Interactive Effect of Meta-Cognitive Strategies-based Instruction in Mathematics and Approaches to Learning on Mathematics Anxiety of Students

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Abstract: *This paper attempts to ascertain the interactive effect of meta-cognitive strategies-based instruction in mathematics and approaches to learning on students' mathematics anxiety. For this purpose, an intervention programme based on meta-cognitive strategies of about 35 hours was developed for students of standard eighthspreading over eight weeks. The aim of the research was to ascertain whether meta-cognitive strategies instruction reduces mathematics anxiety in students. Structured tools were used in study. The participants of the study included 62 and 60 students in the experimental and control groups respectively. The effect size of the intervention programme on the mathematics anxiety of students was found to be 1.084and that of the learning approaches was found to be 1.009 which are both high in magnitude.*

Keywords: *Meta-cognitive strategies, Mathematics Anxiety,Approaches to Learning*

I. INTRODUCTION

Multiplication is vexation, Division is just as bad; The Rule of Three perplexes me, And Practice drives me mad.

According to(Barbara 2004) from Old Rhyme

This is mathematicsanxiety. Mathematics anxiety is defined as a general fear or tension associated with anxiety-provoking situations that involve interaction with Mathematics. Meta-cognitive knowledge encompasses all the knowledge and insight possessed regarding what is already known about cognitions (Schraw and Moshman, 1995). Mathematics is a science or group of sciences, primarily involving quantities, shapes, functions and arrangements, based on deductive reasoning and logic.

Meta-cognitive knowledge about learning processes can be correct or incorrect, and this self-knowledge may be quite resistant to change(Veenman, 2006). For example, a student may think that (s)he has invested enough time in preparation for Mathematics examination, despite repeated failure but the teacher made the questionpaper verydifficult to pass. Such misattributions prevent students from amending their self-knowledge.Meta-cognition is central in problem solving because it managesvarious components and skills required for mathematicalperformance. However, there wasno significant correlation between meta-cognitive ability and mathematical problem solving (Alamolhodaei,2011).

1.1Rationale of the Study:.

eta-cognition is an appreciation of what one already knows, together with a correct apprehension of the learning task and what knowledge and skills it requires, combined with the ability to make correct inferences about how to apply one's strategic knowledge to a particular situation and to do so efficiently and reliably (Carlson).Meta-cognitive strategies refers to methods used to help students understand the way they learn; in other words, it means processes designed for students to 'think' about their 'thinking'.Teachers who use meta-cognitive strategies are expected to influence students positively by helping them to develop an appropriate plan for learning information, which can be memorized and eventually can become routine. As students become aware of how they learn, they will use these processes to acquire new informationefficiently, and consequently, become independent thinkers. This in turn is expected to make students more self-reliant and confident thereby reducing their mathematics anxiety.

1.2 Review of Related Literature

Mathematics Anxiety and Meta-cognitive Awareness:Alikamar (2014)examined the role of meta-cognition on effect of working memory capacity on students' mathematical problem solving, result indicated that meta-cognition had distinctive and challenging variable than other factors in use of working memory capacity in mathematical problem solving.Abbasi(2013) conducted a study of the role of meta-cognition on the effect of working memory capacity on students'mathematical problem solving.Goetz et al(2013)focused on whethergirls really experience more anxiety in Mathematics. Shanna (2013) studied mathematics and meta-cognitionresolving the paradox and results showed that judgment differed across domain and gender. There was a higher incidence of overconfidence in mathematics. Students were over-confident in mathematics, bringing into question the existence of mathematics phobia. Improvement in calibration and gender difference in calibration were most noticeable in mathematics. Lyons and Beilock(2011)conducted a research on a group of students who were especially anxious about mathematics-related tasks.Hellum (2010) opined that effective teaching strategies can be used for alleviating mathematicsanxiety and increasing self-efficacy in secondary students.

Karimi (2009) focused on mathematics anxiety, mathematics performance and academic hardiness in high school students. The researcher established the fact that the performance of students in mathematics can be perceived by mathematics anxiety and females scored slightly higher on this variable but this relationshipis not observed with academic hardiness.

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Geist (2009) discussed negative attitudes of students towardsmathematics. Peker(2009)conducted a study to investigate the differences in the teaching anxiety of pre-service teachers in mathematics according to their style preferences. Jackson (2008)conducted a study ofmathematics anxiety in student-teachers. Gresham(2008) conducted a study onmathematics anxiety of pre-service elementary teachers.Zakaria and Nordin(2007) studied the effects of mathematics anxiety on matriculation students as related to motivation and achievement. Legg(2006) found that meta-cognition moderatesmathematicsanxiety and affects performance on mathematics task. As expected, meta-cognition moderated mathematics anxiety and predicted that performance would decrease as anxiety increased, except at high meta-cognition levels. Further, meta-cognition predicted confidence in accuracy such that individuals with high meta-cognitive ability were more confident in their ability to correctly answer the problems.Marchewka (2006) conducted a study of mathematical anxiety among adult learners. Pradeep (2006) conducted a study ofmathematics anxiety of pre-service teachers enrolled in a teacher – training programme at a primary school teachers training college (PABO) in the Netherlands. Swanson and Nebraska (2006) conducted a research study on teachers' efforts to help their students overcome the feelings of anxiety related to mathematicsof classroom of 7th and 8th grade. Woodard (2004) focused on the effects of mathematics anxiety on post-secondary developmental students as related to achievement, gender and age. Kidmanand Usimaki's(2004) study was concerned withreducing mathematics anxiety. Furner et al(2003) conducted a study of overcoming a major obstacle to the improvement of students'mathematicsperformance. Peskoff(2000) found that the impact of test anxiety on meta-cognitive knowledge monitoring confirmed general expectations of negative relationship between anxiety and indices of meta-cognition. Furner & Duffy (2002) focussed on equity for all students in the new millennium with reference to math anxiety. This study had as a main focus ways to prevent and reduce math anxiety. They found that teachers need to get an understanding of what their students are going through in math by journaling and talking with their students.

II METHODOLOGY

2.1 Statement of the Problem

nteractive Effect of Meta-cognitive Strategies-based Instruction in Mathematics and Approaches to Learning on Mathematics Anxiety of Students

2.2 Operational Definitions of the Terms

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

Learning Approach: It refers to the behaviour in a student which is produced by the interaction of the student with specific learning tasks with specific reference to a deep approach to learning, where students are aiming towards understanding, a surface approach to learning, where they are aiming to reproduce material in a test or exam rather than actually understand it and a strategic approach to learning in which students are wish to achieve positive outcomes in terms of obtaining a pass or better in the subject.

Deep Approach: A deep approach refers to a student's active engagement with the subject matter and seeks real meaning and be interested in the subject matter for its own sake.

Surface Approach:A surface approach refers to memorisation of information and procedures in which a student will tend toward accurate reproduction of facts and will be syllabus bound, often lacking interest in the subject.

Strategic Approach: The strategic approach is that approach which students are said to take when they wish to achieve positive outcomes in terms of obtaining a pass or better in the subject by organising their time well, by finding the right conditions for studying and by putting consistent effort into their study.

Mathematics Anxiety: Mathematicsanxiety refers toa feeling of tension, apprehension or fear that interferes with mathematics performancearising from unpleasant experiences in mathematics.

2.3 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 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 programme inmathematics and learning approaches on mathematicsanxiety of students. It excludes other variables such as SES, IQ, motivation or self-efficacy as other independent variables. Similarly, the study includes mathematics anxiety as the dependent variable and excludes other affective and skills-related variables from its purview. It relies on the quantitative approach to the study rather than the qualitative approach.

2.4 Aim of the Study:

To ascertain the interactive effect of the intervention programmeand approaches to learning on mathematics anxiety of students.

2.5 Objectives of the Study

1. To compare the pre-test scores mathematics anxiety of students of the experimental and control groups.
2. To compare the post-test scores on mathematics anxiety of students of the experimental and control groups.
3. To ascertain the interactive effect of the intervention programmeand learning approaches on mathematics anxiety of students.

4. To compute the effect size of the intervention programmeand learning approaches on mathematics anxiety of students.

2.6 Null Hypotheses of the Study

Following are the null hypotheses of the study:

1. There is no significant difference in the pre-test scores mathematical anxiety of students of the experimental and control groups.
2. There is no significant difference in the post-test scores on mathematics anxiety of students of the experimental and control groups.
3. There is no significant the interactive effect of the intervention programmeand learning approaches on mathematics anxiety of students.

2.7 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-equivalentgroup type was used. It can be described as follows:

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

$O_1 X O_2 O_3 C O_4$

Where,

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

X : Experimental Group & C : Control Group.

The duration of the intervention programmeis 35 hours in the experimental group. The control group was taught using the traditional method.

Factorial Design (2×3)

Factorial design has been used to study the interactive effect of the treatment and approaches to learning of the students on the mathematic anxiety.

2.8 Sample of the Study:

In the present study, the sample has been selected consisting of one intact class each of standard eight from two different schools situated in the Greater Mumbai. The experimental and the control groups included 62 and 60 students respectively.

2.9 Tool of the Study:

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

1. Mathematics Anxiety Rating Scale-India(MARS-I) by Karimi (2008). It contains 31 items of situations which causes mathematics anxiety. It has two subscales- Math test anxiety with 15 items and numerical tasks with 16 items.
2. Learning Approaches by Marton & Saljo (1996).It identifies the tendencies of students to adopt deep, surface and strategic approaches to learning and studying.

2.10 Intervention Programme:

The duration of the intervention programme was 35 hours. The control group was taught using the traditional method. The experimental group was taughtby using theintervention programme which was divided in two levels, first, knowledge about cognition, which is ascertained through KWL Chart and the second was regulation about cognition which consists of three steps planning including understanding the problem,devising a plan, carrying out the plan, looking back.Monitoring including self-awareness of one's thought processes. Control includes self-monitoring of one's thought processes, beliefs and intuitions about one's cognition. Evaluation includesproblems on the topic and self -reflection sheet.

2.11 Techniques of Data Analysis:

The present research used statistical techniques of t-test, ANCOVA and Wolf's formula.

III. FINDINGS AND CONUSIONS

1. Null Hypothesis 1: There is no significant difference in the pre-test scores of mathematical anxiety(MAn) of students from the experimental and control groups.

The technique used to test this hypothesis was the t-test. The following table shows the relevant statistics of the pre-test scores of MAn of students.

Table 1 : Pre-test scores of MAn of students of CG and EG

Group	Mean	N	t	P
CG	79.23	60	0.41	0.682
EG	80.62	62		

The preceding table shows that the t-ratio is not significant at 0.05 level. Hence the null hypothesis is accepted.

It may be concluded that the Mean pre-test scores of MAnof students from the experimental and control groups do not differ significantly.

2. Null Hypothesis 2: There is no significant difference in the post-test scores of mathematical anxiety of students from the experimental and control groups.

The technique used to test this hypothesis was the t-test. The following table shows the relevant statistics of the post-test scores of MAn of students.

Table 2: Post-test scores of MAnof students of CG and EG

Group	Mean	N	t	P
CG	62.03	60	5.47	<0.0001
EG	49.56	62		

The preceding table shows that the t-ratio is significant at 0.0001level. Hence the null hypothesis is rejected.

It may be concluded that the Mean post-test scores of MAn of students from the experimental and control groups differ significantly. The Mean post-test scores of MAnof students from the experimental group is significantly less than that of the control group.

Null Hypothesis 3: There is no significant the interactive effect of the intervention programmeand learning approaches on mathematics anxiety of students.

This hypothesis was tested using two-way ANCOVA in which the pre-test scores of mathematics anxiety of students are controlled.

The following table shows the relevant statistics of mathematic anxiety of students by treatment and approaches to learning.

Table 3: Relevant statistics for ANCOVA

	LEARNING APPROACHES			
	Deep Approach (DA)	Strategic Approach (STA)	Surface Approach (SUA)	Total
	N	N	N	N
CG	12	39	09	60
EG	11	41	10	62
	23	80	19	122
	Mean	Mean	Mean	Mean
CG	66.66	61.17	59.55	62.03
EG	44.90	48.92	57.3	49.56
Total	56.26	54.9	58.36	55.69

The following table shows the ANCOVA for MAn of students by intervention programmeand learning approaches after partialling out the effect of the pre-test MAnof students.

Table 4: ANCOVA for MAn of students by treatment (T) and learning approaches (LA)

Source	SS	df	MS	F	P
Rows (T)	4740.6	1	4740.6	31.07	<.0001
Column (LA)	193.72	2	96.86	0.63	0.5344
Interaction (TxLA)	1001.04	2	500.52	3.28	0.0411
Error	17698.42	116	152.57		
Total	23633.78	121			

The preceding table shows that (a) the F-ratio for rows i.e. intervention programmeis significant at <0.0001. Hence it may be concluded that the Mean Score ofMAn of the experimental group is significantly less than that of the control group. (b) The F-ratio for columns i.e. learning approaches is not significant at 0.05. Hence it may be concluded that the Mean scores ofMAndo not differ on the basis of Approaches to Learning. (c) The F-ratio for interaction effect of intervention programmeand approaches to learning is significant at 0.04 level. Hence it may be concluded that the Mean Score ofMAnof students differ on the basis of the interaction between intervention programmeand approaches to learning.

Since the F-ratio for the interaction effect is significant, the t-test is done to ascertain which Mean scores differ from each other as shown in table 5.

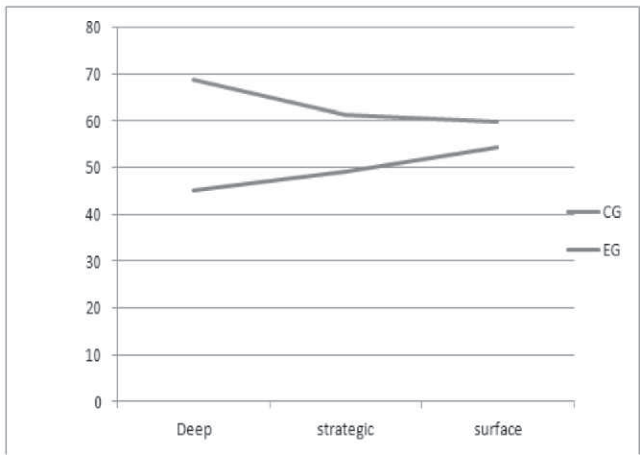
Table 5: Mean differences in MAn by interaction between intervention programmeand learning approaches

Groups	Mean	SED	t	l.o.s.
E-D	45.0	4.787	4.967	0.01
C-D	68.78			
E-ST	49.26	2.582	4.663	0.01
C-ST	61.30			
E-SU	54.42	5.270	0.286	NS
C-SU	55.93			

3.1Conclusion:

The preceding table shows that the t- ratio is significant at 0.01 level for students for deep and strategiclearning approaches. It may be concluded that the Mean scores of MAnof students with deep and strategic learning approaches of the experimental group are significantly lessthan those of the control group. Thus, the meta-cognitive strategies-based instructional programme was found to be effective in reducing mathematics anxiety of students with deep and strategic approaches to learning. On the other hand,in case of mean score ofMAn of students with surface approach of the experimental and control group do not differ significantly. Thus, the meta-cognitive strategies-based instructional programme was not found to be effective in reducing mathematics anxiety of students with surface approach to learning.

The interactive effect of meta-cognitive strategies-based instruction and learning approaches on mathematics anxiety of students is shown in the following figure.



IV DISCUSSION

The intervention programme developed by the researcher is effective for reducing mathematics anxiety of students with deep and strategic approaches to learning. This could be because students with deep approach to learning exhibited greater confidence in their ability to correctly solve mathematics problems, sought to understand the material or the subject actively, interact vigorously with the content, made use of evidence, inquiry and evaluation, took a broad view and related ideas to one another, were motivated by interest, related new ideas to previous knowledge, related concepts to everyday experience and thought about what they knew and what they did not know. They also were more able to relate and distinguish between evidence, facts and arguments. They tend to read and study beyond the course requirements and do evaluation and reflection for themselves. The instructional programme perhaps helped students in perceiving entities, connections, relations and similarities. Thus, meta-cognitive strategies instruction was more effective in reducing mathematic anxiety for students with deep learning approach.

Similarly, students with strategic approach to learning wished to achieve positive outcomes in terms of obtaining a pass or better in mathematics, intended to obtain high marks, organised their time and distributed their effort to greatest effect, ensured that the conditions and materials for studying were appropriate, used previous examination papers to predict questions and were alert to cues about marking schemes.For this purpose, they may have used planning and self-reflection taught to them in the instructional programme.

Thus, the intervention programme was found to be effective in reducing mathematic anxiety for students with strategic approach to learning.

On the other hand, student with surface learning approach are more inclined to use the tacit acceptance of information and memorization as isolated and unlinked facts. It leads to superficial retention of material for examinations and does not promote understanding or long-term retention of knowledge and information. Their entire focus is on passing the examination through rote learning. The traditional instruction and school system encourages this. Thus, the meta-cognitive strategies-based instructional programme was not found to be effective in reducing mathematics anxiety of students with surface approach to learning.

The effect size of the intervention programme on the mathematics anxiety of students was found to be 1.084and that of the learning approaches was found to be 1.009 which are both high in magnitude.

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