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Humanistic Mathematics Education”**

**Presented by :**



**Yogyakarta, July 21-23 2011**

**Department of Mathematics Education  
Faculty of Mathematics and Natural Science  
Yogyakarta State University**





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## THE TEACHING AND LEARNING MATHEMATICS THROUGH METACOGNITIVE STRATEGY

Umy Zahroh

Dosen Prodi Pendidikan Matematika STAIN Tulungagung

### Abstract

To improve the teaching and learning is an important factor that needs to be considered. To improve the students' learning achievement is one of the tasks and the responsibilities of a professional teacher. One of the strategies to improve the quality of teaching is by applying metacognitive technique which is entered not only to improve their achievement but the awareness of learning as well.

The teaching and learning activities done by combining cognitive, affective, psychomotoric and metacognitive domains are able to improve the awareness of the students on what they have learnt. The result of the students' learning is considered to be qualified if they are considerably able to control their cognitive process sustainably and it brings about the improvement of the metacognitive quality.

The implementation of metacognitive technique in mathematics problem solving is able to build the students' characteristics, such as they get used to think reflectively, alternatively, and systematically; they have good control in doing various activities; they have good plan before doing any activities; they are capable of monitoring and evaluating their own activities. Accordingly, metacognitive strategy needs to be implemented in teaching mathematics.

**Key words:** Teaching and learning mathematics, metacognitive

### INTRODUCTION

In improving the quality of education and learning in Indonesia, the government is always renewing the curriculum. The renewal has been done including completion of high school curriculum of 2004 (Depdiknas, 2003). Curriculum of 2004 has been completed to develop standards of competence and basic competence in the operational level of the education curriculum, called the Education Unit Level Curriculum/ *Kurikulum Tingkat Satuan Pendidikan* (KTSP) (Mulyasa, 2006).

The government has tried to improve the quality of teachers through various activities, among others activities Subjects Teachers Council (MGMP), as a meeting of teachers to improve the quality of teaching and learning lesson for each subject. For that reason, it needs to be improved through education reform by taking into account the concept of teaching and learning, how should students learn and how well teachers perform teaching activities (Vienna, 2008).

The learning process is carried out related to the cognitive, affective, and psychomotor and accompanied by metacognitive learning will enable students to increase awareness of what has been learned. Student learning outcomes can be said to



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### INTRODUCTION

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The learning process is carried out related to the cognitive, affective, and psychomotor and accompanied by metacognitive learning will enable students to increase awareness of what has been learned. Student learning outcomes can be said to



be qualified if the student is consciously able to control the cognitive processes on an ongoing basis and have an impact on improving met cognitive skills.

However, the problem of learning that empowers metacognitive abilities has not been revealed. The process of learning and quality education associated with the ability to think. Learning has not made students have the ability to think and to realize what they have learned, empower students to think creatively and enthusiastic and motivated to know the object of learning through active engagement of learning, both to solve real problems in life, and stimulate students to always be responsive to the existing problems in the surrounding environment (Winarno, Susilo, and Soebagio, 2000). Increasing metacognitive ability significantly is the effect resulting from learning, both on students, institutions and society, because it needs to be considered learning strategies that have the potential to uncover metacognitive abilities.

The important role of metacognitive has been clearly stated by Garofalo and Lester (JRME) by stating: "There is also growing support for the view that purely cognitive analyzes of mathematical performance are Inadequate because they overlook metacognitive actions." This shows that the performances (performance) of a student looks at the cognitive aspects only, and ignore metakognitive aspects is not enough. Necessary cohesion analysis, both cognitive and metacognitive performance is related to someone. In the end, this is the noble duty of a teacher of mathematics to help students so that they have the metacognitive knowledge is more complete with age and experience.

So, one-dimensional aspect of the knowledge and skills that are interesting to study more deeply, especially in mathematics learning is the aspect of metacognition. Livingston (1997) states that: Metacognition refers to higher order thinking the 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.

According to Schoenfeld (1992) suggested that there are three ways to describe metacognition in learning mathematics, namely: (a) beliefs and intuition, (b) knowledge about the thinking process, and (c) self-consciousness (self-regulation). Beliefs and intuitions about mathematical ideas what it is prepared to solve mathematical problems and how those ideas are shaping the way to solve mathematical problems. The



Knowledge of the process of thinking is about how accurately a person in expressing his thinking process. While self-consciousness or self-regulation concern the accuracy of a person in maintaining and arranging what to do in solving mathematical problems, and how accurately a person using the input from his observations to direct the activities of solving problems.

Anderson & Kathwohl (2001) argues that metacognition knowledge is about cognition, in general the same as the awareness and knowledge about one's self-cognition. While O'Neil & Brown (1997) suggests that metacognition as a process in which a person thinks about thinking in order to build a strategy to solve the problem. It can be said that metacognition is an awareness of what is known and what is not known. While metacognition strategies refer to ways to increase awareness of thinking and learning processes that has been applied so that when the consciousness is realized, the person can guard his mind by designing, monitoring and assessing what is learned. In his research Keiichi (2000) on "Metacognition in Mathematics Education" produced several findings, namely: (a) Metacognition plays an important role in solving the problem, (b) Students are more skilled at solving problems if they have knowledge of metacognition, (c) In the framework solve problems, teachers often emphasize specific strategies for solving problems and less attention to the important characteristics to solve the problem in other activities, (d) Teachers express more impressive achievement in some intermediate levels in primary schools in which it is important in mathematical reasoning and problem posing strategies.

Based on the description above, it can be said that metacognition plays an important role in regulating and controlling one's cognitive processes in learning and thinking, so that learning and thinking is done by a person become more effective and efficient.

Therefore, the learning of mathematics through metacognitive strategies become topic of discussion in this paper.

## **METACOGNITIVE**

Metacognitive by Flavel was first disclosed in 1976 that brought a lot of debate within defined. Here is some definitions of metacognitive from some experts who argued in Corebima (2006), namely:



1. Awareness and control of cognitive processes (Eggen and Kauchak, 1996).
2. Monitor the process of knowing and thinking processes or cognitive process itself (Arends, 1998)
3. Metacognition refers to the skills learners aware of and monitor the learning process (Peter, 2000)
4. Knowledge about their own learning; about how he learned and how he was doing to monitor learning (Flavell, and Alexander Gardner in Slavin, 1997).

Of these exposures can be seen that the empowerment of metacognitive skills was necessary. The goal of the development of metacognitive skills is the students can understand how the task is performed (Rivers, 2001 and Schraw, 1998 in Hadi, 2007). While from the same source Similarly, Flavell, Gardner, and Alexander in Slavin (1997) mentions that the development of metacognitive skills of students is intended to allow

students to monitor their own learning progress. Here are some of the benefits of metacognitive skills put forward by experts in Corebima (2006):

1. Eggen and Kauchak (1996) stated that the development of metacognitive skills in students is a valuable educational purpose, because the skills that can help them become self-regulated Learners. Self-regulated Learners are responsible for their own learning progress and adapt their learning strategies to achieve the demands of the task.
2. According to Marzano (1988), the benefits of metacognition (strategies) for teachers and students is to emphasize self-monitoring and student responsibility (self-monitoring is a high order thinking skills)
3. Susantini, et al. (2001) states through metacognition students to become independent learners, foster honesty and courage to make mistakes and will improve learning outcomes significantly.
4. Howard (2004) states that metacognitive skills are believed to play an important role in many types of cognitive activity, including comprehension, communication, attention (attention), memory (memory), and problem solving; some researchers believe that the use of ineffective strategies are one cause of disability learning.
5. Peters (2000) argue that metacognitive skills enable students to develop as independent learners, encourage them to be managers of themselves and become assessors of their own thinking and learning.



Based on the benefits that have been raised, the empowerment of metacognitive skills is very important in learning. By having metacognitive skills, students will be able to complete tasks with a good study because they are able to plan learning, organize, and evaluate learning.

Livingston (1997) divides metacognitive knowledge into three categories, namely knowledge of personal variables, task variables, and variables strategy. Knowledge of personal variables associated with knowledge about how students learn and process information and knowledge about the processes they have. For example, a student realized that learning is more productive if it was done in the library than at home. Knowledge of these variables involved the assignment of knowledge about the nature and type of processing tasks to be done to complete the task. For example, students realize that reading and understanding the texts of science requires more time than to read and understand a novel. Knowledge of variables strategy involves knowledge of cognitive strategies and metacognitive as well as conditional knowledge about when and where such strategies are used.

Cognitive and metacognitive skills aren't the same although they are related but different; cognitive skills needed to perform the task, while metacognitive skills necessary to understand how the task is performed (Rivers, 2001, Schraw, 1998 in Corebima, (2006). Indicators of metacognitive skills to be developed are: (1) identify the tasks, (2) monitor progress of work, (3) evaluate this progress, and (4) predict the results to be obtained. Furthermore, the processes that are directed at setting the thought process will also help (1) allocate resources-resources for the task, (2) determine the measures of task completion, and (3) determine the intensity, or (4) speed in completing the task. These indicators are set forth in metacognitive skills inventory (Hadi, 2007).

According to Blakey and Spence (2000) in Andayani (2008), strategies for developing metacognitive skills are as follows:

1. Identifying "what you know" and "what you do not know"
2. Discussing about thinking
3. Keeping a journal to plan and self regulation
4. Explaining the thinking process and evaluation

Various attempts have also been made to improve the ability of students associated with the cognitive, affective, and psychomotor and develop creativity.



Repairs carried out by the student's ability to increase the quantity and quality of teachers, preparation of teaching materials, and develop the utilization of student worksheets. However, the problem of learning that empowers metacognitive abilities has not been revealed. The process of learning and quality education associated with the ability to think. Learning has not made students have the ability to think to realize what they have learned, empower students to think creatively and enthusiastic and motivated to know the object of learning through active engagement of learning, both to solve real problems in life, and stimulate students to always be responsive to the existing problems in his surroundings (Winarno, Susilo, and Soebagio, 2000). Increased metacognitive ability to significantly is the effect resulting from learning, both on students, institutions and society, because it needs to be considered learning strategies that have the potential to uncover metacognitive abilities.

According to Costa (1985) in the learning process there are three teaching thinking, the teaching of thinking, teaching for thinking, and teaching about thinking. In the teaching of thinking, in fact in the implementation of learning may not release the three aspects of it, between the teaching of thinking, teaching for thinking, and teaching about thinking very closely related, even inseparable (Sanjaya, 2006). If these three aspects were implemented in learning at school, it can facilitate the thinking abilities of students, among them to learn mathematics. Thinking skills necessary in the era of globalization is related to the ability to think about the thought processes that involve higher-order thinking and is known as metacognition (Phillips, No year). According to Eggen and Kauchak (1996) states that higher-order thinking, including thinking creatively and think critically, which includes a combination of in-depth understanding of specific topics, skills using basic cognitive processes effectively, understanding and control of basic cognitive processes (metacognition), as well as the attitude and disposition.

High-level thinking skills can be empowered to empower metacognitive skills. Metacognitive skills and strategies related to metacognitive training and can be developed through cooperative learning (Green, Mc Donald, O'Donnell and Dansereau, 1992). In cooperative learning can be developed metacognitive skills in cooperative learning occurs because of communication, between members of the group (Abdur-Rahman, 1999). Communication among members of cooperative groups occurs well



because of mental skills, the rules of the group, the effort to learn each group member, and the goals to be achieved.

Based on the characteristics and phenomena of mathematics learning in school all this time, there are many causes of process problems and learning outcomes of students in learning mathematics were deemed less than optimal; one of them allegedly related to the ability to think. Critical thinking skills for students are metacognitive skills, because students learn to know consciously. Conversely, if students are forced to learn in order to pass the test well, this is different from its meaning for students. Students can learn to consciously achieve the condition, according to Vygotsky emphasized the sociocultural learning, namely social interaction through dialogue and verbal communication. An emphasis on sociocultural learning is cooperative learning. **Cooperative learning can improve students' thinking skills (Smith, 1984 in Corebima, 2006b).**

Cooperative learning contributes to learning outcomes and help students understand difficult concepts, and can receive outstanding achievements in academic learning tasks. Cooperative learning is beneficial for students to become peer tutors for other students who have low ability, to improve the academic abilities of highly capable students, to foster cooperation skills and metacognitive abilities. Abilities acquired as a result of cooperative learning students will grow and thrive because of the awareness and control of cognitive activity. Awareness and control of cognitive activity is known as metacognition, while raising awareness about how students are thinking and learning processes that take place are known as metacognitive strategies.

## **LEARNING MATHEMATICS THROUGH METACOGNITIVE STRATEGIES**

The results of the research of cognitive psychologists about the differences between students who are less intelligent and more intelligent show that metacognitive skills are very important (Djiwandono, 2006). Metacognitive abilities of students can be empowered through learning strategies in schools. Metacognitive ability to monitor student learning outcomes themselves by using certain strategies, in order to learn and remember can flourish. Identify important ideas by underlining or find key words in reading materials, then assemble into one sentence and write it back to the journal study, predict the results, decide how to use time and repeat the information is a high-level



thinking skills. The strategy used to determine a person's cognitive processes and the way he thinks about how information is processed are known as metacognitive strategies (Arends, 1998). A metacognitive strategy is the strategy used for students or learners in learning activities (Corebima, 2006a).

According Dirkes (1998) basic metacognitive strategies is linking new information with previous knowledge; selecting thinking strategies deliberately, to plan, monitor, and evaluate the thinking process. Arends (1997) suggests a knowledge of one's metacognitive knowledge about learning itself or the ability to use certain learning strategies correctly. Based on the basic meaning of metacognitive strategies and metacognitive knowledge (Dirkes, 1998; Arends, 1997), that metacognitive learning for students is important. If students already have metacognition, students will be skilled in metacognitive strategies. Students who are skilled in metacognitive strategies the child will more quickly become self-sufficient (Kompas, 12 February 2006). Presley (1990), states that the thinking skills and study skills are examples of metacognitive skills. Benefits of metacognition for teachers and students is to emphasize self-monitoring and responsibilities of teachers and students. Self-monitoring is a high-order thinking skills. Medium Howard (2004) states metacognitive skills are believed to play an important role in many types of cognitive activity, including comprehension, communication, attention (attention), memory (memory), and solving problems. Researchers believe that the use of ineffective strategies is one of the causes of learning disabilities (Deshler, Ellis & Lenz, 1996 in Corebima, 2006a). According to Livingston (1997) suggests metacognition holds one of the critical roles that is essential for successful learning. Students can learn to be more active, passionate, and confident during the process of learning, because teachers are able to develop metacognitive strategies (Hollingworth & McLouglin, 2001).

Important tips in the application of metacognitive strategies, namely: the strategy should be implemented after students have gained an understanding of concepts / skills: the strategy should be taught, using an explicit systematic instruction; strategy gives students the opportunity to practice independently, which, in turn, build fluency and mastery of skills; strategy can be very helpful for students who have difficulty moving from the level of representation of abstract understanding of the level of



understanding because it allows students to independently practice problem solving in the abstract; students use performance strategies that should be monitored.

O'Neil & Brown (1997) suggests that metacognition as a process in which a person thinks about thinking in order to build a strategy to solve the problem. While Anderson & Kathwohl (2001) argues that knowledge is knowledge about cognition metacognition, in general the same as the awareness and knowledge about one's self cognition. Because it could be argued that metacognition is an awareness of what is known and what is not known. Whereas metacognition strategies refer to ways to increase awareness of thinking and learning processes that has been applied so that when consciousness is realized, the person can guard his mind by designing, monitoring and assessing what is learned.

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Desoete (2001) argues that metacognition has three components on solving mathematical problems in learning, namely: (a) metacognitive knowledge, (b) metacognitive skills, and (c) metacognitive beliefs. But lately, the most common differences in metacognition are separate metacognitive knowledge of metacognitive skills. Metacognitive knowledge refers to declarative knowledge, procedural knowledge and conditional knowledge of one's problem solving (Brown & DeLoache, 1978; Veenman, 2006), while metacognitive skills refer to predictions skills (prediction skills), planning skills (planning skills), monitoring skills (monitoring skills), and evaluation skills (evaluation skills).

According to O'Neil & Abedi (1996), metacognitive is composed of aspects of awareness, cognitive strategy, design and self-evaluation. Through metacognitive approach gives an important role in solving problems and the students has more skills to solve problems if they have the metacognitive knowledge (Keichii, 2000). While the



syntax of the model is the stage of activity are realized in a series of teaching and learning activities. In the syntax of the model determines the types of teacher activity, and tasks for students (Arends, 1997). According Akhsanul (2011) says that the stage model of teaching and learning is designed in five phases: delivery of learning objectives, delivery aspects of consciousness, the implementation of cognitive strategies for understanding the problems of algebra, the use of cognitive strategies for solving algebra problems, and self-evaluation. These are five stages description as follows:

Syntax models

STAGES	TEACHER ACTIVITY
Stage 1 Delivery the learning objectives	Teacher conveys learning goals and provides motivation to learn the subject
Stage 2 Delivery aspects of consciousness	Teacher directs students to understand the subject of algebra stems from something that was understood and activity is done with a verbal question and answer
Stage 3 the implementation of cognitive strategies for understanding the problems of algebra	Teacher convey cognitive strategies to understand a problem that is a) a mark on the important ideas; b) make a marginal note; c) make a summary and d) create a concept map Teachers convey cognitive strategies for problem solving that is a) the heuristic strategy, b) strategy of backward thinking, c) the strategy of forward thinking, and deductive reasoning strategies
Stage 4 Implementation of design to understand and solve algebra	teacher recalls a variety of cognitive strategies in understanding and solving problems
Stage 5 self-evaluation	Teachers reminded again of the various activities already implemented. For this activity students review the settlement of problems that have been carried out with a group that has been previously agreed



Based on the opinions above, it can be formulated into five phases of learning mathematics through metacognitive strategies, namely:

Phase 1, The teacher presents the objectives of learning and motivation to learn the subject.

Phase 2, The teacher directs students to understand the subjects of mathematics, by starting from something already conceived and carried out this activity with a question and answer orally.

Phase 3, The teacher conveys cognitive strategies to understand a problem that is signaled to the important ideas; make marginal notes; summarize and create a map concept and teachers convey the cognitive strategies for problem solving is heuristic strategy, backward thinking strategic, forward thinking strategies, and deductive reasoning strategies

Phase 4, The teacher recalls a variety of cognitive strategies in understanding and solving problems.

Phase 5, The teacher reminded again of the various activities that have been implemented. For this activity students review the settlement of problems that have been carried out with the group.

The application of metacognition in learning mathematics problems can build up a character on students; for example, the students are used to think reflectively, to think alternatives, and to work systematically. Then, there will always be in control of doing various activities, plan well in advance of an event, monitor and evaluate in every activity undertaken. Therefore, the metacognitive strategies need to be taught to students.

## **CONCLUSION**

Based on the discussion, the conclusions of this paper is as follows: Metacognition is the awareness of one's thinking about his thinking process itself while awareness is awareness of one's thinking about what is known and what will be done.

The five phases of learning mathematics through metacognitive strategies, namely: Phase 1, teachers deliver learning objectives and providing motivation to learn the subject. Phase 2, the teacher directs students to understand the subjects of mathematics, starting from something already conceived and carried out this activity



with a question and answer orally. Phase 3, the teacher convey cognitive strategies to understand a problem that is signaled to the important ideas; make marginal notes; summarize and create a concept map, and teachers convey the cognitive strategies for problem solving is heuristic strategy, backward thinking strategic, forward thinking strategies, and deductive reasoning strategy Phase 4, the teacher recalls a variety of cognitive strategies in understanding and solving problems. Phase 5, the teacher reminded again of the various activities that have been implemented. For this activity students review the settlement of problems that have been carried out with the group.

Learning through metacognitive strategy carried out by adding the role of teachers to constantly remind the students to combine the knowledge he already has so that a proper balance in the understanding of knowledge.

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