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PMRI and Metacognitive Scaffolding

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Abstract

PMRI (Pendidikan Matematika Realistik Indonesia) has been implemented in some Primary Schools in Indonesia since 2001. Sanata Dharma University (USD) in Yogyakarta is one of the four universities which founded the PMRI Movement. Sanata Dharma University tries to keep its commitment to apply and develop PMRI as one alternative to improve the quality of mathematics education in Indonesia. In the process of development, P4MRI in USD also pays attention to the results of research in various disciplines, e.g. cognitive psychology, cognitive science and neuro science. One of the weakness of mathematics teaching and learning in Indonesia is the teacher centre approach. It is used in practice by most of teachers in the classroom. Their paradigm is related to teaching paradigm. In PMRI we use the learning paradigm in practicing the idea of Freudenthal that mathematics is human activities and pupils learn mathematics based on their experiences. We ask teachers to help students improving their understanding of mathematics by familiarizing them to pose questions to themselves: what, how and why. In solving a problem, the teacher lets them freely to find out their strategy and discuss it in their small group. The teacher helps them by giving some comments on their planning of solution or some suggestions, e.g. " do some exploration, make a table or a figure, or specialize!"

Key words: PMRI, Metacognition, Metacognitive Scaffolding

I. Introduction

In this paper I describe my experiences innovating the mathematics teaching and learning in schools using PMRI approach since 2001. Up to now, the mathematics teaching and learning in most schools in Indonesia are based on the behavioristic approach, that is teachers transfer their knowledge to students. The students receive the knowledge passively, there are no question or no interactive discussion among them. For the students, learning means to memorize the concepts and the way of solving problems which is introduced by the teachers. If a teacher ask some questions to the students about a concept or a step in the process of solving a problem, almost no body will raise their hands but they answer that questions chooresly if they know the answer or just they look at each other smilingly. Sometimes, if the teacher asks a certain student who involves in answering the questions in choor before to repeat his/her answer, he/she gives no response . That is a scene of the mathematics lesson in the classroom. Later on, they bring this kind of behavior to the next level of schools up to the university. Therefore, no wonder that the position of the Indonesian participants in IMO, TIMSS and PISA stands below median. For example, in PISA 2009 Indonesian

stood in the law ranking, namely in rangking 61 among 65 countries. The question is, is the quality of mathematical thinking of Indonesian students is so bad? I don't think so. My opinion is, the teachers need to change their strategy of teaching and learning mathematics. The strategy should be based on learning paradigm instead of teaching paradigm.

II. PMRI as Innovation of Mathematics Teaching and Learning

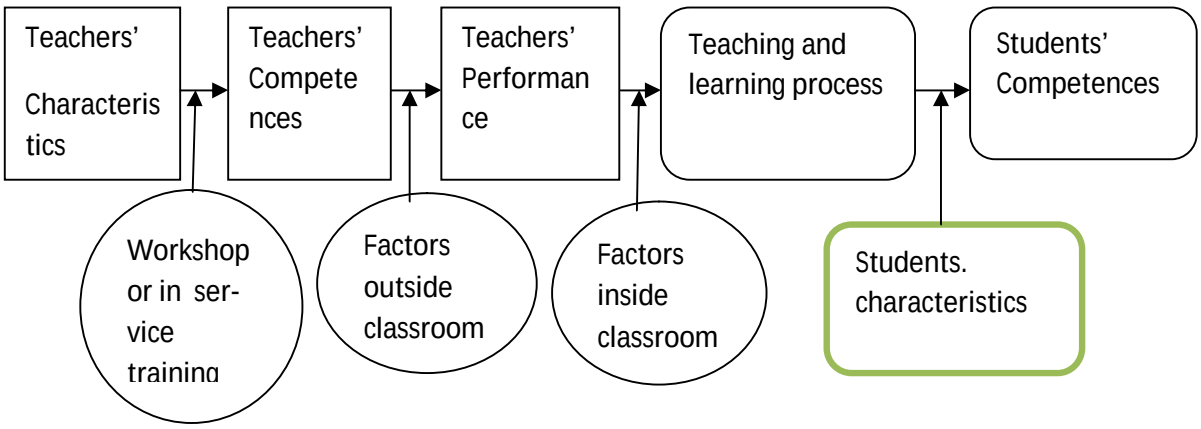
To improve students' mathematical understanding in schools, a small group of mathematics education lectures from 4 universities in Java founded in 2001 a movement for innovation of mathematics teaching and learning in schools, which they call PMRI (Pendidikan Matematika Realistik Indonesia). PMRI is an adaptation (not adoption) of RME (Realistic Mathematics Eduation), which has been developed since 1970 in the Netherlands, based on the idea of Freudenthal, that mathematics is human activities (de Lange, 1987; Gravemeijer, 1994; van den Heuvel-Panhuizen, 1996, Streeflands, 1991). After long discussion, we decided to start the innovation in the 1st grade in primary schools/ ibtidaiyah and next year in the 2nd grade, and continuously up to SMA/MAN (senior secondary school). To date we start to try out PMRI in some junior secondary schools. Sanata Dharma University (USD) in Yogyakarta is one of those universities mentioned above. The USD PMRI Team (P4MRI-USD) started to collaborate with 3 primary schools/ibtidaiyah. USD is a catholic university. She has the vision and mission based on the Ignatian Paedagogy which stress excellence and humanity. P4MRI-USD translate this vision in practicing PMRI approach in schools.

It is our task to connect the vision with the characteristics of PMRI (see Marpaung,, 2007) in such a way so that the teachers in schools can accept the innovation. We are aware that this is not an easy task, because this innovation has to shift the paradigm of teachers from teaching paradigm to learning paradigm. As has been described in the Introduction most of the teachers still use the teaching paradigm. They are familiar to transfer their knowledge to students. To change that paradigm, the first step is to train teachers in workshop, we go to school doing observation, video tape the teaching and learning process, then invite them to attend a meeting to discuss about the process by seeing the video. The second step, we ask the principle to invite the students' parents to meet us and the teachers, in which we tell them about the new

approach and show them their childrens' activities which different then before. Generally, the parents support the new approach and this support enhance the teachers motivation to shift their paradigm. We try to work closely with the teachers.

In 2003 we collaborated with 4 primary schools/ibtidaiyah and in 2004 with 6 primary schools/ibtidaiyah, one among them is in Bumi Serpong Damai (BSD), Tangerang Banten. We train the teachers the same way (see diagram below), but the result is different. The more support given by stakeholders (students' parents, principles, school foundations) the better result. For example, the teachers in BSD, Tangerang, meet together one day in every week to share their experiences implementing PMRI and discuss about the problem they have. This school is the best among 6 schools mentioned above. Up to now the PMRI team in USD has trained many teachers in many primary schools/ibtidaiyahs in Yogyakarta but we have a very limited possibilities to observe the practicing of PMRI in those schools except in 6 schools mentioned before.

After about 5 years, we introduce to the teachers the new idea of helping students to build their knowledge, so that later the students can find out their own strategies of solving a problem independently. We discuss with them that it is very important in learning mathematics, students to be aware of their own knowledge and be able to control them so that later they will be self-regulated learners.



Medley (in Marpaung, 1995)

III. Metacognition

In Matlin (1994), metacognition is described as knowledge, awerenss and control of our own cognitive processes. Cognition is about our knowledge of outside world, that is outside of ourselves, but metacognition is about our knowledge of inside world, that is inside our head. She says, "metacognition is important because our knowledge about our cognitive processes can guide us in arranging circumstances and selecting strategies to improve future cognitive performance" (p. 256). In fact it is not easy to distinguish between what is metacognition and what is cognition.

Flavell defined metacognition: "In any kind of cognitive transaction with the human or non-human environment, a variety of information processing activities may go on. Metacognitin refers, among other things, to the acive monitoring and conseguent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in serves of some concrete goal or objective" (http://www.lifecircles-inc.com/Learningtheories/ constructivism/flavell.html)

"Hacker offered a more comprehensive definition of metacognition, to include the knowledge of one's own cognitive and affective processes and states as well as the ability to consciously and deliberately monitor and regulate those processes and states" (http://www.lifecircles-inc.com/Learningtheories/constructivism/flavell.html).

Brown states, "metacognition refers to understanding of knowledge, an understanding that can be reflected in either effective use or overt description of the knowledge in guestion". (http://homes.dcc ufba.br/~claudiag/thesis/Chapter2_Gama.pdf). Simply, metacognition is cognition about cognition or thinking about thinking (see Kaune, 2006). The role of metacognition in learning mathematics has been researched intensively in the last decade, for example, the project of IKM (Institute for Cognitive Mathematics) in Osnabrueck, Germany (see Cohors-Fresenborg and Kaune, 2005; and Kaune, et al., 2011).

On the other side, we know that (1) Howard Gardner has invented that every individual has 9 kinds of intelligence but only one is dominant (See Suparno, 2004), (2) Goleman (1996) states about the role of emotional intelligence in life, (3) Stoltz (2000) describes the role of adversity quotient in solving problems, and (4) the constructivist teory of learning suggests that students should be active to build their own knowledge. All this show us the need for differentiated learning and the important of

metacognition in learning mathematics. Therefore in our effort to enhance the students' mathematical understanding, especially in the secondary schools, we asked the teachers to start to familiarize students to control their knowledge by asking themselves guestions such as:

a. What does it mean …?
b. What is …?
c. What do I know about …?
d. Do I understand the …?
e. How should I figure out …?
f. How I connect this … with what I have known about …?
g. What will happen, if …?
h. Why is the statement is true (or false)?
i. Why is the conclusion like that?
j. And so on.

IV. Metacognitive Scaffolding

Scaffolding is used for the first time in psychology by Vygotsky, a Russian developmental psychologist. Scaffolding is a help that support students to bridge the gap between what they can do on their own and what they can do with guidance from others. Scaffolding is related to the concept the zone of proximal development. One concept which is very well known in Vygotsky theory is the Zone of Proximal Development. Kozulin (2003) write, "the common conception of the zone of proximal development presupposes an nteraction on a task between a more competent person and a less competent person, such that the less competent person becomes independently proficient at what was initially a jointly accomplished task" (p. 41). The idea behind the concept is, a student is able to solve certain number of problems alone, but in collaboration can perform better in a greater number of problems. "With the collaboration, direction or some kind of help the student is always able to do more and solve more difficult problems that [sic] he can independently. It is not the competence of the more knowlegable person that is important, rather it is to understand the meaning of that assistance in relation to child's learning and development" (Kozulin, 2003, p. 41-43). I interprete this idea in relation to PMRI approach, that students learn better

through interaction with other students, and the teacher as a more competent person help them if they need, by giving them some metacognitive scaffoldings, for examples:

a. What does this … (word or concept) mean?,
b. What do you know about … (concept, rule)?,
c. Can you express the …(problem, task) in your own words?,
d. Can you represent the … (idea, problem) in figure, diagram, table, schema, in mathematics symbol?,
e. What is known (or given) in the problem?,
f. What is unknown in the problem?,
g. Can you see the relation between the given and the unknown?
h. What can you do to understand the problem?, or
i. Do you think, that you can understand the problem by taking a case (specializing)? or
j. Do you see now that it is possible to solve the problem? Will you try it?
k. And so on.

In interaction, it is important that students open to each other. If a less able student still do not understand what the more able student explain to him/her, he/she should say that frankly, so that the more able student try to find out alternative strategy that can make him/her understand the matter. This means, that openness in the interaction is important because it can enhance (improve) the mathematical understanding of both students. The question is, when is better to start giving metacognitive scaffolding to students, as soon as possible when they start to learn mathematics (the 1st grade) or in upper grade in primary schools/ibtidaiyah)?

V. Our Planning for The Development of PMRI

Based on my experiences in implementing PMRI since 2001 in primary schools/ibtidaiyah and now in secondary schools, I am challenged to do more than just training the teachers, go to schools observing the teaching and learning process, discuss with them and help them. Doing research is one answer to many questions and to enhance our own understanding about the development of students thinking, and cooperation with the university which has much experiences in practicing the RME approach is the other choice.

Since three years we have founded a long term cooperation with The Rotterdam University in the Netherlands to enhance the implementation of PMRI in primary schools/ibtidaiyah,and since two years with the IKM (Institut for Cognitive Mathematics) in the University of Osnabrueck, Germany for the secondary schools.. We now preprare a proposal to build a research institute in our university in the domain of metacognition. PMRI should be developed in line with the development of knowledge in various disciplines which also has impact on mathematics teaching and learning..

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