METACOGNITIVE STRATEGIES IN SOLVING QUADRATIC EQUATION WORD PROBLEMS AMONG FORM FOUR SECONDARY STUDENTS

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ABSTRACT

This research was done to determine students' level of metacognitive in answering quadratic equation word problems. Survey and one-group pretest-posttest experiment designs were used in this research, two phases were involved. The first phase was done to determine which group of students used metacognitive strategies frequently when answering word problems and to determine the level of metacognitive activities among the groups by using time line graphs. While the second phase was done to determine the effect of metacognitive training to the group of achievers who less frequently used metacognitive strategies and group of achievers who portrayed low level of metacognitive activities when answering quadratic equation word problems. Research sample consists of ninety form four students in one secondary school in Batang Padang. In the first phase, data were collected from answer sheets and metacognitive questionnaires. Students' responses to the metacognitive red flag questions also had become an indicator of the presence of metacognitive strategies used by the students while solving mathematical word problems. For the second phase, data were collected from observations and answer sheets. The finding of the first phase of the research showed that the higher achiever group was the group that used metacognitive frequently when answering the word problems and level of metacognitive activities varies among groups of achievers. The finding in the second phase showed that metacognitive training enhanced students' performances and problem solving activities in quadratic equation word problems. As a conclusion, metacognitive strategies can help students to overcome the difficulties in mathematics problem solving. The implication of this study is metacognitive strategies should be integrated by teachers in learning and teaching for helping students in solving quadratic equation word problems.

STRATEGI METAKOGNITIF DALAM MENYELESAIKAN MASALAH BERAYAT PERSAMAAN KUADRATIK

ABSTRAK

Kajian ini dilakukan untuk menentukan tahap metakognitif pelajar dalam meyelesaikan masalah persamaan kuadratik berayat. Kaedah tinjauan dan eksperimen satu kumpulan praujian- pascaujian digunakan dalam kajian ini yang melibatkan dua fasa. Fasa pertama dilaksanakan untuk menentukan kumpulan pelajar yang menggunakan strategi metakognitif secara kerap apabila menjawab masalah berayat dan untuk menentukan tahap aktiviti metakognitif antara kumpulan pelajar dengan menggunakan graf tingkahlaku melawan masa. Fasa kedua dijalankan untuk menentukan kesan latihan metakognitif kepada kumpulan pelajar yang kurang kerap menggunakan strategi metakognitif dan kumpulan pelajar yang menunjukkan tahap aktiviti metakognitif yang rendah semasa menjawab masalah berayat persamaan kuadratik. Sampel kajian terdiri daripada 90 orang pelajar tingkatan empat di sebuah sekolah menengah di Batang Padang. Dalam fasa pertama, data telah dikumpulkan daripada kertas jawapan dan soal selidik metakognitif. Respons pelajar terhadap soalan-soalan "amaran" metakognitif juga menjadi penunjuk kewujudan penggunaan strategi metakognitif oleh pelajar semasa menyelesaikan masalah matematik berayat. Bagi fasa kedua, data dikumpul daripada pemerhatian dan kertas jawapan. Dapatan dalam fasa pertama kajian menunjukkan bahawa kumpulan berpencapaian tinggi adalah kumpulan yang menggunakan metakognitif secara kerap apabila menjawab masalah berayat dan tahap aktiviti metakognitif berbeza antara kumpulan pelajar. Dapatan dalam fasa kedua menunjukkan bahawa latihan metakognitif dapat mempertingkatkan pencapaian pelajar dan tahap aktiviti metakognitif pelajar dalam menyelesaikan masalah persamaan kuadratik berayat. Kesimpulannya, strategi metakognitif dapat membantu pelajar dalam mengatasi kesukaran dalam menyelesaikan masalah matematik. Implikasinya, strategi metakognitif seharusnya diintegrasikan oleh guru dalam pembelajaran dan pengajaran untuk membantu pelajar dalam menyelesaikan masalah berayat persamaan kuadratik.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

If you have a bunch of keys to open a door, you should know that only one right key will open the door. What should you do to get the right one? Should you try it one by one or should you identify the characteristic of the door lock in order to open it? If you ask me, I would rather try to identify the characteristic or suitability of the key and the door lock, instead of trying it one by one as it is time-consuming. This ability also will help me during emergency time as I don't want to waste my time in front of the door for a long time. Let us apply this situation in mathematics with the bunch of keys represents the cognitive knowledge that you have while the door represents the problems, the ability to

identify the characteristic of the key to decide which ones will fit in is metacognitive skill and opening the door is the answer or the goal.

Malaysian students who have gone through what Streefland (1991) calls a mechanistic education have emphasized on verifying and applying these rules to problems that are similar to previous one. According to the mechanistic point of view, mathematics is a system of rules and algorithm. The students answer the question, according to the rule and procedure that they have already memorized. It is the situation where teacher actively explains the material, provides example and exercises and students act like a machine, they listen, write and perform the task that initiated by the teacher. Students often do not see the connections between mathematics and real life with an absence of discussion and interaction in the class on real life application. It is, therefore, not surprising that their mathematical experiences lack meaning and purpose. This may also explains why students, who are successful mathematical problem solvers in school, fail to use mathematical insight when making decisions in real life. Word problems enable mathematics to be related in real life as students could see the dynamic of mathematics and how close they are with mathematics in their real life. Word problem in mathematics is becoming something that students wish to avoid as they do not see any number inside it. What they see are only words that contain relational statements as the sentences express a numerical relation between two variables. They find that it is hard for them to translate the statement into numbers and decide what approach need to be used. Word problem-solving requires more thinking process and analyzes beyond the keyword.

In the context of Malaysian mathematics education, one of its goals is to develop students' thinking, in order to increase their ability to think in a systematic, analytical, critical and logical way, ability to solve the problem, ability to apply knowledge of mathematics in life and being able to see the world in the real perspective (MOE, 2013). The main content of the Malaysian Education Development Blueprint (2013-2025) is to prepare the young generation with enough skills to meet the challenges of the 21st century. Low-level thinking in the Blooms taxonomy described as remember and understand the information or knowledge while high level thinking is expressed as a development of students thinking towards their lifelong success (Silbey, 2005). Students with average disabilities are unable to distinguish between relevant and irrelevant information and having difficulty paraphrasing and imagine problem situation (Shanon, 2005). There are a lot of methods introduced to overcome students' inabilities to answer word problems. Means-end analysis, mean calculated value or trial and error, a direct translation; concrete represential abstract (CRA) methods are the examples of the methods that widely used to solve word problems in mathematics (Brittany & Teressa, 2014).

Direct translation has become one of the methods that usually being used in mathematical word problem-solving. Students tend to translate directly the keywords without understanding the problem first. This method has been used widely by students during middle school. Students start to memorize the keyword such as total and sum for addition process, difference and less for subtraction and other keywords. However, this approach is suitable for simple problems only which exist during primary school only.

Students start having problems during secondary school as the problem become more complex, students do not able to identify the key word and the relevant information that they need in order to solve the word problems. Van de Walle (2004) mentioned that the "key words are misleading", "many problems do not have key words" and "key words send a terribly wrong message about doing math". Stark (2008) said that the difficulties with word problems being the inability to grasp key information and find the relevancy to the problem. Based on their findings, even high-achieving students struggled with word problems. Some problems require analysis of the unknown while others provide extraneous, too little or incorrect data. Some can be solved in more than one way or have more than one correct answers and some require multiple steps to attain a solution (Baroody, 1987). In addition, problems can be presented in written or oral form and very rarely present themselves in a nicely formulated textbook manner (Carraher, Carraher & Schliemann, 1987).

However, Schoenfield (2007) mentioned that metacognitive skill as essential elements that determine ones' success or failure in problem-solving. It is because, through metacognition, it enables students to become more flexible when solving the problem as students with metacognition abilities have the ability to change their strategies when it do not lead them to the answer. This type of ability will lead them to become the successful problem solvers. Most of the unsuccessful problem solvers are not flexible with their strategies as they keep to the same strategies, even do it does not lead them to the answer. Researchers, that employ metacognitive training, have also demonstrated that students, who are trained to monitor and control their own cognitive

process for solving mathematics problems, do better than untrained students (Cardella-Ellawar, 1995; Oladunni, 1998). Metacognitive is features of an expert problem solver (Glaser &Chi, 1988).Through metacognitive strategies for example plan, it enables the experts to adapt to changing condition, eliminate unnecessary step and apply alternative in order to solve problems.

According to Pugalee (2001), metacognition is important in that it makes sure that appropriate knowledge and strategies are used throughout the problem solving process. In other words, students use metacognition to explain their ways of thinking while solving problems (Ebdon et al., 2003). According to Larkin (2000), metacognition is important for the development of critical thinking and learning.

In a quality learning environment, the student should be able to learn how to learn, how to remember and how to effectively control and direct her own learning (Loyens et al., 2008). Metacognition is considered an essential component of effective learning, for it enables individuals to monitor and regulate their own cognitive performance (Schraw & Graham, 1997). Similarly, Hartman (1998) maintained that metacognitive awareness allows one to control and self regulate his/her thinking and learning processes and learning outcomes. According to Kuiper (2002), metacognition, once learned, supports reflective thinking, helps problem solving, gives responsibility and improves self confidence for quicker decisions for the rest of one's life. Kuiper (2002) argued that students with better self regulation and metacognitive strategies, regardless of their grade/level, achieve higher academic accomplishment. According to O'Neil and Abedi (1996), there is a significant correlation between achievement and metacognition.

Likewise, Gama (2000) held that metacognition plays a pivotal role in oral comprehension, reading comprehension, problem solving, attention, memory, social cognition, and certain types of self-control and self instruction. As a result, as stated by Yurdakul (2004), metacognition is closely intertwined with a number of significant concepts like learning to learn, life-long learning, flexible learning, independent learning and gaining responsibility for learning, and it is one of the indispensable variables in more effective education. Metacognition is generally described in the literature as a crucial part of successful learning and an essential component that enables one to study strategically and to solve problems successfully (Pugalee, 2001).

1.2 Statement of the Problem

Our education is based on the exam-oriented system, as we tend to drill on skill to equip our students for the exam (Salleh, 2007). Our students will be good in memorizing the step in problem solving but when they encounter the word problems that requires students to construct their own strategy, they will give up as it requires more than what they could offer. Most of the students spending a lot of time deciding on how they can start solving the problem as choosing the inappropriate strategy will lead them to the failure. So, what is the use of all the skills being taught in the class if they do not know when or where they can apply it, when solving quadratic equation word problems? That is why metacognitive strategies are important along with the cognitive strategies as both

these strategies equipped each other (Livingston, 2003). Metacognition enables students to know where and when to apply the knowledge that they had and not only repeating the same thing. Metacognitive knowledge enables students to know the weakness and the strength of the strategy as one shoe doesn't fit all (Schneider & Pressley, 1989).

Quadratic equation is one most conceptually challenging topic in mathematics curriculums (Vaiyavutjamai & Clements, 2006). Even though quadratic equations play an important role in secondary school curriculum around the world, studies concerning teaching and learning quadratic equations are quite rare in algebra education research (Kieran, 2007; Vaiyavutjamai & Clements, 2006). Students tend to simply memorize the procedures and formulas to solve quadratic equations as they have little understanding of the meaning of the quadratic equations and do not understand what to do and why they are doing it. That is why this research focuses on quadratic equation word problem as it requires students to think out of the box and enables students to apply quadratic equation into a real life situation. Students usually repeat steps that they have been memorized through the repetitive exercise by their teachers when solving mathematics problems. Students have struggled to understand quadratic functions (Ellis & Grinstead, 2008). When students solve quadratic equation questions, they only focus on how to do factorization, but not on how the factorization can be applied into our daily life problems. Metacognitive enables students to know when, where and why they are using certain strategy, not only on how they should do it.

Research has confirmed that high metacognition can produce high achievement. However, Alexander, Carr and Schwaneflugel's (1995) indicate that research does not

support the belief that high achievers have better or more advanced metacognitive abilities in all areas of metacognition, but it appears that high and low achievement children are equally capable of using some metacognition. Former studies point out that there is a significant relation between metacognition and academic achievement (Case, Harris & Graham, 1992; Desoete & Roeyers, 2002). There was weak but no significant correlation between student's mathematics achievement and their metacognition. (Chin, Lin, Chuang & Tuan, 2007). The analysis of group effects indicate that on average (across time) there is a differences between students of all GPA levels (i.e. between high, average and low achievers), and not just between high and low-achieving students (Downing, 2009). It is well known that both memory performance and metacognitive performance are worse for young children than for adults (e.g., Pressley, Levin, & Ghatala, 1984; Wellman, 1978; Yussen & Levy, 1975).

Past research has focused on a number of variables that can produce differences in metacognitive performance between groups. These factors can be classified into three broad categories: task demands, measurement difficulties, or differences in ability (Keleman, Frost and Weaver, 2000). Weaver and Bryant (1995) found that metacognitive accuracy in text comprehension depended on the readability level. Few studies have examined important aspects such as individual differences and metacognitive strategies (Proulx, 2011). A significant relationship has been identified between GPA and Information Processing (INP), ability to Select Main Ideas (SMI), Self-Testing (SFT), Motivation, Time Management, and Concentration (CON) (Kern et al., 1998). Human behavior depends on the ability to effectively introspect about our performance. For

simple perceptual decisions, this introspective or metacognitive ability varies substantially across individuals (Song, 2011). Recently, cognitive scientists have begun to marshal the methods of individual differences research to understand the variety of inter-individual performance (Vogel, 2008). In some recent studies with on-campus face-to-face university students, it was found that a relationship exists between academic performance and some students' metacognitive knowledge characteristics (Romainville, 1994). In addition, it was revealed that high achieving students seem to be aware of more cognitive rules and to evoke metacognitive knowledge about cognitive processes and cognitive results. They have also been found to be able to describe more frequently their cognitive strategies, in comparison with their low achieving counterparts (Chan, Jegede, Fan, Taplin, Yum, 1999).

Training of metacognitive skills also increases the achievement (Kramarski, Mevarech & Arami, 2002; Lioe, Fai & Hedberg, 2005; McDougall & Brady, 1998; Schoenfeld, 1985; Schurter, 2002; Teong, 2002; Victor, 2004). Metacognitive training was beneficial to the low achievers. Metacognitive training enabled the low achievers to make progress and solve the same number of problems on the post-test as the normal achievers solved on the pre-test (Pennequin, 2010.). Research by Chinnapan & Lawson (1996), McCrindle & Christensen (1995) and Delclos & Harrington (1991) provide evidence that providing metacognitive training has a significant impact on students' mathematical performance. Lower achievers benefited from the MT method, but their gains did not come at the expense of higher achievers (Mevarech, 2003). There is no significant evidence that the benefits from metacognitive training on mathematical word

problem solving performance vary with the level of students' mathematical achievement (Teong, 2002).

So, this research is on metacognitive strategies on solving quadratic equation word problems as the researcher would like to investigate whether the metacognitive strategies can help students develop a meaningful experience while solving word problems.

1.3 Objectives of the Study

This research aims to determine the effect of metacognitive strategies on answering quadratic equation word problems towards group of students that are not using metacognitive strategies frequently and students that portray low level of metacognitive activities when solving quadratic equation word problems.

1.4 Research Question

The research questions are mentioned as below:

1.4.1 Which group: higher, middle or lower achievers uses metacognitive strategies frequently when answering word problems?

1.4.2 What is the level of metacognitive activities of each of the group achievers?

1.4.3 What is the effect of using metacognitive strategies in answering mathematics word problems towards students that are not using metacognitive strategies frequently and students that portray low level of metacognitive activities when solving quadratic equation word problems.

1.5 Conceptual Framework

Figure 1 describes the conceptual framework of the study where students' achievement in mathematics was influenced by the usage of metacognitive strategies and the level of metacognitive activity during problem solving. It is expected that low achievers student used metacognitive strategies not frequently compared to middle and high achiever. It is also expected that low achiever used lower level of metacognitive activities compared to the other groups of achievers. It is assumed that after the group of students that not frequently used metacognitive strategies and group of students that portray low level on metacognitive activities received training their

performance and their level of metacognitive activities when solving quadratic equation word problems will be increased.

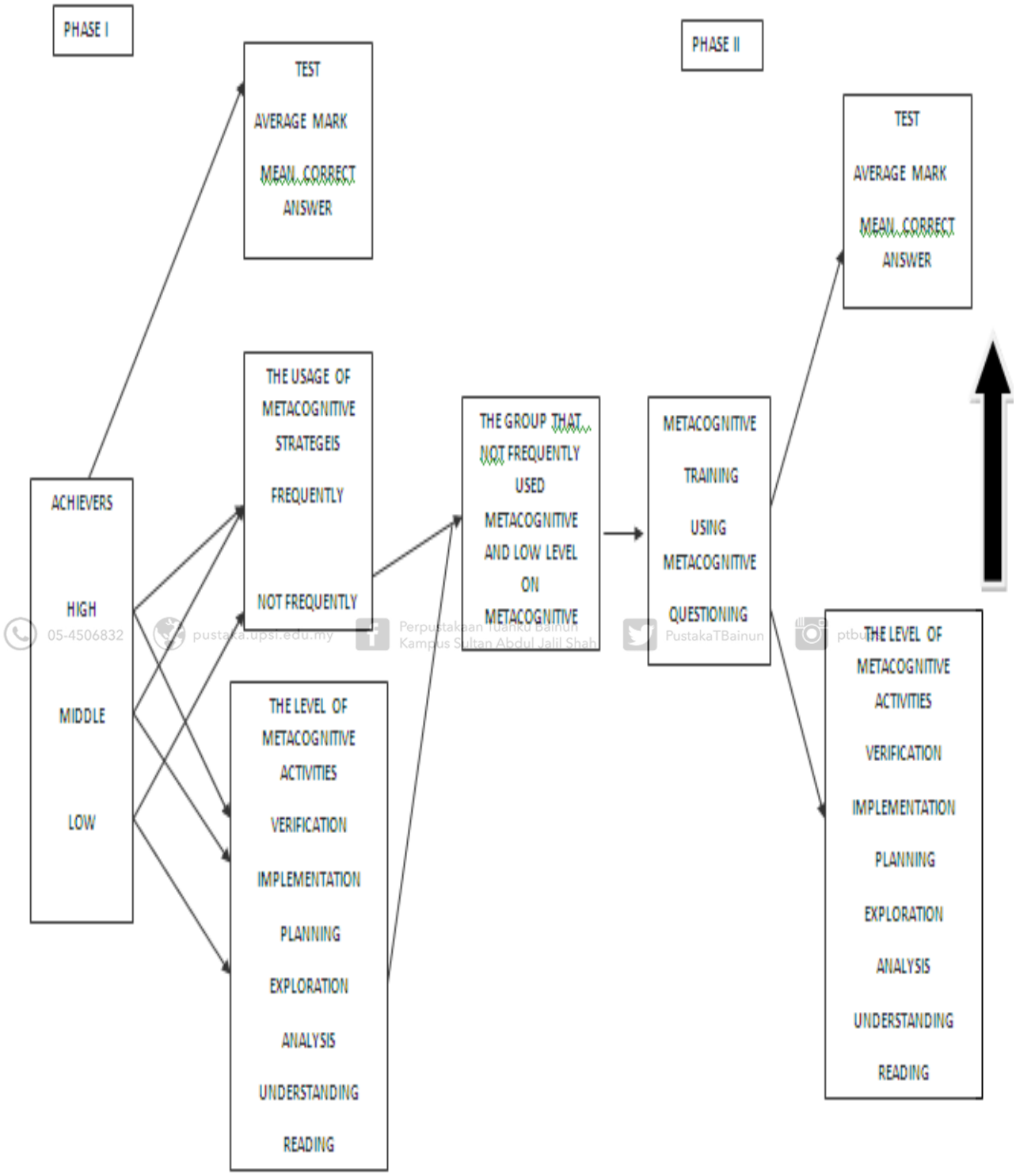

Figure 1.0 Conceptual Framework

1.6 Scope of the Study

This research is focused on the use of metacognitive strategies and the level of metacognitive activity of students while solving quadratic equation word problems.

1.7 Significance of Research

This research is important because this research can be a guideline for teachers on how they could plan an approach that is suitable in applying metacognitive strategies in the classroom. Teachers can create a classroom culture of inquiry which promotes mathematical habits of mind (Goos, 2000). This research is also important for students as through the development of metacognitive strategies, their performance in problem solving will also be improved. According to Pugalee (2001), metacognition is important in that it makes sure that appropriate knowledge and strategies are used throughout the problem solving process. According to Larkin (2000), metacognition is important for the development of critical thinking and learning. In a quality learning environment, student should be able to learn how to learn, how to remember and how to effectively control and direct their own learning (Loyens et al., 2008). Metacognition is considered an essential component of effective learning, for it enables individuals to monitor and regulate their own cognitive performance (Schraw and Graham, 1997).

This research is also significant to increase the awareness of Ministry of Education and educators where they can construct curriculum that support the usage of metacognitive in the classroom. Previous researches in metacognitive involve metacognitive training in problem-solving and word problems which shown a significant effect (Teong, 2003; Ozsoy, 2009; Mevarech, 2003). This research is also significant to the Curriculum Development center, as they can use the result of this research to plan mathematics curricular systematically and appropriately.

This research focuses on quadratic equation word problems. The reason for these problems are used is to discover how students solve the problems which are not routine to them. Through the usage of these problems, it allows students to apply the knowledge that they had already learned to the real word situation as most of the students having difficulties to relate what they learn with real world. It is also significant to prepare students for challenging workplace which drill practice seems to be not applicable. It also could prevent students from repeating the step that they had been memorizing through the repetitive exercise by teachers. Quadratic equation word problems also enable students to use their creativeness in order to answer the questions and think out of the box about the strategy that they should use.