ME – 24

The Role of Metacognitive in Problem Solving: A Case in Logarithm

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***Abstract*—**Problem solving ability is the most important goals of learning mathematics. It needs the ability to understand the problem, control, and monitor cognitive processes. Metacognitive skills are a very important element to assist individuals in identifying and formulating a framework or strategy work. The ability of problem-solving strategy is one of the important factors in solving the problem. Lack to draw up a proper strategy will lead to failure anyway in solving problems. This paper presents the results of tests and interviews with two students in solving of the logarithm. The first subject was a student who successfully solve problems with a high score while the second one was low. The results of this study showed that the student with high performance in mathematics able to plan the solve of problems, able to devise problem-solving strategies, monitor of each step, and evaluate the results. In another word, the student has the ability to use metacognitive skills. Conversely, the student with low mathematics performance indicates a failure in the use of metacognitive skills. The results showed a close connection between the problem solving and metacognitive. That skills will aid students in understanding, strategic planning, monitoring the completion of the steps, and evaluate the results obtained. In other words, metacognitive skills will help students in problem-solving.

Keywords: *metacognitive, problem solving, ratio*

I. INTRODUCTION

Problem-solving ability is the most important goal in mathematics learning. NCTM (*National Council of Teachers of Mathematics*) in the *Principles and Standards for School Mathematics* states: "*a major goal of mathematics is to equip students with the knowledge and tools that enable them to formulate, approach, and solve problems beyond Reviews those that they have studied*" [11]. It means the ability to use their prior knowledge to solve mathematical problems is the essence of mathematics. Problem-solving skills in mathematics is the ability to use prior knowledge or connecting mathematical concepts to solve problems that arise in actual situations or "*real world problems*". It means "*problems*" in problem solving are complex, non-routine, open-ended, and challenging. NCTM [11] states that "*Problem solving means engaging in a task for the which the solution method is not known in advance* .." It means there is no method or the regular way to solve the problem.

To success in solving the problems in mathematics required the ability to understand the problem, control and monitor a cognitive process, or in other words metacognitive skills in problem-solving [2,3,8,10,16], as well as the motivation to solve the problem [10]. Metacognitive skills are also very important components to assist individuals in identifying and formulating a framework or strategy to solve the problems (Davidson and Sternberg in [16]). The ability to design the strategy in problem solving is one of the important factors in solving the problem [3]. Failure to draw up a proper strategy will lead to failure anyway in solving problems. A factor that can hinder problem solving is the *mental set* that frame of mind that involves an existing model to represent a problem, the context of the problem, or procedure for solving a problem. Another term for the mental set is *entrenchment* when problem solver has the mental set that is entrenched, they are fixated on a strategy that usually works well in solving routine problems but that strategy does not work well in solving the non-routine problems [17].

Metacognitive terms in education have been quite widely used in recent times relating to optimizing students' skills in problem solving [6], or students' achievement [5]. The important goals in involves metacognitive in learning activities are to improve the quality of learning, especially in mathematics.

There is no agreement among experts on the definition of metacognitive formally, due to the many different kinds of knowledge and processes included in the metacognitive term [12]. But in general, there is a thread that can be drawn to connect the various opinions.

There are several definitions of metacognitive that developed in the field of cognitive psychology including Flavell and Brown. Flavell (in [9]) defines the metacognitive as: ".. *the ability to understand and monitor one's own thoughts and the Assumptions and implications of one's activities*." In other words metacognitive as the ability to understand and monitor the activity of thinking themselves and assumptions as well as the implications of that person's activities. This opinion emphasizes the metacognitive as the ability to understand and monitor the activity of thinking so that the metacognitive process of each person will be different according to their ability. Meanwhile, Brown (in [9]) defines the metacognitive with: "*... the degree to which learners are engaged in thinking about themselves, the nature of learning tasks, and the social contexts. ... as being comprised of activities for regulating and monitoring human learning*. " This means metacognitive as an awareness of cognitive activity itself, the method used to control the cognitive process themselves and a mastery of how to direct, plan and monitor cognitive activity. Brown's opinion emphasizing metacognitive as awareness of cognitive activity, in this case, the metacognitive relates to how a person aware of his thinking process. That awareness will materialize in the way a person organize and manage the activity of thinking process.

Flavell tends to view the metacognitive as a knowledge aspects about a person's cognitive while Brown tended to view as a process of arranging a person's cognitive. Although Flavell and Brown had a different point of view about metacognitive, but both argued that metacognitive includes two aspects are interrelated and interdependent on one another. Flavell [4] suggests that metacognitive consisting of 1) metacognitive knowledge, and 2) metacognitive experience or regulation. On the other hand, Brown also divides metacognitive into 1) knowledge about cognition, and 2) regulation of cognition [7]. Metacognitive knowledge is described as knowledge or belief about the factors, variables that affect the individual's cognitive processes [4]. Brown (in [15]) distinguishes three types of metacognitive knowledge namely declarative, procedural, and conditional knowledge. Declarative knowledge refers to knowledge about themselves as learners and knowledge of the factors affecting performance. Procedural knowledge refers to knowledge of how to use procedural skills to execute. While the conditional knowledge is the knowledge of when and how to use a variety of cognitive activity possessed.

Furthermore, the metacognitive regulation also called metacognitive skills are defined as awareness of cognitive activities themselves, a method for regulating the cognitive process, as well as orders to organize and plan cognitive activity. Jacobs & Paris (in [15]) presents three essential components of metacognitive regulation, namely planning, monitoring, and evaluating. Planning involves choosing the appropriate strategy and effective resource allocation thus affecting the performance. Monitoring refers to the self-awareness to monitor understanding and the task performed. While the evaluating is the process of assessing the solution and the learning process which have been done. On the other hand, Lucangeli and Cornodi (in [2]) states four components of metacognitive skills with a prediction, planning, monitoring, and evaluation. Prediction is the activities to distinguish between the difficult and easy problems to be determined exactly how much effort and resources needed to solve the problems. Planning includes analyzing the problem, take back the specific knowledge and skills already possessed, and to develop problem-solving strategies. Monitoring includes activities to monitor each troubleshooting step is carried out. This is to ensure that the strategy that has been formulated goes well to solve the problems. While the evaluation is to assess the results of the activity and the steps used to get answers. Simon (in [2]) provides the third component of metacognitive called conception or faith, namely metacognitive idea or theory of how people think about themselves and others, such as attribution, motivation, and self-esteem.

Based on the data of tenth-grade students' achievement in the logarithm of SMK Muhammadiyah Delanggu odd semester of 2015/2016 academic year consisting of 24 students, as much as 81% get less value from minimum passing criteria. This indicates the lack of students' performance in mathematics learning, especially on the subject of a logarithm. Most of the students have not been able to complete mathematics problems in a systematic manner. They immediately focus on calculations that are procedural without first understanding the purpose of the given problem. This paper presents the role of metacognitive skills to solve mathematical problems, especially in the matter of logarithms.

II. Research Method

This research is qualitative descriptive. The subjects were two students of tenth-grade students' of SMK Muhammadiyah Delanggu, Central Java, with the category of high and low math skills. The subjects are selected by first giving five essay test questions to all students. The fifth question must be

completed within 90 minutes. Furthermore, based on the results of the test, the student's ability to solve problems are classified into three categories, namely high, medium, and low. This study will be the focus on with high and low categories students'. The Data will be collected by using observation, test, and interviews. The observation methods used to obtain data about the math learning activities directly and observe the student in completing the questions given by the researcher. The test method used to obtain data on students' ability to solve problems. Meanwhile, the interview method used to find out information on how the metacognitive skills of students in solving logarithms. The Researchers also provide an assessment of the results of student work related to the logarithm. The acquired data were analyzed by reducing the data, presenting the data, and drawing the conclusion. Data reduction was performed by recording the interview result, and observation of teachers and students. The researcher also scored the students' answer related to logarithmic materials. After the data went through reduction process, the data would be presented in a complete narrative text, tables, and records of interview result regarding the students' understanding of logarithmic materials. The last step was to draw conclusion based on the result of data spread

III. RESULT AND DISCUSSION

Based on the test results of 24 students', there were seven students with high math ability and students lower category. The remaining 10 students, that are in the moderate category. Afterward, the students with high category (subject 1) and low (subject 2) are selected as research subjects. In this paper presented the results of the test and a description of metacognitive skills of high and low categories students' in solving problem 3. Problem number 3 is presented as follows:

<u>Question:</u>
Let *log* 2 = 0.3010 and *log* 3 = 0.4771, determine the value of:

a. *log* 12
b. *log* 24

The answer of subjects 1 and 2 in solving problem 3 is presented in Figure 1 and 2 as follows:

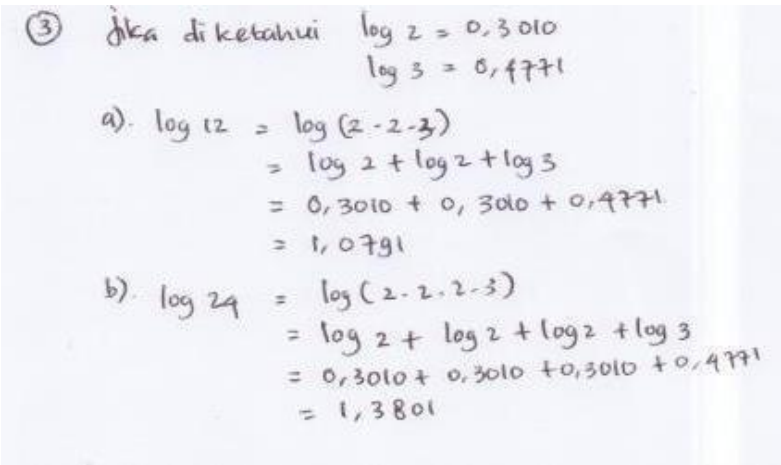

Figure 1. The answer of subject 1

Figure 1 shows the students answer with the high category in solving problem 3. It shows that the students are able to solve problems correctly. Interviews showed that students understand the purpose of the questions that must be resolved namely determining *log* 12 and *log* 24. Students are also able to understand the information given in problem, namely *log* 2 = 0.3010 and *log* 3 = 0.4771. Based on the knowledge that has been owned by the students (prior knowledge), then the students determine the relationship between the known and asked information of the problem. Students said that to determine *to log* 12 first determining the multiplication factors of 12 namely 2, 2, and 3.

Subject 1 : multiplication factors of twelve are 2, 2 and 3. So *log* 12 = *log* (2 x 2 x 3).
Researcher : Why you choose 2 x 2 x 3? Why not 4 x 3?
Subject 1 : Due to the unknown *log* 2 and *log* 3.

Interviews showed that students were able to determine the relationship between the known information on the matter and the problems in question. Furthermore, students able to connect the data obtained, the *log* 12 = log (2 x 2 x 3), with the knowledge that has been held on the multiplication properties of logarithms.

Subject 1 : Continue finished *log* 12 = *log* 2 + *log* 2 + *log* 3

Researcher : Is it the properties of logarithms?

Subject 1 : yes, there is a property in the logarithm *log* (a x b) = *log* a + log b

Interviews showed that students are able to connect information held previously, namely the properties of logarithms, with the information obtained, the log (2 x 2 x 3). The next step is the completion of procedural involving calculations. Students said that after obtaining the answers to the calculation results, students are reassessing to convince the truth of the estimates obtained. Furthermore, to solve the problem 3.b applies same steps with 3.a.

The metacognitive skills of subject 1 in solving problem 3 looks already well underway. Students have been able to understand the purpose of the problem, the information provided on the issues, and to determine a strategy to solve the problems. This means that the student has the ability to perform well completion planning. Furthermore, students have been also able to connect the knowledge that has been owned by information obtained from the problem. Students are doing step by step systematically in order to know where the mistakes if the answer is incorrect. This indicates that the student has the ability to monitor every step in solving a problem. Monitoring measures are taken to ensure the completion of the procedure is done properly. Metacognitive skills that last aspect is evaluation where students have to recalculate to convince the truth of the answers obtained. These results indicate that students who able to control the metacognitive skills will be able to solve the problems appropriately. In other words, metacognitive has a very important role to solve the problems.

Furthermore, the answer of the students with low math skills to solve problems 3 is presented in Figure 2 below:

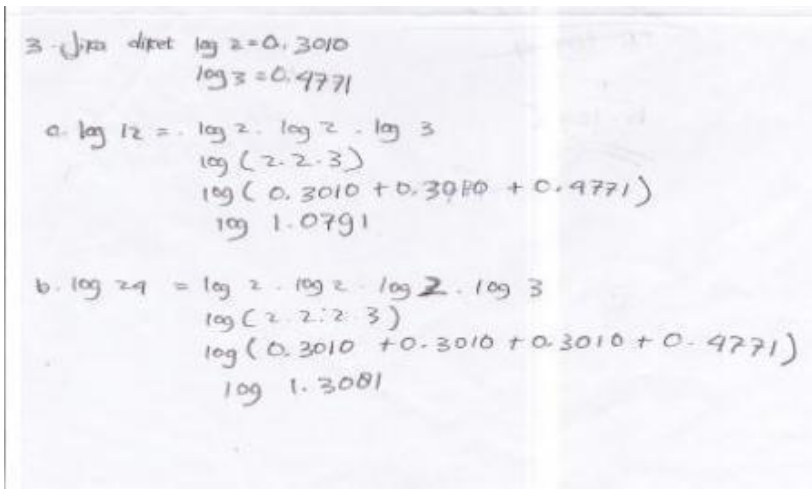

Figure 2. The answer of subject 2

Figure 2 shows that the students answer is not correct. Students can understand the information provided by the problem that is *log* 2 = 0.3010 and *log* 3 = 0.4771. He also understands the purpose of the questions that must be solved namely determining *log* 12 and *log* 24. However, students are not able to determine the exact relationship between the known information with information obtained from the problem. Students understand the multiplication factor of 12 is 2, 2, 3. But the students are not able to connect the concept of multiplying a number by multiplying the logarithms so that students write the *log* 12 = *log* 2 x *log* 2 x *log* 3.

Subject 2 : multiplication factors of 12 is 2, 2, 3

Researcher : How *log* 12 can be *log* 2 x *log* 2 x *log* 3?

Subject 2 : due to the multiplication factors of 12.

The interview results indicate that students are not able to link their prior knowledge with the new knowledge so that they encountered an error. The same thing happened to the completion of a problem 3.b.

Subject 2 is able to understand the information provided by the problem and understand the purpose of the question (asked by the question). But the students failed to design the problem-solving strategy even though he have been able to determine the factors of 12 are 2, 2, and 3. Students are not able to connect the concept of multiplication in decimal numbers with on logarithms. This means that aspects of metacognitive skills in planning the settlement did not go well. Furthermore, a failure in all aspects of planning resulted in less appropriate in solving steps . It appears that students write the *log* (2 x 2 x 3) = *log* (.3010 + .3010 + .4771). The results of these calculations show that students fail to understand the nature of multiplication logarithm.

Researcher : Why *log* (2 x 2 x 3) could be a *log* (.3010 + .3010 + .4771)?
Subject 2 : due to the nature of the logarithm multiplication in that way.
This shows that students do not carry out the monitoring to ascertain whether the steps undertaken are in accordance with the procedure. These results indicate that the failure of students in the use of metacognitive skills will have an impact on the results were not correctly.

The results of this study provide additional information about the importance of metacognitive skills in solving mathematics problems. These results are in line with Bayat and Tarmizi [1] which conducted a study of 86 first-year students who took the algebra courses at universities in Malaysia. The study wanted to test the correlation between metacognitive strategies with the students' ability in solving algebra problems. The results showed that there is a significant impact on the ability of metacognitive strategies algebra students. In other words, students are able to take advantage of metacognitive strategies will be able to solve the problems of algebra well too.

IV. CONCLUSION

Based on the research of two students with high and low math category shows that students who able to plan completion, monitoring every step of completion, and evaluate the results obtained will be able to solve the problems appropriately. In other words, students are able to use metacognitive skills in solving the problems will get the results as expected. Conversely, students who have failed in the use of metacognitive skills would not be able to solve the problems appropriately. Thus, metacognitive skills have a very important role to solve the problems, especially in mathematics.

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