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Associative and Strategic Study Approaches: Their Significant Relationships to Solving Meta Cognitive Problems of Mathematics Majors

MARVIN S. DAGUPLO
ORCID No. 0000-0002-0363-133X
daguplosdv@yahoo.com
Southern Leyte State University-Tomas Oppus
Southern Leyte, Philippines

ABSTRACT

University students still found difficulties in working successfully mathematical word problems. Some researchers attributed this to students' weak cognitive and abstract thinking. To address such problem, this study aimed to understand student's cognitive approaches in processing mathematics information to determine students' level of cognition and come up with classroom activities that enhance the desired approaches in processing mathematical information which influences learning. A total of thirty-seven students of SLSU – Tomas Oppus were the respondents of this descriptive-correlational study. A standardized Mathematics Information Processing Scale (*Cronbach's alpha coefficient=.89*) was utilized to gather the data for this study. Statistical analysis revealed that there is no significant difference in the performance of male and female mathematics majors in solving word problems who performed at below average level. The same findings is found out between male and female mathematics majors in their approaches in processing mathematics information when solving metacognitive problems, when doing deep-associative study, and when doing strategic study. Lastly, Correlational analysis revealed that a strong relationship exists between solving metacognitive problems and, doing associative study and strategic study approaches. This study concludes that students who apply associative and strategic study methods perform well in solving meta-cognitive problems.

Keywords - Mathematics, processing, mathematics, information, action research, Philippines

INTRODUCTION

Students' failure to understand the language that the problem wanted to communicate (Lee, 2006); the process and approaches in performing a mathematical task (Coxeter, 2008); the opportunity to practice the task (Daguplo, 2009); weak foundation in mathematics (Fernandez, 2006); and attitude towards mathematics (Papanastasiou, 2002) were among the major contributors of students poor performance in mathematics.

Students' underachievement in mathematics is not just a concern for particular countries, but has become a global concern over the years (Pisa, 2003). Tuminaro and Redish (2004) of University of Maryland stressed that there are at least two possible, distinct reasons for this poor performance (1) Students lack the mathematical skills needed to solve problems, or (2) students do not know how to apply the mathematical skills they have to particular problem situations.

Moreover, available research presents a variety of views concerning the factors influencing mathematics performance. Those factors can be clustered into two groups: (1) internal student characteristics, such as gender (Hyde, Feenema, & Lamon, 1990), meta-cognition (Desoete & Roeyers, 2001), and math self-efficacy (Pajares & Graham, 1999), and (2) external or contextual variables, such as GDP (Gross Domestic Product) of the geographical school location (Young, 1998), parents' educational level (Sirin, 2005), teachers' educational level (Goldhaber & Brewer, 2000), and teacher beliefs (Mandeville & Liu, 1997).

Very evident to this is the mathematics performances of Maldivian students which have been very low throughout. According to Ministry of Education of Maldives, only 28.4% of students who have participated in Cambridge examination in 2007 have passed above "C" grade. Similar kind of trend was also seen in the results of 2008 where 66.8% of students getting grades below the expected level (Ministry of Education, 2011).

In the Philippines, poor performance of students in mathematics suggests inadequacy of their conceptual understanding (Ancheta, 2008). Moreover, results of the 2008 TIMSS-Advanced showed that among the ten (10) countries that participated in the study, Russian Federation, got the highest average scale score at 561, while the Philippines ranked 10th, with an average scale score of 355

(Ogena, Lana, & Sasota, 2010). This is commented by Abad (2007) saying that the performance of Philippine students was far from satisfactory.

Aware and alarmed by these challenges, educational institutions encouraged and motivated their teaching personnel to devise new and effective strategies and techniques which will be instrumental for a positive performance especially in mathematics – for both male and female. Very evident, as part of the educational endeavor to enhance students' performance, are the conduct of a seminar series and in-house trainings that will enhance more teachers' understanding on the art and science of learning. These are being conducted to control the threat of stereotyping mathematics performance as male dominated area (Nosek, et al, 2009). Today, however, the gender gap in course taking has disappeared in all areas except physics. Insofar as courses taken by students influence their mathematics performance, we would expect that the gender difference in complex problem solving in high school would have narrowed (Lindberg, Hyde, Petersen, & Linn, 2010). However, other factors which explains this gap still has to be investigated to eliminate it completely.

To really compete globally, priority in every training, conference, and meeting is the cognitive development of the students. The content-centered concept becomes the core theory of the move to improve students' academic performance. Various experiences, approaches, and techniques were provided to both teachers and students to assure that learning are really achieved and information are absorbed as planned.

As an institution of higher learning mandated to deliver quality education, it is always a task for educators, to closely monitor the development of our students' cognitive processes. Thus, this study is formulated with the aim to understand cognitive operations of the students especially in mathematical problems so as to design instruction that contributes to high levels of learning and achievement in mathematics.

OBJECTIVES OF THE STUDY

This study aimed to assess the student's cognitive approaches in processing mathematics information. Specifically, evidences on solving problem performance of BSED Math Majors in SLSU – Tomas Oppus as well as their approaches in processing mathematics information are the major information provided in this study.

METHODOLOGY

A total of thirty-seven out of forty-one education (BSED mathematics major) students of SLSU – Tomas Oppus were the respondents of this descriptive-correlational study. Data were gathered through a standardized Mathematics Information Processing Scale (*Cronbach's alpha coefficient=.89*) which was distributed to the identified respondents in one of their class schedules after the permission of the Dean of the Undergraduate Studies. Data analysis (*frequency, percentages, mean, standard deviation, spearman rho, point-biserial*) followed right after the retrieval of the questionnaire.

RESULTS AND DISCUSSION

Problem Solving Performance of BSED Math Majors in SLSU – Tomas Oppus

The National Council of Teachers of Mathematics stressed that solving problems is not only a goal of learning mathematics but also a major means of doing so. It is also a critical process, woven across the entire mathematics curriculum, through which students are able to explore and understand mathematics (NCTM 2000, 52). Through problem-solving experiences, students learn to challenge their thinking about data and probability, test their ideas about numbers and operations, apply their skills in geometry and measurement, and evaluate their understandings of algebra. Through problem-solving tasks, students develop an understanding of math content and ultimately use that content understanding to find solutions to problems. Problem solving is both the process by which students explore mathematics and the goal of learning mathematics.

This NCTM principle and standard elevates problem solving to a higher degree of importance in any mathematical undertakings especially in education which basically focuses on the teaching and learning process of solving problems. While in the past, problem solving may have been viewed as an isolated assignment, problem solving today has an integrated role in the math classroom. However, despite this importance, problem solving is still considered by many students as one of the most difficult undertakings in studying mathematical courses. In fact, previous studies and test results continually revealed students poor performance in mathematical problems (TIMMS, 2003; Daguplo, 2009). This study supports this claim when it finds out that the BSED Math Majors of SLSU – Tomas Oppus has a below average performance in problem solving. Moreover, it is revealed that male and female mathematics majors do not differ significantly in their performance. With a p-value of 0.50, this finding therefore buttresses the earlier assertion of Fennema and Sherman (1978) that available literatures have not been able to identify with a single direction of difference in performance between boys and girls. This further reinforce the claim of other studies that the link between gender and the mathematics performance was very weak (Caplan & Caplan, 2005) rejecting the assertions that there is a gender disparity in the mathematics performance (Halpern, 2000).

Table 1. Problem solving performance of BSED math majors in SLSU – Tomas Oppus

Respondents	Frequency (N=37)	Performance		Qualitative Description	d.f.	p-value	Statistical Description
		$\bar{x}$	s.d.				
Male	16	20	6	Below Average			
					35	.50	No Significant Difference
Female	21	19	5	Below Average			

<u>Score</u> **<u>Qualitative Description (QD)</u>**

Note: **significant at .01 α ; * significant at .05 α

39 - 50 = Above Average
31 - 38 = Average
0 - 30 = Below Average

Approaches in Processing Mathematics Information When Solving Metacognitive Problems

Solving metacognitive problems requires metacognitive skills to be successful in finding solutions. A well-developed cognitive skills aid in the correct formulation of procedures to ascertain accurate answers of the problems posted. Dawson (2008) of Developmental Testing Service stressed saying "adults whose metacognitive skills are well developed are better problem-solvers, decision makers and critical thinkers, are more able and more motivated to learn, and are more likely to be able to regulate their emotions (even in difficult situations), handle complexity, and cope with conflict. A well-developed metacognitive skills, therefore, is a necessary tool that would help students in their approaches in processing mathematical information.

In this study, male and female mathematics majors always look for keywords or phrases that will help solve problems. Moreover, frequently practiced by the respondents are considering clues as contextual information which provides the most relevant data to help better understand the intent of the problem. Literatures have said that looking for clues is one of the most important skills in processing mathematics information. These clues sometimes tell what kind of operations has to perform to accomplish the task.

Aside from finding clues, it is also found that other major procedural strategies as an approach in processing mathematics information were frequently practiced by the mathematics Majors of SLSU – Tomas Oppus. First, students frequently examine all aspects of the question before answering. Examining the problem is a part of defining a problem. Samuels (1989) defines "problem definition as the most crucial step in the entire process and can only come with recognition that problems, like information, exist at many levels". Second, mathematics majors solve problems by clustering information they derived from examining the problem. Johnson (1984) proposes that the common underlying structure of clustering information is established through a reductionist interaction among different data elements. This interaction serves to (1) reduce redundancy by forcing a selection of admissible versus inadmissible data, (2) combine like data elements to form clusters, and (3) gather each cluster of data elements into a unified system or totality. Clustering information, therefore, lessen the confusion in the processing of information which paves the way for an easy solution of the problem.

Table 2. BSED Mathematics majors' approaches in processing mathematics information when solving metacognitive problems

APPROACHES	**Responses**			
	Male		Female	
	$\bar{x}$	QD	$\bar{x}$	QD
• Develop a plan of action and select strategies to carry it out.	4.0	*FP*	3.7	*FP*
• Determine what information in the problem is most relevant.	3.8	*FP*	4.1	*FP*
• Evaluate strategies as I proceed.	3.7	*FP*	3.9	*FP*
• Revise or abandon unproductive strategies and plans.	3.4	*FP*	3.1	*OP*
• Examine contextual information for clues.	3.9	*FP*	3.8	*FP*
• Look for key words or phrases that will help solve problems.	4.2	*AP*	4.2	*AP*
• Focus all energy on finding strategies to answer questions.	3.3	*OP*	4.0	*FP*
• Examine all aspects of each question before beginning to answer.	3.9	*FP*	3.9	*FP*
• Solve problems by clustering information into parts.	3.5	*FP*	3.8	*FP*
OVERALL MEAN	**3.7**	***FP***	**3.8**	***FP***

Value	**Qualitative Description (QD)**
1.0– 1.7	= Never Practiced (NP)
1.8 – 2.5	= Rarely Practiced (RP)
2.6 – 3.3	= Occasionally Practiced (OP)
3.4 – 4.1	= Frequently Practiced (FP)
4.2 – 5.0	= Always Practiced (AP)

Developing a plan of action and strategies in processing mathematics information is the third major approach frequently employed by the students. They evaluate these strategies as they proceed in the analysis of the problem. Revision and abandonment of strategies comes in the process whenever the maneuver is unproductive and less helpful in the attainment of the solution. A distinct finding in this part of the study is observable in the amount of energy mathematics majors gives in the processing of information. It is noted that female mathematics majors frequently focus all energy on finding strategies which their male counterparts occasionally performs.

Generally, there was no difference in the approaches in processing mathematics information when solving metacogntive problems between the male and the female mathematics. Thus, whenever male and female mathematics major solve metacognitive problems, their approaches basically do not differ. This finding supports the claim that gender differences in cognitive functioning and achievement do not always favour one sex (Halpern & LaMay, 2000; Wigfield *&* Eccles, 2002) in contradiction to some findings which states that the gender differences for both metacognitive and problem-solving skills were significant, and the significance is in favor to female students (Fatin, 2005).

Approaches in Processing Mathematics Information when doing Deep-Associative Study

To personalize the problem, making it actual and as a part of getting acquainted with the problem is what constitutes deep-associative study. This study revealed that in doing a deep-associative study, male mathematics major always goes over many examples until deeper understanding is developed. This is a practice which the female mathematics majors are also doing though frequently.

Table 3. BSED mathematics majors' approaches in processing mathematics information when doing deep-associative study

APPROACHES	Responses			
	Male		Female	
	$\bar{x}$	QD	$\bar{x}$	QD
• Attempt difficult questions to improve my problem-solving skills.	3.9	*FP*	3.9	*FP*
• Review notes/modules by relating central ideas to problems.	3.9	*FP*	4.1	*FP*
• Look for new or different methods of solving problems.	4.0	*FP*	3.4	*FP*
• Go over many examples until I develop a deeper understanding.	4.3	*AP*	4.0	*FP*
• Prepare for tests by imagining how I will be thinking and feeling.	3.4	*FP*	3.3	*OP*
• Strive to learn the theory behind a procedure before attempting to perform exercises.	3.9	*FP*	3.5	*FP*
• Create diagrams, pictures, and charts to improve my understanding.	3.6	*FP*	3.4	*FP*
• Does not move on to new section until I master the current section.	3.3	*OP*	3.3	*OP*
• Write mathematical formulas in my own words.	2.9	*OP*	2.5	*RP*
• Look for additional books when encountered with difficulty.	3.9	*FP*	3.6	*FP*
• When studying new section, I break it down into parts.	3.3	*OP*	3.0	*OP*
• Practice many different types of problems as a routine part of my study.	3.7	*FP*	2.8	*OP*
• Tries to reduce the amount of time in solving problems.	3.1	*OP*	2.8	*OP*
OVERALL MEAN	**3.6**	***FP***	**3.4**	***FP***

Value	**Qualitative Description (QD)**
1.0– 1.7	= Never Practiced (NP)
1.8 – 2.5	= Rarely Practiced (RP)
2.6 – 3.3	= Occasionally Practiced (OP)
3.4 – 4.1	= Frequently Practiced (FP)
4.2 – 5.0	= Always Practiced (AP)

Part of the respondents' approaches in processing information when doing a deep-association study is to practice many different types of problems as a routine activity. They even frequently attempt to work on difficult questions to improve problem-solving skills. Part of this is their effort to look for new or different methods of solving problems. The law of Exercise of Thorndike best explains the importance of constant practice allowing the individual to master the activity through constant correct repetition. This law maintains the idea that the connection between a stimulus and a response is strengthened by being exercised frequently, recently, and vigorously (Aquino, 2009). The law further explains that the strength of a stimulus-response association can be increased by use while the connection can be weakened by disuse (Limpingco, Tria, and Jao, 2008). This makes repetition or practice valuable in learning. Thus, whenever encountered difficulty during the study, students frequently and repeatedly look for additional books, review notes and modules and relate it to the central idea of the problem. Along with the books, they also strive to learn the theory behind a procedure before attempting to perform exercises. This shows that the mathematics majors of SLSU – Tomas Oppus value the significance of learning the concepts and theories of mathematics in order to properly execute the required procedures of the operations.

Believing that patterns, relationships, and functions constitute the unifying theme of mathematics, it is the respondents' frequent practice to create diagrams, pictures, and charts to improve understanding. Visual mathematics help students better present the problem, the relationship of the information, and the process involved in the operations. Researchers agree that visual representations enhance students' intuitive view and understanding in many areas of mathematics. Presmeg (1992) argued that the use of concrete pictorial imagery may focus the reasoning on irrelevant details that take the problem solver's attention from the main elements in the original problem representation, whereas other kinds of imagery may play a more positive role. He ascribed the most essential role in mathematical problem solving to pattern imagery, in which concrete details are disregarded and pure relationships are depicted.

At large, this study found that male and female mathematics major do not differ in their approaches in processing mathematics information when doing a deep-associative study. Although table 4 reflects some differences on some indicators, these differences do not establish a value that would establish a difference between the two groups.

Approaches in Processing Mathematics Information when Doing Strategic Study

In order to accomplish the task of solving problems, a strategic study is very important for mathematics majors. Strategic study is a planned technique that the students believed would help them work on the information provided in the problem. This study revealed memorization is an approach always practiced by males but frequently employed by females. They do this in preparation of the examination.

Other approaches that mathematics majors practices frequently involve (i) spending a long time studying if there is a need to know the subject matter, (ii) working hard to understand when and how to apply the formula, (iii) restricting analysis to important information, and (iv) rethinking procedure when difficulty in solving problems arises.

Also reflected in Table 4 is the approaches just occasionally employed by the respondents in processing information when doing strategic study. Information revealed that they do study most few days before the test. This is a manifestation that mathematics majors have weak study habit. Working out problems without assistance from others is another approach occasionally practiced by mathematics majors. This is surprising because this reflects how dependent mathematics majors are in processing mathematics information. These practices could be some of the reasons why they perform at below average in problem solving examination.

Looking at the overall information, male and female mathematics major do not differ in their approaches in processing mathematics information when doing strategic study. This implies that the respondents do not vary in their approaches towards solving problems whenever they do strategic study.

Table 4. BSED mathematics majors' approaches in processing mathematics information when doing strategic study

APPROACHES	Responses			
	Male		Female	
	$\bar{x}$	QD	$\bar{x}$	QD
• Memorize formulas or computations when I prepare for tests.	4.2	*AP*	4.1	*FP*
• Rethinks procedure, if I have difficulty solving a problem.	3.9	*FP*	3.9	*FP*
• Do most of my studying a few days before the test.	3.1	*OP*	2.7	*OP*
• Work hard to understand when and how to apply the formula.	3.6	*FP*	3.7	*FP*
• Rely on immediate recall and sight recognition to answer questions.	3.3	*OP*	3.2	*OP*
• Restrict my analysis to what I think is the most important information.	3.4	*FP*	3.6	*FP*
• Spend a long time studying something if I feel I should know it.	3.6	*FP*	3.7	*FP*
• Working out problems without assistance from others.	3.2	*OP*	3.0	*OP*
OVERALL MEAN	**3.5**	***FP***	**3.5**	***FP***

Value	Qualitative Description (QD)
1.0– 1.7	= Never Practiced (NP)
1.8 – 2.5	= Rarely Practiced (RP)
2.6 – 3.3	= Occasionally Practiced (OP)
3.4 – 4.1	= Frequently Practiced (FP)
4.2 – 5.0	= Always Practiced (AP)

Relationship between Approaches in Processing Mathematics Information and Problem Solving Performance.

Researchers have suggested that overall mathematics achievement is a function of many interrelated variables such as attitudes, behaviors, and approaches to studying mathematics. The students' attitude, some of which are experiences and approaches towards an academic subject, is a crucial factor in learning and achievement in that subject and plays an important role not only in learning but in maintaining a continued interest in the subject (Papanastasiou, 2002). Rangappa (1994) likewise posits that a student's view of their own abilities and willingness to accept responsibility in their learning can impact that student's achievement. Strategic in their approaches and a constant association with metacogntive problems are signs of students' taking of their learning responsibility.

Findings of this study revealed that there is a strong positive relationship between Solving Metacognitive Problems and Doing Associative and Strategic Study which implies that establishing good, excellent, and appropriate study techniques would have something to do with solving metacognitive problems. The more mathematics majors experience and do associative and strategic study, the better will be their approaches in solving metacognitive problems. Moreover, information revealed that a moderate relationship exists between doing associative study and doing strategic study. There is enough evidence in this study which tells that the two approaches are associated with each other. As expected, if students who major mathematics do strategic study, they also do deep associative study.

Table 5. Correlation matrix between experiences, approaches in processing mathematics information, and problem solving performance

	Solving Metacogntive Problems	Doing Associative Study	Doing Strategic Study	Problem Solving Performance
Solving Metacogntive Problems	1	.64	.51	-.03
Doing Associative Study		1	.39	.15
Doing Strategic Study			1	.16
Problem Solving Performance				1

(a) r-value interpretation is based on Pett (1997)

r-value__	**Description**
0.81 – 1.00	Very Strong
0.49 – 0.80	Strong
0.25 – 0.48	Moderate
0.00 – 0.24	Weak

Furthermore, a negative relationship manifests between solving metacognitive problems and problem solving performance. This finding suggests that mathematics majors' frequent practice on approaches in solving metacognitive problems do not help them to perform better in problem solving. This poses a challenge to teachers on the need to enhance metacognition training to ensure that it will improve students' problem solving ability.

CONCLUSIONS AND RECOMMENDATION

The study concludes that students who apply associative and strategic study methods perform well in solving meta-cognitive problems.

It is, therefore, highly recommended that more personal and contextual mathematical experiences must be provided to students in the classroom through real life problem solving to enhance problem solving skills and performance. This will also allow them to intensify training and practice on metacognition, doing deep-associative study, and doing strategic study to assure its importance in processing mathematical information, and ultimately, a possible significant effect to their performance.

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