

# Model Eliciting Activities (MEA) Application in Online Group Discussion for Mathematics Learning

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**Abstract:** *Metacognition is a person's awareness on their own thinking processes in mathematics. Awareness of thinking refers to the awareness of what they know and what they are going to do in learning of mathematics. Metacognition has two components, namely: (1) knowledge of metacognitive and (2) metacognitive skills. Metacognitive knowledge related to declarative knowledge, procedural knowledge and conditional knowledge in mathematics. Meanwhile, the metacognitive skills associated with predicting skill, planning skill, monitoring skill, and evaluating skill in mathematics. This article concludes the mathematics teachers' perceptions and obstacles of modeling after experiencing three model-eliciting activities (MEAs, Lesh & Doerr, 2003) and designing model as a problem solving process to online group discussion, and implementing the MEAs in math classrooms.*

**Keywords:** Learning Model, MEA, Metacognition

## 1. Introduction

Jenning and Dunne (1999) state that most students have difficulties in applying mathematics in real-life situation. Another causes students feel mathematics is difficult is that the lack of the meaningfulness in learning process. Teachers in classroom did not associate the topic with scheme which the students have had, and the students were given less opportunity to discover and construct their own mathematical ideas. Associating students' real-life experiences with mathematical ideas in the classroom are important in order to make learning becomes meaningful (Soedjadi, 2006). In recent years, along with the development of cognitive psychology, the way teachers evaluate learning outcomes achievement, particularly for cognitive domains, also develops. Nowadays, teachers only emphasis on the assessment of the cognitive process without considering the knowledge and skills, particularly on metacognitive knowledge and metacognitive skills in evaluating the learning outcomes achievement. Consequently the efforts to introduce metacognition in mathematics to students are very less or even tend to be ignored. Hence, one aspect of knowledge and skills dimensions which is interesting to be studied more deeply, especially in mathematics are metacognition aspects. Livingston (1997) states that: Metacognition refers to higher order thinking which involves active control over the cognitive processes engaged in learning. Activities such as planning how to approach a given learning task, monitoring comprehension, and evaluating progress toward the completion of a task are metacognitive in nature. Schoenfeld (1992) suggested more specifically that there are three ways to describe metacognition in mathematics, ie: (a) belief and intuition, (b) knowledge of the thinking process, and (c) self-awareness (self-regulation). Beliefs and intuitions concerning any mathematical ideas which are prepared to solve mathematical problems and how these ideas form the path/way to solve mathematical problems. Knowledge of the thinking process regarding how accurately a person in expressing his/her thinking process.

While the self-awareness or self-regulation concerning the accuracy of the one to maintain and organize what to do

when solving mathematical problems, and how accurately the one using the input of observations for directing the problem solving activities. O'Neil & Brown (1997) states that metacognition as a process which is someone thinks of their thinking in order to develop strategies to solve problems. While Anderson & Krathwohl (2001) states that metacognition knowledge is knowledge of cognition, generally same with the awareness and knowledge of one's self-cognition. Because of that, metacognition can be said as awareness of what is known and what is unknown. While the metacognition strategy refers to a way to raise awareness about the process of thinking and learning that applies so if the awareness is true, then a person can escorting her/his thoughts by designing, monitoring and assessing what he/she learned. Paris, Lipson, and Wixson (Nurdin, 2004) state that students need to develop conditional knowledge for general cognitive strategies; or in other words, they need to develop knowledge of when and why using strategies appropriately. Conditional knowledge refers to knowledge of which situation a person can use metacognition knowledge (Anderson & Kathwohl, 2001). While Winkel (1996) suggests the students' personal aspects, which is closely related to the students' metacognition ability, namely cognition function which covers: the level of intelligence, creative power, special talent, cognitive organization, the level of language skills, fantasy power, learning styles (cognitive style, learning style and thinking styles), and study techniques. Keiichi (2000) in his research on "Metacognition in Mathematics Education" produced some findings, ie: (1) Metacognition plays an important role in problem solving; (b) Students are more skilled at solving problems if they have metacognition knowledge; (c) In the framework of solving problem, teacher often emphasize specific strategies to solve problems and gives less attention to the important characteristics of other problem-solving activities; (d) Teacher reveals impressively some more achievement at intermediate level in elementary school where these matters are important in mathematical reasoning and problem posing strategy. From discussion above, it can be said that metacognition has an important role in regulating and controlling one's cognitive processes in learning and thinking, thus learning and thinking done by someone become more effective and efficient.

## 2. Theoretical Background

We organized the theoretical background of the research into three parts. First were the components of MEAs, second were the model development sequences and third were six principles of designing MEAs.

### 2.1 The components of model-eliciting activity

Lesh and Doerr (2003) referred to “Case Studies for Kids” as many cases of model-eliciting activities. Each case consisted of four main parts: newspaper articles, readiness questions, problem statements and process of sharing solutions. The purpose of the newspaper articles and readiness questions was to introduce the students the context of the problem and students can get more familiar with the situations of the case via reading the article and readiness questions just like a warm-up period. The problem statements should be the central part of the teaching and teachers presented to the students according to the grade level and previous experiences they have. Whether the students could identify that the client they were working for and the product they should create must be made sure. Then it came the process of sharing solutions and it was the stage of presentations of solutions and the teacher tried to encourage students to not only listen to the other groups’ presentations but to also try to understand the other groups’ solutions and considered how well these solutions meet the need of the client.

### 2.2 Model Development Sequences

The instruction of the study adopted the model development sequences (showed as figure 1.) (Lesh & Doerr, 2003). The sequences included three stages that were, model-eliciting activity, model-exploration activity and model-adaptation activity.

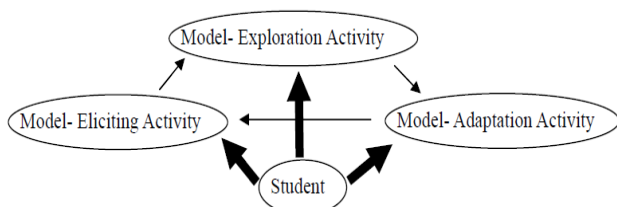


Figure 1: Model development sequences (Lesh & Doerr, 2003, p.40)

In the model-eliciting activity, it usually required one or two full class periods to complete, and students worked in the group of 3 or 4 persons. They were encouraged to discuss with their partners and work together. Students were required to express their way of thinking in forms that visible to teachers, and these were important resources that teachers made their decisions in the next model-exploring activity. In the model-exploration activity, it often involved computer graphics, diagrams, or animations (Lesh, Post, & Behr, 1987). No matter what kinds of the embodiments were used, the main goal was for students to develop a powerful representation system for making sense of the targeted conceptual system (Lesh & Doerr, 2003). This system was useful to go beyond thinking with the relevant conceptual system to also think about it. In particular, students often developed powerful conceptual tools that can used to crush

the problem they were given in the follow-up model-adaptation activity. In the model-adaptation activity, also called model-application activities or model -extension activities, the goal was to modify the tool developed in the model-exploration activity and let the tool be used in a new situation with some significant adaptations (Lesh & Doerr, 2003). We used the sequences as teaching strategy in the study to promote the modeling process of students.

### 2.3 Six principles of designing model-eliciting activity

On the other hand, the six principles that Lesh and Doerr (2003) mentioned to evaluate the quality of a modeling activity were also crucial points that we considered.

- 1) Construction principle ensured that the solutions to the activity required the construction of an explicit description, explanation, procedures, or justified prediction for a given mathematically significant situation.
- 2) Reality principle also called the meaningfulness principle and it required the activity to be designed so that students can interpret it meaningfully from their different levels of mathematical ability and general knowledge, and also pose a problem that could happen in real life.
- 3) Self-assessment principle ensured that the activity contained criteria that students can identify and use to test and revise their solutions and also include information that students can assess the usefulness of their alternative solutions.
- 4) Documentation principle ensured the activity required students to create some form of documentation that can reveal explicitly how they are thinking about the situation.
- 5) Share-ability and re-usability principle required students to produce more generalized solutions that others can also use or the solutions can reuse in other similar situations.
- 6) Effective prototype principle ensured the solution of the activity to be as simple as possible yet still mathematical significant and provide useful prototypes for interpreting other similar situations.

## 3. Model Eliciting Activities (MEA)

MEAs are:

- **Model-eliciting**, meaning that students are required to develop a model to not only solve the problem at hand, but also others like it. This usually looks like a step-by-step method for *how* to solve the problem, rather than just an answer to one question. This is important because it helps students understand the mathematical structure of the problem.
- **Self-assessable**, meaning the individual or student team can critique their own work for accuracy and effectiveness.
- **Open-ended** to allow for creative and thoughtful interpretation of the lesson. Rarely in the real world is there one way to solve a complex problem—and you can’t find the answer in the back of a textbook! MEAs let students develop their own ways of thinking about the problem, in that they design the model for the problem based on their own prior knowledge and experiences, thus improving their problem-solving capabilities.

- **Realistic** to connect students with familiar topics, like solar energy or paper airplanes. MEAs illustrate how STEM subjects can help solve the problems—big and little—of the world.
- **Generalizable** in that MEAs are useful tools for *all* STEM disciplines: science, technology, engineering and math.

#### 4. Problem Solving in Mathematics Learning

The mathematician got difficult to agree on their problem solving concept. Problem solving on students have goal that start from remediation of critical thinking to the development of creativity. Halmos (Schoenfeld, 1992) states that students should be involved in solving real problems. Furthermore Halmos stated that: I do believe that problems are the heart of mathematics, and I hope that as teachers, in the classroom, in seminars, and in the books and articles we write, we will emphasize them more and more, and that we will train our students to be better problem-posers and problem solvers than we are. (Hamos, (Schoenfeld, 1992)) Stanic and Kilpatrick (Schoenfeld, 1992) suggests three basic points about solving problems related to its use: First, problem solving as a context, while the issue used as a tool to achieve curriculum objectives. Furthermore, Stanic and Kilpatrick identified five roles played by such problems, ie: as justification for mathematics teaching. Historically, problem solving partially been incorporated in mathematics curriculum, because the problem provide the justification of mathematics teaching overall. Allegedly, at least one problem, associated with realworld experience, included in the curriculum to ensure students and teachers about math scores. Giving special motivation on subjects topic. Problems are often used to introduce the topic with implicit or explicit understanding that if you ever learn the next lesson, you will be able to solve such kind of problems. as recreation. Recreational problem is intended to motivate. It shows that mathematics can be fun and skills students have mastered can be an entertainment as a tool to develop new skills. Problem that sorted properly can introduce students a new material and provide an atmosphere to discuss material techniques. as practice.

Milne's exercise, and most school math assignment, included in this category. Students are shown the techniques and then given a problem to practice until they master the technique. Based on that fifth roles then the problem is seen as something unusual and actually used as a tool for a problem with a purpose as shown above. Therefore problem solving cannot be seen as a destination unto itself, but problem solving is seen as a tool to achieve other goals. Hence problem solving is to complete the presented task. Second, problem-solving as skill. Thorndike (Schoenfeld, 1992) removes any doubt about mental exercise, because he thinks that learn reasoning skills in the mathematics domain will produce improvement in reasoning ability performance generally to the other domain. Therefore, if mathematical problem solving is considered important, it was/is not because it creates a person who can solve problems better generally, but because solving mathematical problem has its own value. Even though there is disagreement, but most of curriculum development and implementation which is mentioned as solving problems in the 1980s are on this type.

Stanic and Kilpatrick (Schoenfeld, 1992) reveal that problem solving is often viewed as one of a number of skills that taught in the school curriculum. Based on this view, then problem solving should not be regarded as a skill, but there is a clear skill. Furthermore he says that puts problem solving in the hierarchy of skills obtained by the students led to certain consequences for the role of problem solving in curriculum. In addition, he revealed that there is a difference between solving routine problems and non-routine problems. Solving non-problem characterized as a higher level of skill that must be acquired after skill of solving routine problem (which students will obtain after learning basic mathematical concepts and skills). Although the interpretation of the second problem solving is seen as a skill, but a basic explanation of the pedagogical and epistemological assumptions similar to Milne's stated. Therefore, problem solving techniques (such as drawing a diagram, looking for a pattern if  $n = 1, 2, 3, \dots$ ) is taught as a lesson materials, with practical assigned problems so that the technique can be mastered. After obtaining teaching about this type of problem solving (often separate from the curriculum), a collection of students' mathematical skills considered includes problem solving skills and facts and procedures that have been studied. Thus, expansion of knowledge contents are considered contain of students' mathematics understanding and knowledge.

Third, problem solving as art. This view is very different from the two previous views which implies that real problem solving (ie working on the problem as a kind of confusing) is the core of mathematics, if not the mathematics itself. Problem solving as art means everybody include students are interested in online grup discussion because of technology advance. So, before students are made busy by technology advance, we make them busy by mathematic online grup discussion. There, they can discuss to solve the problem. The teacher as admin in that grup always share the question or study case to the grup anytime. So the students will be usual to solve the question everywhere. Even, the teacher can give funny question first to entertain the students and make them love mathematic.

#### 5. Conclusion

Metacognition as a form of cognition, or thinking processes two or more levels involve control of cognitive activity. Therefore, metacognition can be regarded as a person's thinking about his/her own thinking or as a person's cognition about his/her own cognition. Moreover, metacognition involves knowledge and awareness of one's own cognitive activity or anything related to cognitive activity. Thus, a person's cognitive activities such as planning, monitoring, and evaluating the completion of a particular task is metacognition naturally. Therefore, students' metacognition have an important role in mathematics learning, especially in regulating and controlling students' cognitive activity in learning and thinking, so that learning and thinking by students in mathematics learning becomes more effective and efficient. The basic principle of constructivist view in learning mathematics, ie: (1) Students build knowledge; (2) Students are actively involved in learning both emotionally and socially; (3) Knowledge cannot be transferred from teacher

to students; (4) Teacher just provides facility in order to students can take the construction process. Three points about problem solving associated with its use: (1) problem solving as a context, while the issue used as a tool to achieve curriculum objectives; (2) problem solving as skill; (3) problem solving as art can entertain the students and make them love mathematics by the math problems but it depends on the creativity of the math teacher.

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