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EXPLORING METACOGNITIVE REGULATION AND STUDENTS' INTERACTION IN MATHEMATICS LEARNING: AN ANALYSIS OF NEEDS TO ENHANCE STUDENTS' MASTERY

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Abstract

Purpose of the study: This study is a survey of teachers' and students' perceptions of mathematics teaching and learning practices. The purpose of this study was to determine the level of learning practice based on metacognitive regulation strategies and student interactions to increase student achievement.

Methodology: A quantitative survey of 45 mathematics teachers and 52 Form 2 students using questionnaires was conducted to look at the level of mathematics teaching and learning practices and to obtain agreement on the need for learning metacognitive regulation strategies and student interactions.

Findings: The findings show that teachers' level of knowledge about metacognitive regulation strategies, level of teaching and learning based on metacognitive regulation and student interaction strategies, and level of mastery and application of student mathematics skills are moderate.

Implications: Furthermore, teachers and students agree that teaching and learning practices based on metacognitive regulation strategies and student interaction need to be implemented as a mathematics learning intervention to enhance students' mastery in mathematics. Implications of this study led to the suggestion that metacognitive regulation strategies be used as a best practice and guide to transform teaching and learning methods.

Novelty/Originality of this study: This study is an extension of the study of aspects of metacognitive skills by looking at both the view of the teacher and the student. Results show that students' metacognitive skills and interactions are related to and influence learning.

Keywords: *Metacognitive Regulation, Students' Interaction, Students' Mastery, Mathematics Learning, Teaching and Learning Practices, Metacognitive Skills.*

INTRODUCTION

Excellence in mathematics learning is a measure of students' ability to manage their learning well while mastering what is being learned and improving their level of mathematics skills. One of the key factors that have been proven to influence student learning processes is metacognitive skills (Du Toit & Du Toit, 2013; Phi, 2017; Menz & Cindy Xin, 2016). A key component of metacognitive skills acting and ensuring students master the lessons is metacognitive knowledge and regulation (Amin & Sukestiyarno, 2015; Abdul Qohar & Utari Sumarmo, 2013; Zumbrunn, Tadlock & Roberts, 2011). Metacognitive knowledge and regulation are positive motivators that will keep students active during the learning process. According to Schraw & Moshman (1995), metacognitive regulation will work by ensuring students manage they are cognitive by controlling, organizing and taking better and systematic actions. Metacognitive regulation consists of three subcomponents, which are constructs that ensure the emergence of processes or agents that shape the construction of new knowledge (Hasbullah, 2015; Schraw & Moshman, 1995; Zumbrunn, Tadlock & Roberts, 2011).

The first construct is planning, which is the situation where students will set learning goals by developing questions about how to learn, and how to build connections between existing knowledge that can be used as a current learning medium (Moos & Ringdal, 2012). The second construct is monitoring, in which students will always be aware of the level of understanding, strategies used and creating measures to reduce error and ensure that new knowledge is built into the accurate learning concept (Stephanou & Mpiontini, 2017). The last is the evaluating construct, which acts to ensure that the new knowledge gained is accurate, the strategy is applied appropriately and reflects the strength of the understanding (Schraw & Moshman, 1995). This metacognitive regulation skill plays a major role in solving mathematics problems, as it will ensure that students' mathematics problems are more complete and accurate (Su, Ricci & Mnatsakanian, 2016; Cheng, 2011).

However, these metacognitive regulation skills will be optimized through learning as students are exposed to collaborative activities, interactions and creative tasks (Adnan & Arsad Bahri, 2018). According to Wood (2017), learning activities and processes that encourage active student engagement and can have optimal interaction effects should be considered when teachers are choosing teaching and learning approaches. According to Smith & Mancy (2018), when students interact during learning, the discussions between them focus heavily on metacognitive aspects, and this will lead to training for improving their metacognitive skills. According to Dagarin (2005) and Jose(2016) interactions are in many ways including, students-teachers, students-students, and even students-themselves. In conclusion, these interactions can form a mediator or factor in learning outcomes whether the internal factors that are students' skills, abilities and readiness and, external factors are seen to affect the learning as well, learning materials, learning activities and the interaction itself. Interaction is a way for students to express and share ideas, through the use of numbers, symbols, diagrams and so on, whether verbal, written or visual (NCTM, 2000).

In the context of successful mathematics learning, mastery of mathematical concepts and problem-solving skills is still a key issue. A low level of mastery is still a major issue in the development of the mathematics curriculum. From the perspective of practice and metacognitive research, metacognitive skills can help students to master mathematics better. Studies conducted by Do Toit & Kotze (2009), Su, Ricci & Mnatsakanian (2016), Shaw (2008), Hasbullah (2015), Palennari, Taiyeb & Siti Saenab (2018), Van der Stel, Veenman, Deelen & Haenen (2010), Nongtodu & Bhutia (2017), and Leidinger & Perels (2012) have shown that metacognitive skills are very important in influencing mathematics learning and improving student achievement. However, according to Tarricone (2011), metacognitive has certain taxonomy and even the position of the components of metacognitive regulation is seen as a secondary cluster rather than knowledge and experience of metacognition. According to Du Toit & Kotze (2009), metacognitive regulation is a precursor to activities and thinking processes as students complete mathematics tasks. It can be concluded that mastery of mathematics is determined by the practice of students' metacognitive regulation skills. According to Menz & Cindy Xin (2016), Nik Pa (1999) and Rillero (2012), interaction during learning can lead to learning practices based on metacognitive strategies. The question is whether mathematics learning today has implemented the practice of metacognitive regulation strategies, whether mathematical learning processes and activities have been implemented to encourage students' metacognitive regulation practices and whether there is a need for mathematical learning practices that can enhance student achievement through metacognitive regression and interpersonal practice.

Therefore, to complement existing gaps and emerging issues, a survey needs to be conducted to look at students' level of mastery and mathematics skills, level of teaching and learning of mathematics based on metacognitive regulation strategies and level of need for the practice of metacognitive regulation strategies. Besides, further studies are needed to see the influence of metacognitive regulation as students solve mathematical problems and the impact on students' mathematical learning processes.

METHODOLOGY

The objective of this study was to examine teachers' and students' perceptions of teaching and learning practice based on metacognitive regulation strategies. To achieve this objective, several research questions have been developed, namely:

i. What are the levels of mastery of mathematical concepts and applications of students' mathematics skills?

ii. What are the levels of learning practices of metacognitive regulation strategies and student interactions for mathematics learning?

iii. What are the levels of teachers' knowledge of metacognitive regulation strategies?

iv. What is the level of teacher teaching practice based on students' metacognitive regulation strategies and student interactions?

v. Is there a need for the practice of metacognitive regulation strategies and student interactions to increase mathematical mastery based on teacher and student perceptions?

The study involved 52 Form 2 students and 45 mathematics teachers in the Pasir Gudang district, Johor, Malaysia, which were selected using the purposing sampling technique. This study aims to gain students' and teachers' perceptions of the level of mathematics mastery as well as the practice of metacognitive strategies and student interaction in current mathematics learning. These survey methods and sampling techniques can be used to obtain a description of a situation and also to reduce costs and to visualize the entire population (Mohammad Najid, 1999 in Mustapha, 2017).

The instruments of the study were used two separate questionnaires that were distributed to teachers and students. Items in both surveys were identified and modified from inventories such as the Junior Metacognitive Awareness Inventory, Jr.MAI (Sperling, Howard, Miller & Murphy, 2002), the General Metacognitive Strategies Inventory, GMSI (Farieri, 2013), Motivated Strategies For the Learning Questionnaire, MSLQ (Pintrich & DeGroot, 1990) and the Inventory of Metacognitive Strategies, IMS (Takacova, 2016). In addition, items used by some researchers such as Jamian & Ismail (2013), Ahmad &Tamuri (2010) and Yahaya, Saidun & Rahman (2008) have been modified to meet the needs of this study. The table below shows the constructs, dimensions and number of items contained in the two questionnaires.

To ensure that the questionnaire complies with and qualifies as a research instrument, experts have been referred to review and evaluate the content of the questionnaire items. Experts have made it possible for the language, sentence structure, indicators, dimensions, and suitability of the respondents' maturity level. Furthermore, to ensure that the tool has the characteristics of stability, consistency, friendliness, and accuracy as stated by Nunally& Bernstein (1994) as cited in Mustapha (2017), Cronbach's Alpha model was used to obtain a reliability index on the questionnaire items. To this end, a pilot study was conducted with 16 Form 2 students and 15 teachers used as a sample. According to the recommendations of Hill (1998) and Julious (2005) as cited in Johanson & Brooks (2010), a pilot study sample of survey-based studies, quite enough sample size of at least 12 samples. As a result of testing the reliability index through this Cronbach's alpha model, the researchers found that the overall alpha index value for both questionnaires was *a* = 0.96 for the teacher questionnaire and *a* = 0.817 for the student questionnaire. It can be interpreted that these two questionnaires have excellent levels of trust and are suitable for use as instruments in assessing teachers' and students' perceptions of the practice of metacognitive regulation strategies.

Table 1: The Constructs Dimensions and Number of Items in the Teachers' Questionnaire and Students' Questionnaire

Questionnaire	Construct	Dimension	Number of Items
Teacher	Section A Teachers' demographic data	i. Gender ii. Teaching experience	2
	Section B Teacher knowledge level of the metacognitive regulation strategy	i. Knowledge of metacognitive skills ii. Knowledge of metacognitive strategy iii. Knowledge of thinking and creative activity	5
	Section C Levels of the teaching of metacognitive regulation strategies and student interactions	i. Implementation of interaction, discussion, collaborative activities ii. Metacognitive activity, planning, monitoring and evaluation	14
	Section D Levels of need for the practice of metacognitive regulation strategies and student interactions to improve mathematical mastery	i. Requirements for interaction activities, group discussions ii. Need for metacognitive regulation strategies, planning, monitoring and evaluation	13
Student	Section A Students' demographic data	i. Gender ii. Recent test performance	2
	Section B Mastery level mathematical concepts and applications of mathematics skills	i. Mastery of concept ii. Mastery of skills iii. Ability to apply mathematics skills	6
	Section C Levels of learning of metacognitive regulation strategies and student interactions	i. Interaction practices, discussions with peer ii. The practice of planning, monitoring and evaluating learning	14
	Section D Levels of need for the practice of metacognitive regulation strategies and student interactions to improve mathematical mastery	i. Requirements for interaction activities, group discussions ii. Need for metacognitive regulation strategies, planning, monitoring and evaluation	16

Source: Research questionnaire

The data were analyzed using computer software, *Statistical Packages for the Social Science, SPSS* version 23. Due to the questionnaire using a 4-point Likert scale, data were collected descriptively in the form of percentages, mean and standard deviation. To interpret the data, the following **Table 2** was used as a guide to see the mean position of each questionnaire.

Table 2: 4-Point Likert Scale Mean Range by Four Levels.

Mean Range	Interpretation
1.00 – 1.74	Low
1.75 – 2.49	Moderate Low
2.50 – 3.24	Moderate-High
3.25 – 4.00	High

Source: Alico & Guimba (2015)

RESULTS

The following table shows the demographic distribution of the respondents.

Table 3: Teachers' demographic data

Teachers' Demographic		Number of Respondents	Percentage (%)
Gender	Male	6	13.3
	Female	39	86.7
Teaching experience	5 years and less	6	13.3
	6 - 10 years	7	15.6
	11 - 15 years	22	48.9
	16 years and above	10	22.2

Table 4: Students' demographic data

Students' Demographic		Number of Respondents	Percentages (%)
Gender	Male	18	34.6
	Female	34	65.4
Recent Test Performance	Poor	18	34.6
	Medium	19	36.5
	High	15	28.8

Based on the demographic distribution of respondents in **Table 3** and **Table 4**, it was found that female teachers had a total of 39 people with a percentage of 86.7%, exceeding the number of male teachers with only 6 people with 13.3%. In addition, a total of 22 teacher respondents with teaching experience between 11-15 years showed the highest percentage of 48.9% and the lowest was teachers with a teaching experience of fewer than 5 years of only 6 people with 13.3%, involved in this study. Meanwhile, the number of female students was higher at 34 with a percentage of 65.4%, compared to only 18 boys with 34.6%. Besides, the performance for the latest test obtained by the students involved in this study showed that the scores were 34.6%, 36.5%, and 28.8%, respectively, for the poor, medium and high performing levels with a total of 18, 19 and 15 students.

Further, the researcher summarized the constructs in both the teacher questionnaire and the student questionnaire in the following table.

Table 5: Descriptive Analysis of Practice Levels Based on Teacher and Student Perceptions

Perception	Construct Description	Descriptive Analysis		Level's Interpretation
		Mean	SD	
Teacher n=45	Teacher knowledge level of the metacognitive regulation strategy	2.82	0.786	Moderate-High
	Levels of the teaching of metacognitive regulation strategies and student interactions	2.56	0.581	Moderate-High
	Levels of need for the practice of metacognitive regulation strategies and student interactions to improve mathematical mastery	3.27	0.616	High
Student n=52	Mastery level mathematical concepts and applications of mathematics skills	2.04	0.66	Moderate Low
	Levels of learning of metacognitive regulation strategies and student interactions	2.52	0.756	Moderate-High
	Levels of need for the practice of metacognitive regulation strategies and student interactions to improve mathematical mastery	3.33	0.681	High

Based on the results obtained in **Table 5**, the highest mean analysis was for "Levels of need for the practice of metacognitive regulation strategies and student interactions to improve mathematical mastery" from students' perceptions of mean 3.33, while the lowest mean was for analysis of "Mastery level mathematical concepts and applications of mathematics skills", perceptions of students with a mean of 2.04.

Further, the descriptions of the questionnaire construct as a whole indicate the simplest possible interpretation. The "Teacher knowledge level of the metacognitive regulation strategy" was at a mean level of 2.82 and a standard deviation of 0.786. "Levels of teaching and learning of metacognitive regulation strategies and student interactions" perceptions of teachers and students showed moderate to high levels of mean scores of 2.56 and 2.52 and standard deviations of 0.581 and 0.756. According to teachers' perceptions, "The level of need for the practice of metacognitive regulation strategies and student interactions to improve mathematical mastery" is high with a mean of 3.27 with a standard deviation of 0.616. These results suggest that learning strategies for metacognitive regression are poorly practised so that students' mathematical mastery and skills are not as good and based on perceptions of students and teachers, the practice of metacognitive regulation skills is essential for improving math performance.

DISCUSSION

This study aimed to examine students' and teachers' perceptions of the practice of metacognitive regulation strategies in teaching and learning to improve student mathematics mastery. In this study, the results show that the level of mastery and application of mathematical skills among students is still low. Although some students achieve high test results, they still feel that their level of mastery and mathematical skills are moderate. Abdullah, Rahman & Hamzah (2017) study conducted on 304 students to look at the practice of students' metacognitive skills in solving non-routine mathematics problems, found 38.8% with a total of 118 and 22.7% with 69 of the total sample showing very low performance and mathematics skills. These results and the findings that researchers have gained from this study show similar trends where the level of mastery and application of mathematical skills is low while the practice level of metacognitive regulation learning strategies is moderate. In line with the results of the study by Ibrahim & Iksan (2017), the level of metacognitive regulation among students was moderate. They are conducted a study involving 145 Form 2 and Form 4 students to look at metacognitive strategies in teaching and learning to improve high-level thinking skills.

Similar results were also obtained by Haryani, Masfufah, Wijayati & Kurniawan (2018) who found that students' metacognitive skills were still at a moderate level despite treatment being implemented in their experimental studies. This situation exists as the implementation of a metacognitive learning strategy greatly influences student learning practices. A studied by Hasbullah (2015) shows that students are more motivated and enjoy learning through the practice of metacognitive learning strategies than conventional learning practices. In metacognitive strategies, interaction is a priority as reported by Smith & Mancy (2018) in their study, which shows that interactions and discussions between students enhance aspects of collaboration and metacognitive skills. This is in line with the results of this study which indicate the high level of student perceptions of the level of activity requirements or learning strategies of metacognitive regulation. Students agree that metacognitive regulation strategies can encourage interaction while increasing motivation, interest, and action in mathematical learning. These results are in line with studies by Salawati Asmuni (2011), Suriyon, Inprasitha & Sangaroon (2013), Du Toit & Kotze (2009), Du Toit & Du Toit (2013) and Palennari, Taiyeb & Siti Saenab (2018) which shows that students' behaviour and actions change in learning through metacognitive strategies. According to the suggestion by Ibrahim & Iksan (2017), metacognitive strategies are very important and need to be adapted and applied in the teaching and learning process. Studies by Leidinger & Perels (2012), Hasbullah (2015), Listiani, Wiarta & Darsana (2014), Nongtodu & Bhutia (2017), Cheng (2011), Shaw (2008), Su, Ricci & Mnatsakanian (2016), Stephanou & Mpiontini (2017) and Idris, Abdullah & Sembak (2015) show a significant relationship between activity in metacognitive strategies and student achievement. Kazemi, Fadaee & Bayat (2010), Cheng (2011) and Stephanou & Mpiontini (2017) find that students' metacognitive skills are widely used to solve math problems, especially non-routine problems.

However, the results show that teacher instructional practices based on metacognitive regulation strategies are still at a moderate level. The results also show that the level of teachers' knowledge of metacognitive skills and metacognitive regulation strategies are also moderate. In line with the study by Ahmad, Febryanti, Fatimah & Muthmainnah (2018) who found that teacher teaching practices lack cognitive and metacognitive development as their main targets. They found that students' metacognitive abilities and skills could not be fully developed. The results of Alzahrani's (2017) study indicate that metacognitive teaching or metacognitive strategies need to be planned and targeted according to the purpose of the learning intervention, which can then be implemented effectively and successfully. The results of Alzahrani (2017) are also in line with the findings of teachers' perceptions in this study which show that the level of need for metacognitive regulation learning strategies is high to increase students' mathematics mastery. Teachers agreed to implement a metacognitive regulation strategy as an intervention in mathematics learning. Also, teachers agree that through discussion and interaction between students can enhance active engagement and can thus stimulate the development of student metacognitive regulation. This is in line with Schoenfeld's (1992) view that in order to produce mathematical thinkers in the future, teachers or instructors must first set objectives in each mathematics teaching through stimulation and open up the cognitive and motivational aspects of students.

CONCLUSION AND RECOMMENDATION

The objective of this study was achieved along with results obtained, showing that teaching and learning practices based on metacognitive regulation strategies are at a moderate level. This means that it is only in certain situations or learning activities that students optimize the application of metacognitive regulation skills. These results also indicate a significant relationship with the student's level of mathematics mastery. Therefore, teachers should increase their knowledge of the latest pedagogy and need to transform teaching by increasing activities that can enhance the interaction effect. The results also show that teachers and students acknowledge that metacognitive regulation skills can be trained and enhanced through active involvement in learning by optimizing the impact of interactions with peers or teachers. In addition, it can be seen that metacognitive regulation skills are an important factor in influencing student achievement. Based on this decision, one of the suggestions that can be made is to develop a mathematical learning intervention to improve mathematical mastery. These metacognitive regulation strategies can be successfully applied or may be integrated with other methods such as integrating technology or through web-based learning, mobile applications or the internet. Further study can be done by developing a model or module of pedagogical learning. In addition, further studies may be performed in support of this result by possibly changing the subject, sample or using different study designs.

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M.A.A.B designed the study, prepared the original draft, and contributed to writing the paper. N.I contributed to writing and provided editing.

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