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Metacognitive awareness: how it affects mathematical problem-solving process

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Abstract. Problem-solving is one of the basic skills in learning mathematics where in the process needs awareness in every step. Metacognitive awareness means to be aware of how to think. This study aimed to know the effect of metacognitive awareness in the mathematical problem-solving process. This is a descriptive-qualitative study. The samples of this study are 10 students. Data of metacognitive awareness were collected using questionnaire adapted from Metacognitive Awareness Inventory (MAI) developed by Schraw and Dennison, data about mathematical problem-solving process were based on the test result. The MAI measures two components which include the knowledge about cognition and the regulation of cognition. The results indicate that the two components of metacognitive awareness, that is knowledge about cognition and regulation of cognition gave the effect to mathematical problem-solving students especially for regulation of cognition. The Student with high levels of regulation of cognition is able to reach a more complete problem-solving process than the students with medium levels of regulation of cognition.

1. Introduction

Problem-solving is one of complex-basic skill that students must have in learning mathematics. NCTM [1] stated that problem-solving is an important part of overall mathematics learning and this doesn't have to be an isolated element in mathematics programs. NCTM [1] also states that problem-solving in mathematics, must include all five areas in the process standard. The OECD (Organization for Economic Co-operation and Development) periodically compared and measured the progress of mathematics education by holding PISA (*Programme for International Student Assessment*) [2] and Indonesia ranked in 63rd out of 70 countries. The result implied the failure of Indonesian students to reach the required minimum level. Study by Retnawati [3] shows that one of students' difficulties in learning mathematics is understanding the narrative text items. It needs to be handled because mathematics is a core subject in the school curriculum related to other disciplines.

Student's problem-solving process is not applying and adjusting various problem-solving strategies, but also to monitor and reflect the process of problem-solving which faced. The problem-solving process requires a kind of high-level thinking skill including analyzing, interpreting,



reasoning, evaluating, and reflecting, so awareness is needed in every step which is taken. Metacognitive awareness allows individuals to plan, sort and monitor students' thinking processes. This awareness gives the students basis for planning, allocating their time and effort in the problem-solving process. Based on it allows the effect of students' metacognitive awareness on students' problem-solving process.

Polya [4] suggested at least four steps that are believed to be effective in helping students in the problem-solving process. The first step is understanding the problem, where in this step involves activities such as re-reading, determining the needed information and not. The second step is making a plan, in this step involves the best strategy to get solution. The third step is applying the plan, it involved the implementation of a planned strategy to solve the problem. The final step is look back (checking and interpreting), which in this step involved the answer revising process which is gained to determine the accuracy of the problem given. Joseph [5] explained that to solve the problems depend on five factors e.g. detail, expertise, knowledge of concept, metacognition, and action. Metacognition is one of the influential factors in solving problems.

Flavell [6] divined metacognition as an awareness, consideration, and individual control their cognitive process and strategies. Wilson & Clarke [7] explain that metacognition is students' awareness, monitoring, and control their thinking process. So that the metacognition process that occurred in solving problems are related to the way students thinking about their awareness, monitoring, and control, and the ability in choosing and determining the right strategy to solve the problems.

Desmita [8] explain that metacognitive or metacognition is a complex psychological construction that include knowledge and awareness about cognitive processes or knowledge of mind and how it works. Brown stated that metacognition refers to understanding knowledge, and understanding that can be reflected both in effective use or clear explanations of relevant knowledge [9]. In line with this, Wilson & Clarke [7] described that metacognition consist three part, e.g. (1) Metacognitive awareness; (2) Metacognitive evaluation; and (3) Metacognitive regulation. It means that metacognition contain of two domain, those are metacognitive knowledge and metacognitive awareness.

The definition of metacognitive awareness developed from the knowledge and regulation of cognition into the strategy and skill that encourage students to solve the problem and think forward [10]. Schraw & Dennison [10] divided the component of metacognition into two, those are the knowledge about cognition and the regulation of cognition. The knowledge about cognition consist of three sub-sections that facilitate the reflective aspect of metacognition, those are (i) declarative knowledge, the knowledge about one-self and strategy; (ii) procedural knowledge, knowledge about the way to use the strategy; and (iii) conditional knowledge is knowledge of when and why the strategy be used. Based on its development, metacognitive awareness defined the ability to reflect, understand, and control in learning.

The results of research conducted by Ýz [11] on 10 middle school students concluded that 7 out of 10 students had high metacognitive awareness. Schleifer & Dull [14] found a strong relationship between metacognitive attributes and academic achievement, and interaction of the two metacognitive components in accounting class. The students who are succeed caused by having a better meta-knowledge of meta-regulation. Abdellah [12] found that metacognitive awareness and cognitive regulation had a positive relationship, but it didn't find in cognitive knowledge. There is no relationship of cognitive knowledge and cognitive regulation. Based on the result, this study will identify the level of students' metacognitive awareness and their effect on the students' mathematical problem-solving process.

2. Method

2.1. Participant

This is a descriptive exploratory study with qualitative approach to identify students' level of metacognitive awareness and its effect in the process of solving mathematical problems. The participant in this study are ten 9th students in Junior High School.

2.2. Instrument

2.2.1. Metacognitive awareness. Data on students' metacognitive awareness obtained by using the Metacognitive Awareness Inventory(MAI) adapted from Schraw & Dennison [10]. The item in MAI categorized into six sub-components of metacognitive awareness, that are declarative knowledge, procedural knowledge, conditional knowledge, planning, monitoring, and evaluating [13]. The data were analysed by using descriptive statistics to obtain the level of metacognitive awareness component.

2.2.2. Problem-solving. Data of students' mathematical problem-solving process obtained by using the test. Test instrument consists of two items. The test questions given are related to congruence.

3. Result and Discussion

3.1. Metacognitive awareness

The result of metacognitive awareness were analysed to obtain the level of metacognitive awareness from each student. The questionnaire of metacognitive awareness divided into two parts: the knowledge about cognition and regulation of cognition. The score for each domain divided into three subintervals named high, medium, and low. Table 1 shows the acquisition of students' metacognitive awareness level based on the knowledge about cognition and regulation of cognition. The results showed that there were 40% respondents were in high level of knowledge of cognition 60% of respondent were in medium level, and there were no students who place in a low level. While the result of regulation of cognition are 60% of students were in a high level, 40% of students were in medium level, and none students were in a low level.

Table 1. Distribution of metacognitive awareness inventory

Metacognitive Awareness	Knowledge of cognition		Regulation of cognition	
	F	%	F	%
High	4	40	6	60
Medium	6	60	4	40
Low	0	0	0	0
Total	10	100	10	100

In table 2, the data from each student were classified based on metacognitive awareness level in the field of knowledge about cognition and regulation of cognition. The result shows that there are three students who placed in a high level for both of them, one student who placed in a high level for knowledge of cognition and they are in medium level for regulation of cognition there are three respondents who placed in medium level for knowledge of cognition while they have a high level for regulation of cognition, and there are three students who placed in medium level for both.

Table 2. Distribution of students' level of metacognitive awareness

Knowledge about cognition		Regulation of cognition		
		High	Medium	Low
Knowledge about cognition	High	3	1	0
	Medium	3	3	0
	Low	0	0	0

3.2. Problem-solving

3.2.1. Students with a high level of knowledge about cognition and regulation of cognition

Problem-solving process	Students		
	1	2	3
Understanding the problem	Yes	Yes	Yes
Devise a plan	Yes	Yes	Yes
Carry out the plan	Yes	Yes	No
Look back (check and interpreting)	Yes	Yes	No

Base on the result above, it can be concluded that students who have a high level of knowledge about cognition and regulation of cognition, they are able to understand the problem and able to give a solution, able to solve the problem match to the plan that has been made. The next step is analyse the solution. Here the students were asked to re-check the calculation.

3.2.2. Students with a medium level of knowledge about cognition and high level of regulation of cognition

Problem-solving process	Students		
	1	2	3
Understanding the problem	Yes	Yes	Yes
Devise a plan	Yes	Yes	Yes
Carry out the plan	Yes	Yes	Yes
Look back (check and interpreting)	Yes	No	No

Base on the result above, describe that the students who have a medium level of knowledge about cognition and high level of regulation of cognition, they are able to understand the problem and able to give a solution, able to solve the problem match to the plan that has been made, but in the part of checking and interpreting, the students didn't check the solution and write the conclusions.

3.2.3. Students with a high level of knowledge about cognition and medium level of regulation of cognition

Problem-solving process	Students
Understanding the problem	Yes
Devise a plan	Yes
Carry out the plan	No
Look back (check and interpreting)	No

Base on the result above, it can be concluded that the students who have a medium level of knowledge of cognition and high level of regulation of cognition, they are able to understand the problem and able to give a solution, able to solve the problem match to the plan that has been made, but in the part of checking and interpreting, the students didn't check the solution and write the conclusions.

3.2.4. Students with a medium level of knowledge about cognition and regulation of cognition

Problem-solving process	Students		
	1	2	3
Understanding the problem	Yes	Yes	Yes
Devise a plan	Yes	Yes	Yes
Carry out the plan	Yes	Yes	Yes
Look back (check and interpreting)	Yes	No	No

Base on the result above, it can be concluded that the students who have a medium level of knowledge of cognition and high level of regulation of cognition, they are able to understand the problem and able to give a solution, able to solve the problem match to the plan that has been made, but in the part of checking and interpreting, the students didn't check the solution and write the conclusions.

3.3. Students' metacognitive awareness in problem-solving process

Table 3. Distribution of students' problem-solving process

Problem-solving process	Level of knowledge about cognition and regulation of cognition			
	H&H	M&H	H&M	M&M
Understanding the problem	Yes	Yes	Yes	Yes
Devise a plan	Yes	Yes	Yes	Yes
Carry out the plan	Yes	Yes	No	Yes
Look back (check and interpreting)	Yes	No	No	No

This can be seen from the results where the students who have a high level of knowledge about cognition but have different level of regulation of cognition reached different stages of problem-solving process. The students who have a high level of knowledge of cognition and high level of regulation of cognition are able to achieve all stages of problem-solving, those are understanding the problem, making a solution implementing the plan, and looking back. While the students who have a medium level in regulation of cognition are only able to reach the stage of making a plan in problem-solving.

The students who have a medium level in the knowledge of cognition are able to reach the same stage and implementing the solution in the problem-solving process, even though it has different level in regulation of cognition. This is proves that regulation of cognition gave an effect to the mathematical problem-solving process, appropriate to the previous research conducted by Abdulleh [12] that there is a positive relationship between metacognitive awareness and regulation of cognition, because at the same level of knowledge of cognition, students who have high level in regulation of cognition reach a more-complete problem-solving process than the students in the medium level of regulation of cognition.

Knowledge about cognition also effect students' problem-solving process. The students who have a high level in regulation of cognition and high level in knowledge of cognition are able to reach higher problem-solving stage than the students who have high level in regulation of cognition, but the level in knowledge of cognition is medium. The students who have medium level in regulation of cognition and high level in knowledge of cognition reach a lower stage of problem-solving process than the students who have medium level in knowledge of cognition. This result is a bit contrary to the previous study conducted by Schleifer and Dull [14] which stated that students who are successful due to having a better meta-knowledge than meta-regulation.

4. Conclusion

The result of the study shows that the component of metacognitive awareness are knowledge about cognition and regulation of cognition gave an effect to mathematics students in problem-solving process. Based on these results it can be concluded that the two components of metacognitive awareness can affect mathematical problem-solving process, especially regulation of cognition.

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