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How Does Metacognition of Senior High School Students Participate in Mathematical Problem Solving Process?

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Abstract

Metacognition is an important factor in mathematical problem solving. It is the ability to monitor and control our own thoughts, how to approach the problem, how to choose the strategies to find a solution, or to ask ourselves about the problem. In other words, metacognition can be defined as thinking about thinking. By using metacognition, students will solve mathematical problems precisely because they are aware of the thinking process to plan, monitor and evaluate each step taken. This research was conducted to identify students' metacognition profiles in solving mathematical problems. This was a descriptive qualitative study. The research was conducted in Class X of SMAN 1 Surakarta. Data were collected using interviews based on mathematical problem-solving tasks. Based on data analysis, the subjects cannot fulfill all indicators of the stages of metacognition, namely planning, monitoring and evaluation. Therefore, it can be concluded that not all students can use their metacognition abilities well.

Keywords: *mathematics, metacognition, problem-solving.*

Introduction

Mathematics is one of the subjects that takes an active role in formatting human resources. According to NCTM, one focus of mathematics learning is on problem-solving (Fathurrohman, Porter, & Worthy, 2017; Young, 2017). Therefore, problem solving in mathematics is an important aspect to be studied and mastered by Primary right through to

University level students. Through mathematical problem solving, students are directed toward developing the ability of building new mathematical knowledge, solving problems in various contexts related to mathematics, implementing the necessary strategies, and reflecting on the mathematical problem solving process (Anggo, 2011).

One of the abilities that greatly affect a person's success in solving a mathematical problem is metacognition. Jacobs et al. stated that the problem solving process needs metacognition to help students solve problems (Maretasani, 2016). The term metacognition is usually defined as knowledge and cognition of either a cognitive object or how to learn (Fetsco & McClure, 2005; Flavell, 1979; Schraw, 1998; Slavin & Davis, 2006). Metacognition refers to high-level thinking processes that involve active control of cognitive processes in the learning process (Livingston, 2003). Meanwhile, Brown defined metacognition as an awareness of the self-cognition activities as well as the methods used to regulate the cognition process and a mastery of how to direct, plan, and monitor cognitive activities (Miyoung, 2006).

Dunlosky and Bjork stated that metacognition is someone's ability to observe and control themselves against the problems encountered (Mokos & Kafoussi, 2013). According to Scott, metacognition involves individuals' planning their information about their own and others' cognitive processes before they fulfill their task, observing their thinking, learning and understanding while performing a task, controlling and regulating their thinking (Akturk & Sahin, 2011). In this study, metacognition is defined as a person's self-awareness and self-control toward their own thinking process used to solve problems.

Izzati stated that metacognition gives a positive influence on mathematical problem solving ability. The higher the metacognition ability, possessed by students, the better the student is in solving mathematical problem (Izzati & Mahmudi, 2018). The use of metacognition in problem solving can also help students to recognize the existence of problems that need to be resolved, to find out what the problem really is and to understand how to achieve the solution (Kuzle, 2013).

Metacognition organizes the thinking process of students. According to Woolfolk and Kleitman, there are three important activities in metacognition, namely action planning, monitoring and evaluation. Planning is the selection of the right strategy and the allocation of appropriate cognitive abilities before completing the task. This includes deciding how much time to spend on a task, which strategy to use, how to start it, what information to collect, what steps are taken to resolve the task, what information to be ignored and what needs to be taken seriously. Monitoring is an awareness of self-understanding and self-performance, while completing tasks. For example, "Did the activities carried out make sense? Am I trying to complete tasks too fast? Have I learned enough?" The third is evaluation. It is an assessment of performance after someone has completed the task. This involves an assessment of the process and results of thinking. Questions that will arise at the evaluation stage include: "Should I change the existing strategy? Do I need help? Do I have to give up for now?" (Kisac & Budak, 2014; Daher, 2018).

Based on the definition of metacognition above, the metacognition abilities of students in this research can be identified based on the indicators presented in Table 1.

The purpose of this study is to analyze the role of students' metacognitive abilities in the process of mathematical problem solving, especially activities in the stages of action planning, monitoring and evaluation.

Materials and Method

This research was a descriptive ualitative analysis using a qualitative method and using a case study strategy. Qualitative research is research that is used to understand the phenomenon, experienced by research subjects, holistically through descriptions in the form of words

(Moleong, 2007). Merriam defined a case study as "*intensive and holistic description and analysis of limited phenomenon such as a program, an institution, a person, a process, or a social unit*" (Yazan, 2015). Thus, in this study, qualitative research with a case study is used to explore and understand the subject and phenomena that are intensive and holistic through verbal description. The phenomenon here refers to the metacognition of students' in general and specifically as found in each indicator.

This research was conducted in SMAN 1 Surakarta, Indonesia. The subjects in this study were students of class X MIPA. Then, 2 subjects were selected based on a purposive sampling technique, in which the academic ability of the two subjects was balanced. Data in this study were obtained from interviews based on problem-solving tasks. The interview process was carried out when the subject solves a mathematical problem. This was because the purpose of this study was to describe the ability of metacognition concerning students' thinking processes. To obtain credible data, time triangulation was carried out ie the same method was carried out at different times.

Result and Discussion

In this study, researchers collected information based on the results of interviews and problem solving results of essay test items. The description of the results of this study will be focused on the stages of planning, monitoring and evaluating subject I and subject II, when the subject solves the formal problem of a two-variable linear equation systems.

The results of the interview and answer sheets of problem solving of subject I

1. Planning

In the first stage of the metacognition activity on the subject I mentioned that what had to be considered first was knowing the information contained in the problem given. Then, the subject I mentioned that what was known from the problem was the original circumference of a rectangle and the circumference of the rectangle after changes in length and width. Furthermore, the subject I began to compile the next step, namely determining the way or method to solve the problem, by using the method of elimination and substitution in the material system of two-variable linear equations. However, the subject I cannot estimate the time that will be spent in the process of solving the problem. When getting a question about how long it would take to solve the problem, the answer was "I can't determine the length of time to resolve it, but I will try as soon as possible to solve it".

2. Monitoring

The second stage in metacognition activities was monitoring actions. At this stage, students begin to carry out what was planned in the previous stage. Subject I began to change the information in the problem by creating modifiers and equations (i) and (ii). Subject I then continued the completion process to determine the original length of the rectangle using the elimination method. Then students ask "is this correct?", While thinking for a moment subject I then resumed the process to determine the initial width using the substitution method.

3. Evaluation

Subject I in evaluating the action revealed the answer that he had completed was believed to be correct without looking back at the answer sheet. Snippets of the written answers to the subject I are in figure 1.

Results of interviews and problem-solving answer sheets subject II

1. Planning

Subject II in planning actions, when he saw the problems given he read it over and over again. Then when getting a question from the researcher about what was thought at the time of getting the problem, subject II seemed to think and then answered that the question had to be solved. He further stated that the material that must be mastered to solve the problem is a system of linear equations. When interviewed that what was asked was approximately how much time you spent in solving this problem, subject II then replied that he did not know.

2. Monitoring

At the action monitoring stage, the subject began by writing down the information he knows from the problem given ie the circumference of the original rectangle that was 70cm. Subject II then proceeded to solve it using a circular rectangle formula to make mathematical equations. Subject II chose to use the method of elimination first then substitution. After entering the p-value that has been obtained in the equation, subject II looks confused. When the researcher asked, were there any obstacles in carrying out the calculation operations? Subject II answered, "yes, but I don't know which part I should fix".

3. Evaluation

The final stage of metacognitive activity was evaluating actions. After experiencing problems during the problem-solving process, subject II was seen rereading the answer sheet. When asked what was thought about the problem-solving process that has been resolved?, the subjects only answered: "I don't know, I'm confused to solve it". Snippets of the written answers to subject II are in figure 2.

Discussion

Based on problem-based task-based interviews conducted on the subject I and subject II shows that at the action planning stage, the two subjects were able to show indicators identifying information contained in the problem provided and restating it in an operational form. In indicators exploring relevant prior knowledge before developing a solution plan, it appeared that both subjects were able to meet these indicators. But, the indicators made predictions about the information in the problem to be solved based on what has been read, there were differences in the two subjects. Subject I hesitantly said that it would try to solve it quickly but subject II did not make these predictions at all.

In monitoring actions, subjects I and II were able to investigate the information contained in the problem provided and change it with more accurate information. Both of these subjects were able to make mathematical equations from existing information even though in the process of solving the subject II experienced obstacles so that it was unable to complete the problem-solving process. In the evaluation phase of the action, the subject I seemed convinced by the answers he had completed so there was no need to check again. Whereas in subject II, when evaluating his actions he rechecked the results of his work but did not know what steps to take to solve the problem.

Conclusion

Based on data analysis, the researcher concluded that the ability of each student to use the metacognition they had during the problem-solving process was different. Therefore, students were expected to try more to solve various mathematical problems, to be able to encourage them to practice and sharpen their metacognition abilities.

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Table 1. Indicator of Metacognition Activity

Component of Metacognition	Indicator
Planning	• Identifying the information on a topic and restating it in a more operational statement. • Exploring previous relevant knowledge prior to developing a solution plan. • Predicting information stated in the problem to be solved based on what

	they have read.
Monitoring	• Investigating a topic by verifying, developing or altering the initial statement with more accurate information. • Producing new information and explaining the problems using images, symbols or tables as they are organized into a plan. • Classifying related ideas and identifying strategies used.
Evaluation	• Evaluating success and removing inappropriate strategies. • Identifying strategies that can be used later and looking for promising alternative approaches.

Given :

- The circumference of rectangle at first = 70cm.
- If the length is made twice the original length and the width is made $\frac{1}{3}$ times the original width, then the circumference of rectangle is 90cm.

Asked : Length and width of rectangle at first.

Answer :

- Ex : the length of rectangle at first = p
  the width of rectangle at first = l

So, $2(p+l) = 70$ .... (i)
$2\left(2p+\frac{1}{3}l\right) = 90$ ....(ii)

$$2p + 2l = 70$$
$$4p + \frac{2}{3}l = 90 \quad \times 3$$

$$2p + 2l = 70$$
$$12p + 2l = 270 \quad -$$
$$-10p = -200$$
$$p = \frac{-200}{-10}$$
$$p = 20$$

Put the value of $p = 20$ in (ii)

$$2\left(2p+\frac{1}{3}l\right) = 90$$
$$2\left(2\cdot 20+\frac{1}{3}\cdot l\right) = 90$$
$$2\left(40+\frac{1}{3}l\right) = 90$$
$$\frac{2}{3}l = 10$$
$$l = \frac{10}{3}$$

Figure 1. Answer of Subject I

1. Circumference ▭ = 70 cm
$2(p+l) = 70$ cm
$p + l = 35$ cm ⇨ $2(2p+\frac{1}{3}l) = 90$ cm
$4p + \frac{2}{3}l = 90$ cm

⇨ $p = 35$ cm $- l$
put the value of $p = 35 - l$ in equation $4p + \frac{2}{3}l = 90$
So, $4(35-l) + \frac{2}{3}l = 90$
- p =
- l =

Figure 2. Answer of Subject II

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