Identification of student’s metacognition level in solving modeling mathematical problem

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Abstract. This study aims at identifying the students’ metacognition level in solving mathematical modeling problem. Subjects of this study is eight seventh grade students in junior high school which selected based on their latest mathematics test exam score and communication ability test. The results of this study are obtained by using mathematical modeling problem test and interview. The results of this study are that students in the tacit use level is not know the reason why did they use the certain ways that they did to solve the problem, most of the time they just use ‘try and error’ method. Students in the aware use already know the reason why they use a certain ways to solve a certain problem. Students in the strategic use are capable on create their own strategy before solving the problem. Students in reflective use are not only building a plan before solving the problem, but also reflecting and evaluating during and after they obtain the result of the problem.

1. Introduction
Metacognition is defined as knowledge about, awareness of, consideration, and control over one’s cognitive processes, strategies and its results; an ability to monitor and manage one’s cognitive processes, strategies and its results; as well as evaluate and regulate one’s cognitive processes, strategies and its results. In other words, the metacognition can be categorized into some components, namely components related to the knowledge or self-awareness and components related to monitoring and evaluation of the thinking process and its result [1]–[3].

Metacognition is the ability to be aware and be able to control one’s cognitive process and strategies which are highly important in the learning and problem solving process. Metacognition is an understanding about their ability, strategy, resources needed to complete a task that included: finding the main idea, training informations, create assosiations or a big picture, using technique to do cognitive tasks, using tests to confirm doubts [4]. Metacognition have a big part of controlling one’s cognitive in learning process in order to think and solve problem a lot more effective and efficient. However, every pupil has different ways and ability to perceive a problem. Some pupils might be consciously aware of the given problem and solving it hierarchical while other pupils might solve it recklessly and completely unaware of the essence of the problem. This type of understanding is due to students’ different level of awareness or different level of metacognitive [5]. Perkins [6] categorize students’ metacognition level into four different categories. The first category is tacit use level. In tacit use level, learners are making decision without thinking through it. Learners are unaware of their cognition process. Learners are only using “try and error” method where one uses randoms mathematical formulas without using any cognitive strategy to solve the problem. The second in the
category is aware use. In this level of thinking, learners are starting to be aware of their own thinking. Learners are starting to understand about what strategy and knowledge has to be used in a certain situation. The third level is strategic use which in this level of thinking, learners are capable of organizing their thought and aware of some certain strategies that can be used to help overcome a certain situation. The fourth one on the list is reflective use. In this level of thinking, learners not only aware and using cognitive strategies to help them to do some problem solving activities easier, but they also capable to reflect upon their strategies that they had used before in order to improve or fix just in case some mistakes are found and to evaluate the result of their own work in order to get the best mistake free result.

Metacognition is the ability to be aware and be able to control one’s cognitive process and strategies which are highly important in the learning and problem solving process. Metacognitive have a big part of controlling one’s cognitive in learning process in order to think and solve problem a lot more effective and efficient. When the way of thinking and solving problem become a lot more efficient, more effective, and easier, the ability to think and to solve problem will grow. Therefore, metacognition is very beneficial to increase one’s ability to learn and solve problem. Along with the ability to think and solve problem increasing, the learning achievement is too will be increasing. Therefore one’s level of metacognition is equal with one’s learning achievement. The study conducted by Agustina and Trineke [7] about metacognition level in solving mathematical problem about circumference of square and rectangle concluded that students’ who gain high score in solving the problem belong in strategic use level of metacognitive, while the moderate and lower score belong in aware use and tacit use consecutively. Unfortunately the study had not been able to find a student categorized in reflective use level. Another study conducted by Panaoura and Philippou [8] about the measurement of young pupils’ metacognitive ability in mathematics concluded that students that have high ability in knowing and organizing their cognition and aware of their own cognitive capability showing more capability in thinking strategically and problem solving compared to those who do not have aforementioned ability.

Mathematical modeling problems is a mathematical problem which contain a real life mathematical problem by which the learners cannot directly solving the problem using mathematical formulas, but has to go through certain chain in activities in which starting from the learners translate said real life problem to a situation model which then structured and simplified into a real model and thereupon transformed to a mathematical model which activities called ‘mathematizing’. The problem then solved using the suitable mathematical formulas to solve the problem by then the results are generated into a certain context of the initial problem. The chain of activities then run by several times until the desired results are obtained [9], the process is called mathematical modeling. Mathematical modeling is a process to build a model based on an applied mathematics problem and using it to solve the problem [10].

Real life problem is the most common problem that is going to be faced by every human being all their lives. Therefore it is important to understand the most effective, efficient, and easiest way to solve it. Considering that metacognition offer more effective, efficient, and easier way to solve mathematical problems, it is important to understand how metacognition would play a role in solving a mathematical modeling problem. Thus based on previous references, a study entitled “Identification of Student’s Metacognition Level in Solving Modeling Mathematical Problem” is carried out.

2. Research Methodology
This study is a descriptive explorative that aims to describe students’ metacognition level in solving mathematical modeling problem. The subject in this study is eight seventh grade students in the academic year of 2018/2019. Subjects are chosen based on their ability to communicate their thoughts which obtained by a conducted communication ability test beforehand and their mathematics ability which obtained by the latest mathematics exam’s result conducted by teacher. Based on the test results then the students are divided into four groups of students in high, upper moderate, lower moderate, and low. Then, from each category, two students are chosen to the subject of the study. Aside from the
researcher as the main instrument, there are three other auxiliary instrument, namely communication ability test, two mathematical modeling problems that was given one by one and each problem was given by a distinct period of time, and interview guideline.

3. Findings
From the study conducted, each subject shows different metacognition activities. Written below are the metacognition activities from each subject in each metacognition level. The first elaboration is the result came from students in tacit use level. There were two students that put in the tacit use level of metacognitive based on their latest mathematics exam score which are two of the lowest score in class. Both students had to read the problem repeatedly and took them a quite long time to understand the given problem. They tried to solve the problem with a certain ways that they didn’t even understand the reason why they did it. They mostly just used “try and error method”, they tried to solve it with random mathematical formulas, like adding and multiplicating without understanding the problem and the needs of the problem real well. It is relevant with Gregory [11] that stated that subjects in the metacognition level of tacit use made a decision without thinking about those decision beforehand. This result also relevant with a study conducted by Lauren [3] which concluded that the subjects in the level of tacit use had something called instrumental understanding, it is an understanding of using a way without knowing or realizing the reason behind it. After they got an answer to the problem, they got so confident that they didn’t feel the need to check twice to know
whether their answer was the correct answer. By the way they acted while solving the problem; it looked like they tried to solve the problem in hurry and tried to finish the work as soon as possible.

**Figure 2.** Subject 8: “1 little bottle equals 2 glasses of water; 1 medium bottle equals 4 glasses of water; 1 big bottle equals 16 glasses of water.”

**Figure 3.** Subject 7: “4 medium bottles equal 1 big bottle; 2 little bottles equal 1 medium bottle; 6 glasses equal 1 little bottle and 1 medium bottle; If 1 little bottle produces 2 glasses and 1 medium bottle produces 4 glasses; How many glasses does it take for big bottle?; 4 medium bottles equal 16 glasses; 4 times 4; So, 1 big bottle produces 16 glasses.”

The second level is aware use. There were two students that put in the aware use level of metacognitive based on their latest mathematics exam score which are two of the lower-moderate score in class. Both students had to read the problem repeatedly to understand the given problem. Students in the aware use level of metacognitive capable of explaining the reason why they did a certain mathematical process to solve the problem after they got the answer, but found it hard to planned it beforehand. This result is relevant with a study conducted by Danang [12] who stated that the subject in this level was eliciting the reason and the steps of the thinking that was used, the story behind the made decision, and the awareness of the weakness. By the way they acted while they solve the problem, it looked like they found the way to solve the problem as they go. After they got the answer, they felt very confident on their work and didn’t feel the need to check the correctness after.

**Figure 4.** Subject 6: “4 medium bottles equal 1 big bottle; 2 little bottles equal 1 medium bottle; 2 glasses equal 1 little bottle; 4 glasses equal 1 medium bottle; 4 glasses fill up 1 medium bottle; 4 medium bottles fill up 1 big bottle; equals 4 glasses times 4 medium bottles; equals 4 times 4 equals 16 glasses.”
Third on the list is strategic use level of metacognitive. There were two students that put in the strategic use level of metacognitive based on their latest mathematics exam score which are two of the upper-moderate score in class. Both students had to read the problem repeatedly to understand the given problem. Before they solved the problem, researcher asked all subjects to create a plan to solve the problem, what they should do after they understand the problem until they find the final answer. Both students in strategic use level of metacognitive were capable of created and explained more than one way to solve the problem, and then chose the simplest way to find the solution. It is similar with a result concluded by Danang [12] that subjects in this metacognition level started to realizing their skill and capability and capable of defending their thoughts, knowing how to convince. Although the subject in this study showing a little different result with Danang’s subjects [12] where their subjects did some recalculating, revising, rechecking, and comparing the answer to the initial problem where subjects in this study still didn’t feel the need to check their final answer when researcher asked them to.

**Figure 5.** Subject 5: “First method: 1 big bottle equals 4 medium bottles; 1 medium bottle equals 2 little bottles; 1 little bottle equals 6 glasses; 6 (glasses) times 3 equals 18 glasses; and 1 medium bottle; If 1 little bottle produces 2 glasses and 1 medium bottle produces 4 glasses, then how many glasses does it take to fill 1 big bottle?; 4 medium bottles equal 16 glasses; 4 times 4; So, 1 big bottle produces 16 glasses.”

**Figure 6.** Subject 3: “1 medium bottle equals 2 little bottles; 6 glasses equal 1 little bottle and 1 medium bottle which being equalized to 2 little bottles; 1 big bottle equal 8 little bottles; 8 little bottles equal 16 glasses; need 6 little bottles equal 12 glasses; 1 little bottles equal 2 glasses; the amount of water glasses that you pour into the big bottles is 16 glasses.”
The last one is the highest level of metacognitive named reflective use. There were two students that put in the reflective use level of metacognitive based on their latest mathematics exam score which are two of the highest score in class. Both students had to read the problem repeatedly to understand the given problem. When asked, both students in strategic use level of metacognitive were capable of created and explained more than one way to solve the problem, and then chose the simplest way to find the solution. Both subjects were highly elaborate and checked the initial problem repeatedly while they did the problem solving activity to make sure that they did the correct way to solve the problem. It is similar with the result of a study conducted by Lauren [3] where the subjects doing a reconsideration and check for compatibility to the initial problem after a solution had been found. After they found the final answer and asked whether they need to check their answer again, they accepted the offer and meticulously checked it again. They gave the correct answer to the problem but didn’t look as confident as the other subjects in other levels. They were highly elaborate in solving the problem and took their time doing it while keep checking their steps repeatedly as they went, and keep checking it even after they got the final answer. This result is relevant with a study conducted by Danang [12] who concluded that the subjects in this level of metacognitive reflect their thinking constantly from the moment they saw the problem, while doing the problem, and after they got the answer.
4. Conclusion
Based on the analysis, it resulted that students in the tacit use level is not know the reason why did they use the certain ways that they did to solve the problem, most of the time they just use ‘try and error’ method. Students in the aware use already know the reason why they use a certain ways to solve a certain problem. Students in the strategic use are capable on create their own strategy before solving the problem. Students in reflective use are not only building a plan before solving the problem, but also reflecting and evaluating during and after they obtain the result of the problem.

5. Suggestion
This study about identification of student’s metacognition level in solving modeling mathematical problem needs to be developed more. This study is an attempt to creating a connection between two interesting theme in mathematics education field namely metacognition and modeling mathematics. Although this study is only using modeling mathematics as an instrument to found out subjects’ metacognition and hardly mention about subjects’ modeling process and focusing more on subjects’ metacognition process. There should be another study conducted to engage those two interesting aforementioned theme in the future.

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