INTERACTIVE EFFECT OF META-COGNITIVE STRATEGIES-BASED INSTRUCTION IN MATHEMATICS AND SELF-EFFICACY OF STUDENTS ON THEIR META-COGNITIVE AWARENESS

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This paper attempts to ascertain the interactive effect of meta-cognitive strategies-based instruction in mathematics and self-efficacy on meta-cognitive awareness of students. For this purpose, an *intervention programme based on meta-cognitive strategies of about 35 hours was developed for students of standard eighth spreading over eight weeks. The aim of the research was to ascertain whether meta-cognitive strategies-based instruction facilitates the meta-cognitive awareness of students, and if so, for which level of self-efficacy of students. Structured tools were used in study. The participants of the study included 62 and 60 students in the experimental and control groups respectively. Students were found to be significantly influenced by the intervention programme as well as their self-efficacy. The effect size of the intervention programme on meta-cognition of students was found to be 0.64 which is moderate in magnitude and that of the self-efficacy was found to be 1.20 which is high in magnitude. It also needs to be mentioned that a students' self-efficacy had an effect on their meta-cognitive awareness.*

Keywords: meta-cognitive strategies, self-efficacy, meta-cognitive awareness

INTRODUCTION

Meta-cognition is a model of cognition, which acts at a meta-level and is related to the object-world, through the monitoring and control functions (Efklides, 2001). Meta-cognition is a regulatory system that helps a person understand and control his or her own cognitive performance. It allows people to take charge of their own learning. It involves awareness of what they know, understanding what they need to know for a certain task, how they learn, how to use their current skills to learn what they do not know, generating strategies to meet these needs and then implementing the strategies.

Bandura (2000) stated that the sense of self-efficacy is concerned with the belief that a person is having about his/her ability to organize the sequence of correct actions to achieve certain results and to succeed in a particular situation. Students who have a high sense of self-efficacy tend for example, to identify key objectives and are willing to make use of all their hard work and perseverance to achieve them. In contrast, students with low sense of self-efficacy are vulnerable to anxiety and are not able to conduct their own studies.

Thus, meta-cognitive strategies-based instruction is expected to enable a student to understand and control his or her own cognitive processes whereas self-efficacy enables a student to view challenging problems as tasks to be mastered, develop deeper interest in the activities in which they participate, form a stronger sense of commitment to their interests and activities

and recover quickly from setbacks and disappointments. Both are therefore expected to influence students' meta-cognitive awareness.

Rationale of the Study

The essence of meta-cognition is awareness of one's cognitive processes, as well as an ability to develop a plan for achieving a goal and evaluating one's effectiveness of reaching that goal. The importance of meta-cognition for high quality learning and problem solving is widely accepted. The ultimate goal of a mathematics teacher is to enhance the knowledge of and performance in mathematics of a student. If a student's meta-cognitive awareness is high, he/she will be more strategic and will perform better than those with low meta-cognitive awareness, allowing individuals to plan, sequence and monitor their learning in a way that directly improves performance. Thus, in order to facilitate mathematics learning, it is essential to enhance meta-cognitive awareness of students (Young & Fry, 2008). It is expected that meta-cognitive strategies-based instructional programme would enhance meta-cognitive awareness of students. Moreover, self-efficacy is the measure of one's own ability. It is expected to enhance the perseverance of a student. If a student's self-efficacy is high, it is likely to enable him/her to complete tasks and reach goals. Besides, if such a student is taught to share his/her difficulties with peers to solve problems and regulate their academic work, their meta-cognitive awareness is likely to be high. Previous research suggests that self-efficacy may affect academic performance when combined with other factors; including working memory and metacognition (Hoffman & Schraw, 2009; Hoffman & Spatariu, 2008; Landine & Stewart, 1998). There is ample research on the relationship between self-efficacy and performance as well as between meta-cognitive awareness and performance. However, the link between effect of self-efficacy and meta-cognitive strategies-based instruction on meta-cognitive awareness is missing. It is therefore expected that the meta-cognitive strategies-based instructional programme will interact with the self-efficacy of a student and will have a combined effect on a student's knowledge concerning his/her own cognitive processes.

Review of Related Literature on Meta-cognitive Awareness and Self-Efficacy

Schraw (1998) studied two aspects of meta-cognition, knowledge of cognition and regulation of cognition, and how they are related to domain-specific knowledge and cognitive abilities. Four instructional strategies are described for promoting the construction and acquisition of meta-cognitive awareness. These include promoting general awareness, improving self-knowledge and regulatory skills, and promoting learning environments that are conducive to the construction and use of meta-cognition. Tobias and Everson (2002) completed 23 studies of knowledge monitoring and its relationship to learning from instruction. The work reported here attempts to address a number of general issues, e.g., the domain specificity of knowledge monitoring, measurement concerns, and the relationship of knowledge monitoring to academic ability. Hoffman and Spatariu (2008) studied a regression design which was used to test the unique and interactive effects of self-efficacy beliefs and meta-cognitive prompting on solving mental multiplication problems while controlling for mathematical background knowledge and problem complexity. Problem-solving accuracy, response time and efficiency (i.e. the ratio of problems solved correctly to time) were measured. Before solving a series of multiplication problems, participants were randomly assigned to either a prompting or control group. Findings suggested that self-efficacy and meta-cognitive prompting increased problem-solving performance and efficiency separately through activation of reflection and

strategy knowledge. Educational implications and future research are suggested. Wei (2008) conducted a study based on the theories of meta-cognition and learner autonomy, and by analyzing the relationship between meta-cognitive awareness training and learner autonomy theoretically and statistically, the paper argued that in ELT (English Language Teaching) meta-cognitive awareness training should go before the training of meta-cognitive strategies, and only when students are conscious about meta-cognitive awareness can they strengthen their effort, motivation and persistence, seek assistance from peers and teachers when needed, and provide self-instruction while learning and take responsibility for their learning. Maghsudi and Talebi (2009) studied cognitive versus meta-cognitive strategies. The major aim of the study was to find out whether being mono or bilingual has any impact on the awareness and use of meta-cognitive, cognitive and total cognitive meta-cognitive strategies with respect to students' proficiency levels. The researchers found that mono and bilingual students differed significantly in their cognitive, meta-cognitive as well as total cognitive meta-cognitive strategy scores, meaning that bilinguals had significantly higher scores than monolingual students. Further, students with high proficiency had significantly higher scores than students with low proficiency in their cognitive, meta-cognitive and also total cognitive/meta-cognitive strategies. Jadhav (2012) studied meta-cognition in areas of school success. Jayaprabha (2013) conducted a study aimed at examining the effects of inquiry based learning and co-operative learning on meta-cognitive awareness in science class room. A quasi experimental design involving three groups namely, two treatment groups- inquiry based learning and co-operative learning and control group was adopted. Standardized tool developed by Schraw and Dennison (1994) was used to measure meta-cognitive awareness in three groups. Results revealed that students in co-operative learning received higher meta-cognitive awareness compared to other groups. Aurah, Cassady & McConnell (2014) studied predicting problem solving ability from meta-cognition and self-efficacy beliefs on a cross validated sample. Grounded in social cognitive theory of self-efficacy and self-regulation, this study examined the influence of meta-cognition and self-efficacy beliefs on genetics problem solving ability among high school students in Kenya using a quasi-experimental research design. The study was conducted in Western Province, Kenya. A total of 2,138 high school students were purposively sampled. Findings revealed that meta-cognition and self-efficacy significantly predicted genetics problem-solving ability. Furthermore, self-efficacy moderated the relationship between meta-cognition and genetics problem-solving ability.

Need of the Study

Meta-cognition enables students to benefit from instruction (Carr, Kurtz, Schneider, Turner & Borkowski, 1989) and influences the use and maintenance of cognitive strategies. While there are several approaches to meta-cognitive instruction, the most effective involve providing the learner with both knowledge of cognitive processes and strategies (to be used as meta-cognitive knowledge), and experience or practice in using both cognitive and meta-cognitive strategies and evaluating the outcomes of their efforts (develops meta-cognitive regulation). Landine and Stewart (1998) showed that a positive relationship existed between meta-cognition, self-efficacy, and motivation. Downing (2009) found that meta-cognition was used as coping strategy and that when an individual failed in their coping it led to decreased self-efficacy, which ultimately had a negative effect on learning.

Operational Definitions of the Terms

Meta-cognition: Meta-cognition refers to a learner's awareness of his/her own knowledge and cognitive processes and ability to understand, control and manipulate his/her own cognitive processes.

Meta-cognitive Strategies: Meta-cognitive strategies refers to methods used to help students understand the way they learn and refers to the processes designed for students to manage, monitor and evaluate their learning and 'think' about their 'thinking'.

Meta-cognition Awareness: Meta-cognition awareness is ability of a student's knowledge concerning one's own cognitive processes.

Self- Efficacy: Self-efficacy is the measure of one's own ability to complete tasks and reach goals.

Statement of the Problem: Interactive Effect of Meta-cognitive Strategies-based Instruction in Mathematics and Self-Efficacy of Students on their Meta-cognition Awareness

Scope and Delimitations of the Study

In the present study, English medium schools from the Greater Mumbai affiliated to the SSC board have been included. It excludes schools with other media of instruction such as Marathi, Hindi, Urdu, Gujarati etc. The present study includes eighth standard students from English medium schools situated in Greater Mumbai. Students from other primary and secondary classes have been excluded. It also excludes schools affiliated to ICSE or CBSE boards.

The present research studies interactive effect of meta-cognitive strategies-based instructional mathematics and self-efficacy on meta-cognition awareness of students. It has adopted the quantitative approach to the study rather than the qualitative approach.

Aim of the Study

To ascertain the interactive effect of the intervention programme and self-efficacy of students on their meta-cognitive awareness.

Objectives of the Study

1. To ascertain the interactive effect of the intervention programme and self-efficacy on meta-cognitive awareness of students.
2. To compute the effect size of the intervention programme and self-efficacy on meta-cognitive awareness of students.

Research & Null Hypothesis of the Study

H_1: There is a significant the interactive effect of the intervention programme and self-efficacy on meta-cognitive awareness of students.

H_o: There is no significant the interactive effect of the intervention programme and self-efficacy on meta-cognitive awareness of students.

METHODOLOGY OF THE PRESENT STUDY

The study has adopted the quasi- experimental method. In the present research, the quasi-experimental design of the pre- test post-test, non-equivalent group type was used. It can be described as follows:

The pre-test-post-test non-equivalent groups design:

$O_1 X O_2 \quad O_3 C O_4$

Where,

O_1 and O_3: Pre-test Scores & O_2 and O_4: Post- test Scores

X: Experimental Group & C: Control Group

Sample of the Study

In the present study, the sample has been selected consisting of one intact class each of standard eighth from two different schools situated in the Greater Mumbai. The experimental and the control groups included 62 and 60 students respectively. The schools were selected using simple random sampling technique (lottery method) from a list obtained from Department of Education Mumbai.

Tool of the Study

In the present study following tools was used by the researcher to collect data:

1. Self-Efficacy (Muris, 2001)

2. Meta-cognitive Awareness Inventory (Schraw & Dennison, 1994).

Intervention Programme

The duration of the intervention programme is 35 hours. The control group was taught using the traditional method. The experimental group was taught using intervention programme, which was divided into two levels. The first level included knowledge about cognition, which was ascertained through KWL chart and the second level included regulation about cognition which consisted of three steps, namely, planning (understanding the problem, devising a plan, carrying out the plan and looking back), monitoring (self-awareness of one's thought processes), control (self-monitoring of one's thought processes, beliefs and intuitions about one's cognition) and evaluation (problems on the topic and self -reflection sheet). The three step process is explained further using the following questions: (a) **Planning:** What is the nature of the task? What is my goal? What kind of information and strategies do I need? How much time and resources do I need? (b) **Monitoring:** Do I have a clear understanding of what I am doing? Does the task make sense to me? Am I reaching my goals? Do I need to make changes? and (c) **Evaluating:** Have I reached my goal? What worked? What didn't work? Would I do things differently the next time? The meta-cognitive strategies included in the study were (a) Knowledge about cognition, (b) Regulation about cognition, (c) Ask questions, (d) Foster Self-reflection, (e) Encourage self-questioning, (f) Think aloud and (g) Self-explanation. The teaching units were selected from the syllabus prescribed for the schools affiliated to the SSC board for the state of Maharashtra and included the topics on Cube, Indices, Construction of Quadrilateral, Joint Bar Graph and Discount and Commission.

TECHNIQUES OF DATA ANALYSIS

The present research used statistical techniques of ANOVA and Wolf's formula.

Data Analyses

Null Hypothesis 1: There is no significant the interactive effect of the intervention programme and self-efficacy on meta-cognitive awareness of students.

This hypothesis was tested using two-way ANOVA in which the pre-test scores of students is controlled. The following table shows the relevant statistics of meta-cognitive awareness of students by treatment and self-efficacy.

	Self-Efficacy			
Group	LAW SEff (LSEff)	MODERATE SEff (MSEff)	HIGH SEff (HSEff)	Total
	N	N	N	N
CG	13	31	16	60
EG	16	28	18	62
	Mean	Mean	Mean	Mean
CG	34.61	38.38	40.12	38.03
EG	36.93	42.25	44.66	41.58
Total	35.89	40.22	42.52	39.83

Table 1: Adjusted mean of MCAS by treatment and SEff

Table 2 shows the ANOVA for meta-cognitive awareness of students by intervention programme and SEff after partialling out the effect of the pre-test MCAS of students.

Source	SS	df	MS	F	P
Rows (T)	383.69	1	383.69	12.57	0.0006
Column (SEff)	705.43	2	352.72	11.56	<.0001
Interaction (TxSEff)	49.23	2	24.62	0.81	0.4474
Error	3540.37	116	30.52		
Total	4678.72	121			

Table 2: ANOVA for MAI of students by treatment (T) and self-efficacy (SEf)

Since the F-ratios for SEf effect is significant, the t-test is applied for further analysis as shown in table 3.

No.	Groups	Mean	N	t	l.o.s.
1	H-SEf	42.52	34	1.93	NS
	M-SEf	40.22	59		
2	H-SEf	42.52	34	4.75	0.01
	L-SEf	35.89	29		
3	M-SEf	40.22	59	3.46	0.01
	L-SEf	35.89	29		

Table 3: Mean differences of MCAS between treatment and SEf

The preceding table shows that (a) the F-ratio for rows i.e. intervention programme is significant at <0.0001. Hence it may be concluded that the Mean Score on MAI of the experimental group is significantly greater than that of the control group. (b) The F-ratio for columns i.e. self-efficacy is significant at 0.05. Hence it may be concluded that the Mean Scores on MAI do differ significantly on the basis of self-efficacy. (c) The F-ratio for interaction effect of intervention programme and self-efficacy is not significant at 0.447 level. Hence it may be concluded that the Mean Score on MAI of students differ on the basis of the interaction between intervention programme and self-efficacy.

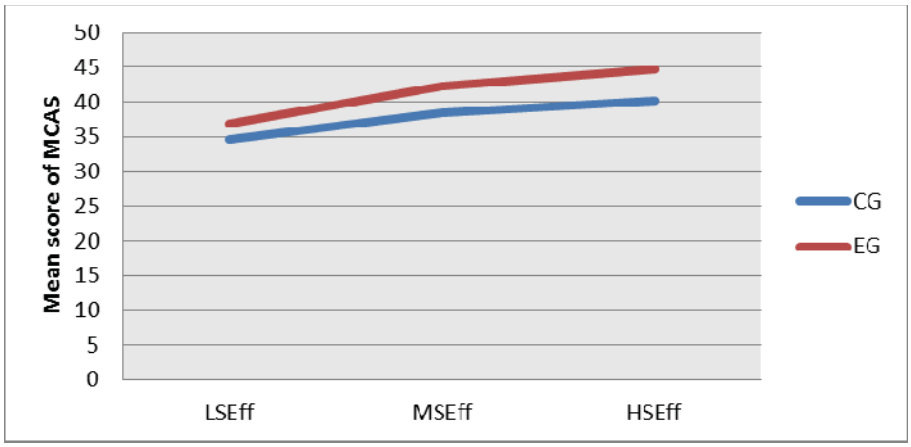

Figure 1: Interactive effect of treatment and Sef on MCAS

DISCUSSION

The treatment i.e. the intervention programme developed by the researcher is effective for enhancing meta-cognitive awareness of students. Moreover, the intervention programme is found to be more effective for students with high self-efficacy as compared to those with moderate and low self-efficacy. KWL chart, think aloud method of teaching and various meta-cognitive strategies may help to improve students Bandura and Schunk (1981) found that students' mathematical self-efficacy beliefs were predictive of their choice of engaging in subtraction problems rather than in a different type of task. The higher the children's sense of efficacy, the greater their choice of the arithmetic activity.

Experimental group students have high self-efficacy as compare to control group because self-efficacy also called perceived ability, refers to the confidence people have in their abilities for success in a given task (Bandura, 1997) which might be increase by the meta-cognitive strategies and meta-cognitive awareness.

Students with high self-efficacy is have more awareness about their own thinking process because student plan, monitor and evaluate their learning in a way that directly improve performance. Unrealistically low self-efficacy, not lack of capability or skill, can be responsible for maladaptive academic behaviours, avoidance of courses and careers, and diminishing school interest and achievement.

Students who have a low sense of efficacy for acquiring cognitive skills may attempt to avoid tasks, whereas those who judge themselves more efficacious should participate more eagerly.

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