The Analysis of Students’ Metacognition in Solving Math Problems Based on Self-Efficacy

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Abstract. Metacognition holds a particular part in the learning process, especially in mathematics because solving math problems is not enough just by using numeracy skills, but metacognitive knowledge is also essential. The aim of this research is to analyze the metacognition of students’ junior high school in solved math problems based on students’ self-efficacy. Data collection techniques used in this study were questionnaires, tests, and semi-structured interviews. The main instrument in this study is the researcher and additional instruments were self-efficacy questionnaires, geometry tests and interview guides. This is a qualitative study with a case study design. The participants of the study were 20 students of grade 8th. Two out of twenty become the subjects of the study who selected using purposive sampling technique. The study showed that students with high self-efficacy in solving math problems can fulfil all indicators of each metacognition component, consisting of knowledge about cognition and regulation of knowledge.

1. Introduction

Metacognition is necessary for learning mathematics because it establishes students to take control of their cognitive skills and overcome their weaknesses in the learning process by developing new cognitive skills [1]. Metacognition affects students in learning mathematics because students have to monitor and manage their action and strategies used to solve the problems [2]. Metacognition holds a particular part in the learning process, that eventually influences the academic achievement of students at school and their mathematical performance. A variety of metacognitive processes are needed to effectively solve any complicated problem [3]. The failure of the student to conduct the necessary method of monitoring and controlling their learning is a reason behind the low performance of mathematics rather than the failure of mathematical knowledge [4]. The success of the problem-solving process may increase as students are aware of the monitoring and control of their own learning experiences [5] through the use of metacognition skills [6]. Hence, solving math problems is not enough just by using numeracy skills, but metacognitive abilities are also essential.

Metacognition was introduced by Flavell in 1976 and it means students’ ability to control awareness of their thinking processes in the learning process [7]. Metacognition refers to high order thinking which involves active control over the cognitive processes engaged in learning [8]. There are two-component of metacognition, namely knowledge about cognition and regulation of cognition [9]. Knowledge about cognition indicates to students’ knowledge about their cognition or cognition in general. It includes declarative knowledge, procedural knowledge, and conditional knowledge. Regulation of cognition related to knowledge about planning, information management strategies, comprehension monitoring strategies, debugging strategies, and evaluation in the learning process [10,11].
Students will be aware of their learning processes when believing that they can succeed in learning achievement and use effective strategies. Awareness of students’ learning processes is referred to as metacognition [12] and that beliefs in learning performance will affect their cognitive, motivation, and affective processes, it is called self-efficacy [13]. Self-efficacy is a student’s beliefs about their ability to manage and perform a task to obtain certain goals [14]. Student’s beliefs in their ability to obtain the desired effects of making decisions are the fundamental theory of self-efficacy, it is established of students’ behaviors when decided to be bound and persevere in their efforts to face obstacles and challenges [15]. Self-efficacy influences students’ ability in the learning process, their motivation, and their performance, as people will often make an effort to learn and perform only those problems for which they believe they will be successful [16]. Self-efficacy establishes perception into why students choose to be involved in specific tasks, while metacognition assists to encourage the use of self-regulation strategies, including understanding a problem, monitoring the strategies, evaluating the results, and even using other strategies when they are unsuccessful in solving the problem [17,18]. Many previous kinds of research have revealed that students with metacognition will be followed by high self-efficacy. Metacognitive skill and individual thinking help to increase a sense of students’ self-efficacy and students can manage their time in solving a problem to be more efficient when the have high self-efficacy, using various strategies, high effort and persistence particularly in face difficulties [7,19,20,21,22]. Therefore, analyzing students’ metacognition based on self-efficacy is important to research, considering that it affects student success in the learning process and solving the problems, especially solving geometry problems.

2. Methods
This research uses qualitative research. The participants were collected from 20 students of class VIII C of SMPN 1 Lape in Sumbawa. Data analysis techniques used data reduction, data presentation and conclusions, while the validity of the data used triangulation methods. Data collection techniques used in the study consisted of questionnaires, tests, and semi-structured interviews. The instruments used in this study were self-efficacy questionnaires, geometry tests and interview guides. Self-efficacy data collection uses a validated questionnaire containing 20 items with the following indicators based on [14]:

| Table 1. Indicators self-efficacy |
|----------------------------------|
| **Aspect** | **Indicator** |
| Level | Belief in strategy use |
| | Belief in varying degree of difficulty |
| Generality | Belief in throughout the learning process |
| | Belief in dealing with various condition and situations |
| Strength | Belief in the effort made |
| | Belief in gets good result |

Metacognition data collection by using tests and semi-structured interviews. There were also two-components of metacognition, knowledge of cognition and regulation of cognition with the following indicators based on [10]:

| Table 2. Indicators of metacognition |
|-----------------------------------|
| **1) Knowledge of cognition** | **Indicators** |
| Declarative Knowledge | knowledge about what to do in learning process |
| Procedural Knowledge | knowledge about how to perform learning strategies |
| Conditional Knowledge | knowledge about when and why to use learning strategies |
2) Regulation of cognition

Planning

Information Strategies

Ability in planning learning activities

Ability to manage information strategies in learning process

Comprehension Strategies

Ability to monitor the learning process

Debugging Strategies

Ability to correct the wrong action in learning

Evaluation

Ability to evaluate learning strategies

Based on the results of filling out the questionnaire by 20 students, the mean value of data was 54.75, and a standard deviation of 0.62. The data from the analysis of the self-efficacy questionnaire obtained are presented in Table 3:

| Statistic         | Category     | Respondent | Percentage |
|-------------------|--------------|------------|------------|
| $\chi < \chi - 0.5s$ | Low          | 11         | 55%        |
| $\chi - 0.5s \leq \chi \leq \chi + 0.5s$ | Medium       | 4          | 20%        |
| $\chi > \chi - 0.5s$ | High         | 5          | 25%        |

Then to describe students' metacognition, students with high categories of self-efficacy were selected to serve as subjects in this research. Out of 5 students who had a high self-efficacy level, 2 subjects were selected to be analyzed for their metacognition. The selection of the two subjects was based on considering problem solving abilities and being able to communicate their thoughts orally and in writing well based on the information obtained from the mathematics teacher so that an analysis of students' metacognition in solving math problems could be carried out. Metacognition data was collected by assigning mathematical tasks of geometry for each research subject. The subjects completed the task while being interviewed by the researcher, so that information related to students' metacognition in solving math problems could be obtained.

3. Results and Discussion

Metacognition analysis based on students' answers in solving mathematical problems was carried out using semi structured interviews with R as Researcher, S1 as Subject 1 and S2 as Subject 2. The test questions used to measure students' metacognition are as follows:

![Figure 1. Geometry test](image)

3.1. Metacognition data of subject 1 (S1) in solving math problem

Based on the results of interviews with S1 subjects, it shows that the subject is aware of his thought process when identifying the information contained in the given problem and then communicating it. Furthermore, the subject also tries to dig up the previous knowledge they have when interpreting the information provided. Subjects are aware of the prior knowledge needed and are able to relate concepts...
to be used in problem solving. The information contained in the problem and restates it in a more operational form by writing a unit of information that is known to be in a simpler form, namely interpreting it in the form of a kite shape, then calculating the area of decoration given to the problem. The subject is also able to control his thinking process by making predictions about the length of time for completion based on the solution plan used. The subject is aware of the thought process carried out because when explaining the procedures or strategies, the subject can categorize related ideas and identify the strategies used and find out the reasons for using these strategies. This identification is able to make the subject feel more confident about the results obtained because the steps taken are correct and have paid attention to important information about the problem. The subject realizes his thought process by assessing and believing that the results obtained are correct. The subject can also control his thinking process by mentioning other alternative solutions to problems that can be used. This can be seen in the S1 Subject interview excerpt as below:

R : What information do you get from the problem?
S1 : Two triangular decorations and determine the area of the decoration.
R : From the problems given what math material do you use to help understand and solve problems?
S1 : Of course, the material of plane figure
R : Try to say what you did to solve the problem?
S1 : First I drew the two triangular decorations into a kite and then calculated the area.
R : Why did you choose to use this strategy?
S1 : Because in my opinion this is the fastest way to solve the problem.
R : Ok, next. Do you think your solution is the only way to solve the problem?
S1 : I think this is not the only way, because this problem can still be solved by calculating the area of each triangle and then adding it.
R : After you solve this problem, what do you think about your answer?
S1 : Re-check my answer whether it is correct or wrong in the process.
R : So, what do you think about your answer?
S1 : Insha Allah, it is correct.
R : Are you sure you do not need correction?
S1 : I do not think so.

The results of the analysis are also reinforced by the results of students' written answers as follows:

Figure 2. Answer of subject 1

3.2. Metacognition data of subject 2 (S2) in solving math problem
Based on the results of interviews with S2 subjects, it shows that the subject has realized the thought process when identifying the information contained in the given problem and then communicating it.
Furthermore, the subject also tries to dig up the previous knowledge they have when interpreting the information provided. Subjects are aware of the prior knowledge needed and are able to relate concepts to be used in problem solving. Information contained in the problem and restarting it in a more operational form, namely by writing the unit of information known to be in a simpler form, namely calculating the area of each triangle given to the problem. Monitoring actions is the subject is aware of his thought process when explaining the problem-solving procedure used by investigating his written answers and identifying the strategies used. The subject is aware of the thought process carried out because when explaining the procedure or steps taken, the subject can categorize related ideas and identify the strategy used and find out the reasons for using the strategy. The subject realizes his thought process by assessing and believing that the results obtained are correct. The subject can also control his thought process by mentioning other alternative solutions to problems that can be used and changing the strategies used. From the alternative problem solving, the subject is able to determine a more effective problem-solving solution. This can be seen in the S2 Subject interview excerpt as below:

**R**: What information do you get from the problem?
**S2**: There are 2 triangular cupcake decorations with the same base size and different heights.
**R**: From the problems given what math material do you use to help understand and solve problems?
**S2**: Material about plane figure material.
**R**: Try to say what you did to solve the problem?
**S2**: First I drew two triangles then calculated the area of each of these triangles.
**R**: Why did you choose to use this strategy?
**S2**: Because it is the easiest way for me.
**R**: Do you think your solution is the only way to solve the problem?
**S2**: emmm, let me look back at the problem.
**R**: Now try to pay attention to the two shapes of the triangle shape
**S2**: ah, I got it. If the two triangles are combined, it can form a kite shape.
**R**: Ok, now from the two different events, do you think the method of completing is the most effective?
**S2**: I think using the kite formula it will be faster to solve the problem because you do not need to count twice what will be done successfully.
**R**: After you solve this problem, what do you think about your answer?
**S2**: Re-check my answer whether it is correct or wrong in the process.
**R**: So, what do you think about your answer?
**S2**: I am sure, it is correct.
**R**: Are you sure you do not need correction?
**S2**: I do not think it is necessary for correction, but I need to change the way of solving it so that it is faster in solving problems.

The results of the analysis are also reinforced by the results of students' written answers as follows:
Based on analysis interview of the subjects, it seems that student has knowledge of what information they need to solve the problems by reading instructions first and looking for information about the problems, being aware of the strategies that they have to use based on information in the problems, using various learning strategies, remembering subject matter that they need to solve problems and think about various strategies to solve the problems, translate the information into their own word to help them understand the problems, has considered various strategies to solve the problem, make predictions about the solution plan that will be used, changes the strategies and recheck the answer to make sure it is correct or need correction.

The finding of this study indicates that students with high self-efficacy are able to reach all metacognition components. The results of this study are in line with [12], it found that students with high self-efficacy in their skills are effective in monitoring and achieving their strategies (metacognition). It is also in line with [23] research which has shown that the inherent orientation of the target, the confidence in the importance of the task, the regulation of learning perceptions, and self-efficacy in learning and success are predictors of the use of student metacognition. Students with a strong sense of self-efficacy and students who see the learning process as essential and beneficial are supposed to be critically focused [23]. Self-efficacy and metacognition are important factors in constructivist learning processes [24]. This study also shows that students who can reach all metacognition indicators are able to solve math problems well. This is in line with research conducted [25] students with high metacognitive ability are successful at problem-solving. If one has a high metacognitive ability and knows how to implement it, there is a stronger possibility that problem solving will be effective.

4. Conclusion
The results showed that the analysis of metacognition subjects with high self-efficacy when solving a geometry problem was able to fulfil all indicators of each metacognition component, namely knowledge about cognition and regulation of cognition. Students with high self-efficacy, means students already have knowledge about what information they need to solve the problems (declarative knowledge), students have knowledge about learning strategies that they used to solve the problems (procedural knowledge), and how to use the strategies (conditional knowledge). Students can make predictions about the solution plan that will be used (planning), able to control the thought process by making predictions about the length of time to complete based on the solution plan used (information management strategies), being aware of the strategies that they have to use or the learning strategies that are appropriate with the learning problems they face (comprehension strategies), changes the strategies (debugging strategies) and evaluate their learning (evaluation).

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