. Contemplative thinking, thus, enables them to set hypotheses, present reasonable interpretations and suggest solutions so that they can recognize the consequences of the problem and analyze its components which, in turn, will lead to solving that problem or situation. Dewey put three essential keys to prepare individuals for contemplation: open mind, self-motivation, and responsibility. It was found out that contemplative thinking passes through three stages: Reflection for action, reflection in action, and reflection on action(Jamal Al-Khaldi & Mohammed Awamreh, 2012).

The purpose of the present study was to examine the extent to which metacognitive strategy training can be used to improve mathematical problem solving process and contemplative thinking skills of primary school children with learning disabilities. The primary research question was, what effects will metacognitive strategy training have on mathematical problem solving process and contemplative thinking skills of primary school children with learning disabilities?

Method

Participants

Forty grade five students identified with LD were invited to participate. Each student participant met the following established criteria to be included in the study: (a) a diagnosis of LD by teacher's references, and learning disabilities screening test (Kamel, 1990) (b) an IQ score on the Mental Abilities Test (Mosa, 1989) between 100 and 116 (c) absence of any other disabling condition. The sample was randomly divided into two groups; experimental (n= 20 boys) and control (n=20 boys).

The two groups were matched on age, IQ, achievement and attitude tests. Table 1. shows means, standard deviations ,t-value, and significance level for experimental and control groups on age (by month) , IQ, mathematical problem solving process and contemplative thinking skills (pre-test).

Table 1. *Pre-test Means, standard deviations, t- value, and significance level for experimental and control groups on age (by month), IQ, mathematical problem solving process and contemplative thinking skills .*

Variable	Group	N	M	SD	T	Sig.
Age	Experimental	20	130.80	2.25	.618	-
	Control	20	130.55	2.76		
IQ	Experimental	20	114.15	2.38	-.816	-
	Control	20	115.25	3.49		
mathematical problem solving process	Experimental	20	52.15	2.00	.488	-
	Control	20	50.40	1.87		
contemplative thinking skills	Experimental	20	99.85	1.46	-.393	-
	Control	20	102.35	2.13		

Table 1 shows that al t-values did not reach significance level. This indicated that the two groups did not differ in age, IQ , mathematical problem solving process and contemplative thinking skills (pre-test).

Instruments

Mathematics Problem-Solving Process Questionnaire (MPSPQ).(Doehee, 1998). This questionnaire consisted of a 5-point, Likert-type format of 24 items mainly drawn from the Problem-Solving Questionnaire (Mulcahy, 1987) as a general measure of students' perceptions of problem-solving strategies .The Likert-scale ranged from "describes me very well", "describes me well", "describes me somewhat", "does not really describe me" to "does not describe me at all." The 24 items are classified into four groups. The first three groups are components of the cognitive process involved in mathematics problem-solving (i.e., orientation, organization, execution). The fourth group is a component of the metacognitive process involved in mathematics problem solving (Le., verification) as suggested by Flavell (1985) and Lester (1985). With regard to the measure of internal consistency, Cronbach's alpha for the MPSPQ was estimated to be -80, indicating a high degree of reliability. The maximum score for the MPSPQ was 120.

Contemplative Thinking Skills Scale(Jamal Al-Khaldi & Mohammed Awamreh, 2012). This scale consisted of a 5-point, Likert-type format of 36 items The Likert-scale ranged from "describes me very well", "describes me well", "describes me somewhat", "does not really describe me" to "does not describe me at all.". With regard to the measure of internal consistency, Cronbach's alpha for the scale was estimated to be .87, indicating a high degree of reliability. The maximum score for the scale was 180.

Procedure

The metacognitive instructional approach of Strategies Program for Effective Learning and Thinking (SPELT) was used in the teaching of two strategies in this study. The metacognitive nature of SPELT is reaüzed in its training techniques. SPELT combines two types of training as identified by Brown and Palincsar (1982. as cited by Mourad Ali, 2010). It is an 'Informed Training" (explicit instruction in strategies and their use) and a 'Self-Control Training" (explicit instruction in planning, monitoring and evaluating strategy use) program as opposed to 'Blind Training (students are taught strategies with no explanations as to why, where or when). The program is comprised of three phases (Mourad Ali, 2010, Amaal Ahmed Mostafa, 2014). Phase I, Direct Teaching of Strategies, requires the teacher to introduce students to the benefit and use of strategies. Strategies are taught directly to students: students are Med, and reminded and prompted to use strategies. This is teacher-imposed strategy instruction. in Phase II, Maintenance, Evaluation and Generalization of Strategies, students continue to use the strategies, but also evaluate their strategy use and use the strategies in different subjects or settings. Students begin to take a more active role in their learning during this phase. Phase III, Strategy Generation by Students, necessitates complete student involvement in utilizing, monitoring, evaluating and generating strategies. Students progress from being passive to active learners, self-regulating their learning and performance. Students received 3 training sessions a week, lasting between 40 and 45 min. Instruction took place in the regular classroom in order to naturalize the situation.

Results

Table 2. shows data on ANCOVA analysis for the differences in post- test mean scores between experimental and control groups in mathematical problem solving process test scores. The table shows that the (F) value was (146.793) and it was significant value at the level (0.01).

Table 2. *ANCOVA analysis for the differences in post- test mean scores between experimental and control groups in mathematical problem solving process test scores*

Source	Type 111 sum of squares	df	Mean square	F	Sig.
Pre	59.285	1	59.285		
Group	16944.693	1	16944.693	146.793	0.01
Error	4271.015	37	115.433		
Total	21222.400	39			

Table 3. shows T test results for the differences in post-test mean scores between experimental and control groups in mathematical problem solving process test. The table shows that (t) vale was (12.175). This value is significant at the level (0.01) in the favor of experimental group. The table also shows that there are differences in post- test mean scores between experimental and control groups in mathematical problem solving process test in the favor of experimental group.

Table *3. T- test results for the differences in post- test mean scores between experimental and control groups mathematical problem solving process test*

Group	N	Mean	Std. deviation	T	Sig.
Experimental	20	96.25	1.79	12.175	0.01
Control	20	55.15	2.01		

Table 4. shows data on ANCOVA analysis for the differences in post- test mean scores between experimental and control groups in contemplative thinking skills test scores. The table shows that the (F) value was (19.431) and it was significant value at the level (0.01).

Table 4. *ANCOVA analysis for the differences in post- test mean scores between experimental and control groups in contemplative thinking skills test scores*

Source	Type 111 sum of squares	df	Mean square	F	Sig.
Pre	839.081	1	839.081		
Group	5610.475	1	5610.475	19.431	0.01
Error	10683.469	37	288.742		
Total	16881.775	39			

Table 5 shows T. test results for the differences in post- test mean scores between experimental and control groups in contemplative thinking skills test. The table shows that (t) vale was (4.204). This value is significant at the level (0.01) in the favor of experimental group. The table also shows that there are differences in post- test mean scores between experimental and control groups in contemplative thinking skills test in the favor of experimental group.

Table 3. *T- test results for the differences in post- test mean scores between experimental and control groups thinking skills test*

Group	N	Mean	Std. deviation	T	Sig.
Experimental	20	128.00	1.02	4.204	0.01
Control	20	104.85	2.11		

Discussion

The purpose of the present study was to examine the extent to which metacognitive strategy training can be used to improve mathematical problem solving process and contemplative thinking skills of primary school children with learning disabilities. Participants were selected, then pretest data were collected using mathematical problem solving process and contemplative thinking skills(pre-test). The metacognitive instructional approach of Strategies Program for Effective Learning and Thinking (SPELT) was used in the teaching of two strategies in this study. Students received 3 training sessions a week, lasting between 40 and 45 min. Instruction took place in the regular classroom in order to naturalize the situation.

The results of this study as revealed in tables 3, 5, show that the metacognitive instructional approach of Strategies Program for Effective Learning and Thinking (SPELT) was effective in improving mathematical problem solving process and contemplative thinking skills of the target students in experimental group, compared to the control group whose individuals were left to be taught in a conventional way .

Participants of this study fall into IQ of 114 or more, nevertheless, they are learning disabled. Thus IQ score cannot account for learning disabilities. The results of the present study support that conclusion with evidence that students who participated in the study do not fall into the low IQ range, however they have learning disability. When designing a program based on the metacognitive instructional approach of Strategies Program for Effective Learning and Thinking (SPELT), they had statistical increase in mathematical problem solving process and contemplative thinking skills. This goes in line with what Mourad Ali et al (2006) notes that there is one problem " students who are identified as learning disabled often cover any special abilities and talents, so their weakness becomes the focus of their teachers and peers, ignoring their abilities. Mourad Ali (2007) , however, notes that " learning disabled, as well as gifted students can master the same contents and school subjects", but they need to do that in a way that is different from that used in our schools.

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