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Designing Joyful and Meaningful New School Mathematics Using Indonesian Realistic Mathematics Education

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Abstract

A new issue in education in Indonesia is the change of curriculum in 2013. This paper presents what are the changes in content, media, method, and evaluation of mathematics subject at the school levels. As informed by the minister of education and culture in the national newspaper, the changes in the primary school mathematics will connect and integrate with science. This might increase the understanding of students in both the concept of mathematics and the application of mathematics in their daily lives that is also related to science. Hence, mathematics teachers need a way to design meaningful learning materials to integrate the two subjects. It is called thematic-integrated approach or one intertwined among strands or subjects. This article will discuss these both approaches. The former is mentioned in the new curriculum while the latter is one of five characteristics of Indonesian Realistic Mathematics Education (PMRI). Then the current development of PMRI after 12 years of implementation and dissemination in Indonesia will be discussed. During this discussion it will reveal how to design and implement joyful and meaningful mathematics learning materials by using the Indonesia context or culture.

Keywords: Realistic Mathematics Education, PMRI, joyful and meaningful school mathematics

Issues on Mathematics in Curriculum 2013

The Indonesian Minister of Education and Culture, Muhammad Nuh, stated in 2012 that the curriculum was going to be changed next year (Kompas, 2012). Some of the reasons why the curriculum was to be changed were linked to the results of PISA and TIMSS which were very low, the lack of ICT used in the classroom, and too many subjects in the curriculum.

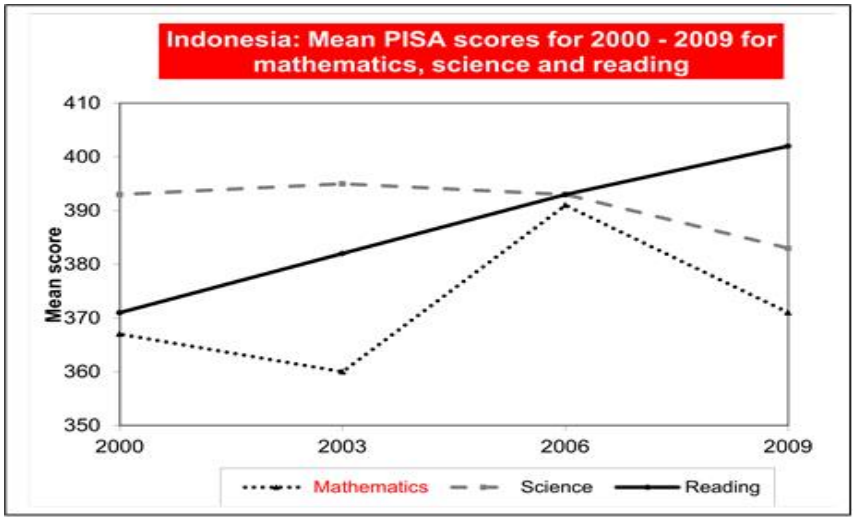

Figure 1. PISA results of Indonesia from year 2000 to year 2009 (Stacey, 2010)

Learning from the last PISA results (Stacey, 2011), Indonesia was ranked 61 out of 65 countries. From figure 1, one can see that the results for mathematics is sinking down or is unstable compared to the results of reading. In general, Indonesian students are only able to solve PISA problems at the levels 1-4, but almost none of students are able to solve problems at levels 4-6. Hence, the new curriculum is really focusing on the competences that were evaluated in PISA such as reasoning, problem solving, argumentation, modelling and communication.

Many subjects including mathematics will be changed at all school levels. The new curriculum for mathematics is analyzed based on the three main components of curriculum that is contents and competences, instructional media and method and assessment. These components are explained below.

Changes in the Three School Levels

The development of ICT is supported by the development of mathematics in the field of number theory, algebra, analysis, probability and discrete mathematics. Hence, students have to understand better in mathematics while young in order to create new technology in the future. Mathematics subjects need to be learned by students at all levels.

In the primary school (SD) some mathematics topics will connect and integrate with some topics of science. This might increase the understanding of students of both the concept of mathematics and the context or application of mathematics in their daily live that is also related to science. Yet, how do teachers develop or design such instructional materials that integrate mathematics and science? Hence, mathematics teachers need a way to design contextual and meaningful learning materials. It is called a thematic-integrated approach or is intertwined among strands or subjects.

At Junior high school level (SMP), it was also mentioned in the newspaper that information communication technology (ICT) will be integrated in all subjects including mathematics. ICT or the internet will be used as a tutor or a tool in helping students to learn mathematics.

In the senior high school (SMA), mathematics will be categorized into three levels namely: mathematics A; mathematics B; and, mathematics C.

New Content and Goals

New knowledge and skills need to be mastered through mathematics such as logical thinking, critical thinking, consistency, alternatives, innovation, creativity and teamwork. These competences are needed in getting, managing and using information for a better life in the competitive world. In addition, the knowledge and skills of problem solving and communication are also important (MoEC, 2012).

Use of context to make interesting and meaningful mathematics in the new curriculum (MoEC, 2012; Zulkardi, 2012), it is stated in the new curriculum that each mathematics lesson should use a contextual problem [*Dalam setiap kesempatan, pembelajaran matematika hendaknya dimulai dengan pengenalan masalah yang sesuai dengan situasi* (contextual problem)]. This is one of the positive changes in the new curriculum. Lee (2012) stated that the use of context in mathematics problems has been used in China for over 1500 years. By using context, moreover, he mentioned that the problem should be easy to understand, easy to use and easy to transfer to another problem with a different context. In Realistic Mathematics Education, Freudenthal (1991) stated that the use of context can help students in exploring mathematics and progressing their mathematical thinking. In PMRI, the contextual problems have been used to make mathematics more interesting and meaningful for more than a decade (Zulkardi, 2002; Sembiring, Hoogland & Dolk, 2010). In brief, contextual problems can play a role in making joyful and meaningful mathematics.

Example of Meaningful Contextual Problems

The following is an example of student materials. The context is Finding the Price of an Item. In this section you will use the strategy of exchanging to solve problems involving money.

Question 1

Without knowing the prices of a pair of glasses or a calculator, you can determine which item is more expensive. Explain how.

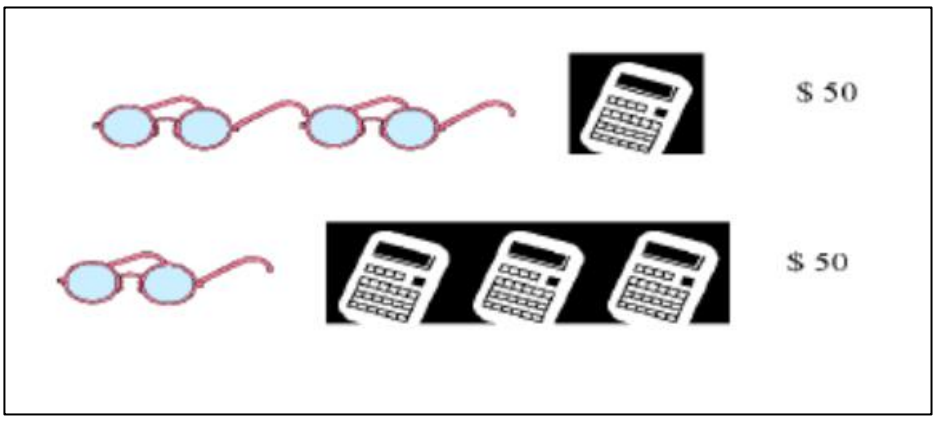

Figure 2. Find the Price: Calculator and pair of glasses

How many calculators can you buy for $50? What is the price of one pair of glasses? Explain your reasoning.

Question 2

Which more expensive, a cap or an umbrella? How much more expensive is it? Use the pictures below to make a new combination of umbrellas and caps. Write down the cost of combination.

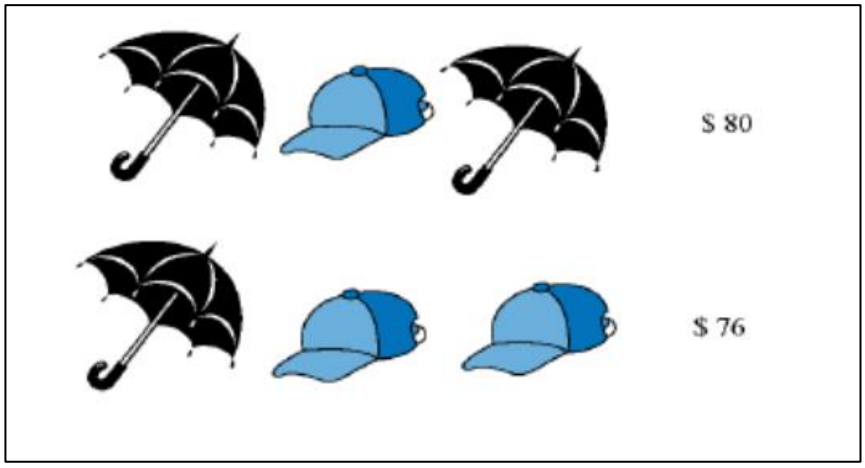

Figure 3. Find the Price: Cap and Umbrella

Make a group of only caps or only umbrellas then find its price. What is the price of one umbrella? What is the price of one cap?

From the contextual problems above, students are guided to use informal methods or an exchanging strategy before the use of a formal algebraic strategy such as the elimination method or substitution method. In fact, when this activity is offered to the pre-service teachers (student teachers) most of them use the formal one.

New Goals of Learning Mathematics

The following are the goals of school mathematics in the draft of the new curriculum (MoEC, 2012).

Goal 1: Understanding mathematics concepts by explaining and using them in problem solving. To make it easy for teachers, it is suggested they use context and manipulatives in instructional process.

Goal 2: Use of patterns, reasoning and generalization based on the availability of data. The goal is to guide students learn how to reason.

Example: 1. If two angles of a triangle are 60° and 100° then the third angle is?
Example: 2. How to read and predict data.

A TV reporter presented data about robbery in the graph from 1998 to 1999 saying it has increased by a big number. Is this a correct statement? Give your reasoning.

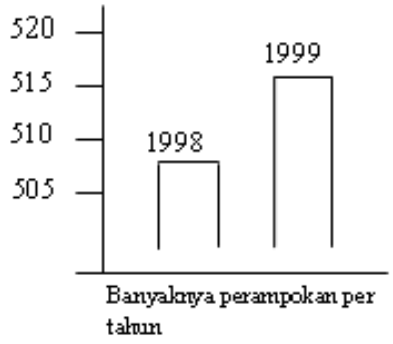

Figure 4. Robbery data 1998 - 1999

Goal 3: Using reasoning in manipulating and analyzing the steps in the problem solving either in a direct mathematics context or indirect mathematics context (such as real life, science and technology). The steps are: understanding the problem; developing a mathematics model; manipulating the model; and use the results to solve the real life problem.

Goal 4: Able to communicate ideas, reasoning and justify, or proof in mathematics using full sentences, symbols, tables, diagrams or other media to clarify solution of the problem.

Goal 5: Having a good attitude towards mathematics and its uses in the daily life such as curiosity, attention, and motivation to learn mathematics, and confidence in solving problems. Here an interesting and meaningful instructional mathematics plays an important role in supporting students to be more creative, interactive and joyful.

Goal 6: Having good attitude and habit that matches with the values in mathematics and its learning such as consistency, democracy, self-confidence, openness, discipline and honesty.

New Instructional Media and Method

In order to achieve the new goals, successful media and methods have to be used. For instance, to increase the effectiveness of the instructional process, it is suggested that schools use simple manipulatives and ICT such as the computer and internet. More information on the use of ICT in mathematics can be found at http://p4mri.net, a learning environment for learning PMRI on the web.

As far as the teaching and learning methods are concerned, teachers are suggested to design instructional sequences that foster the creativity of students. In other words, the instructional sequence is designed in such a way to stimulate students to develop their ideas in creative and innovative ways. Some techniques are proposed such as teachers should: (1) use interesting and meaningful contexts that guide their learning from informal to formal mathematics; (2) give students chances to develop their contributions and productions; (3) use their students contribution and products; (4) give students more time; and (5) ask questions that guide students to think in a creative way such as: “why”, “how”, “what if ….” (MoEC,

2012). In addition, teachers are also suggested to use a problem solving approach and a constructivist learning theory during the instructional process.

New Assessment

There are two main components of assessment in the new curriculum: focus on problem solving; and use of open problems. Open problems means problems that have multiple solutions or multiple strategies. Students are asked to communicate their solutions or strategies in a systematic and logical way. Actually these two have been stated and used in the *Kurikulum Tingkat Satuan Pendidikan* (KTSP) or current school level curriculum, yet not too many used either in the mathematics textbooks or in the national examinations. These components match with the domain of problem solving especially for higher-order thinking in mathematics.

The following example is a problem that was used in the Mathematics Literacy Contest (KLM). The problem is called a PISA-typed problem. Basic Competence: *Memecahkan masalah yang berkaitan dengan perbandingan dan skala*.

Problem: Guess how tall is the name label *Jembatan* Barito. Explain your reasoning.

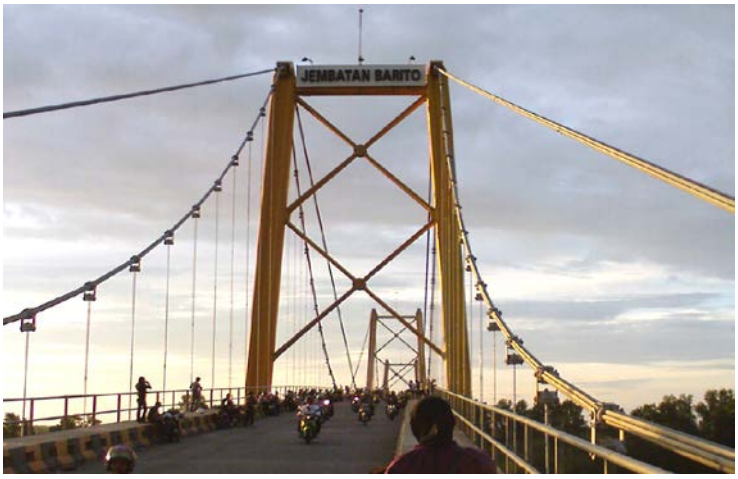

Figure 5. The Barito Bridge - http://www.google.co.id/

An alternative solution is by guessing how tall a man is who is standing on the bridge and then use it in guessing the height of the bridge. This problem has multiple strategies and solutions. The important issue is both the accuracy of the answer and the quality of the reasoning. Of course, since this is a guessing problem then the answer has a range from 18 - 22 metres.

RME or PMRI

Realistic mathematics education (RME) is an instructional or teaching and learning theory in mathematics education that was originally developed in the Netherlands. It stresses the idea that mathematics is a human activity. It is called a global philosophy of RME. RME was introduced and developed by Freudenthal in the Netherlands (Freudenthal, 1991).

Three Principles of RME

Guided reinvention and didactical phenomenology.

Because mathematics in the RME theory is a human activity, guided reinvention can be described where teacher gives students a chance to understand and do the mathematics process by themselves and discover the mathematics needed. This principle can be inspired by using a procedure informally. This effort will be reached if teaching and learning processes use real life context that are related to the mathematics concept.

Progressive mathematization.

The situation that contains the phenomenon that can be used as an application area in the teaching and learning mathematics should begin from a real situation before moving to the formal mathematics. Two kinds of mathematization should be used as references in teaching and learning mathematics from concrete to abstract (formal).

Self-developed models.

The role of self-developed models is as a bridge for students from concrete to abstract or informal to formal.

The Characteristics of RME

RME of PMRI has five characteristics: (1) use real-life contexts as a starting point for learning; (2) use models as a bridge between abstract and real, that help students learn mathematics at different levels of abstractions; (3) use student's own production or strategy as a result of their doing mathematics; (4) interaction is essential for learning mathematics between teacher and students, students and students; and (5) connection among the strands, to other disciplines, and to meaningful problems in the real world. PMRI is RME but using Indonesian context and culture.

The Development of PMRI in Indonesia

PMRI was initiated in Indonesia since 2001 in 12 Sekolah Dasar (Primary schools), 4 Madrasah Ibtidayah Negeri (MIN – Islamic primary schools), in collaboration with 4 LPTKs (teacher training universities): Universitas Pendidikan Indonesia (UPI), Universitas Negeri Yogyakarta (UNY), Universitas Sanata Darma (USD), and Universitas Negeri Surabaya (UNESA). This activity was conducted by the PMRI team with a small budget founded by Dikti (Directorate for Higher Education) and the Dutch government. Up to 2012, 23 LPTKs were involved, with each LPTK working with a number of schools either SD/MIN or SMP/MTs (Junior secondary schools/ Islamic junior secondary schools).

Many activities (see also Sembiring & Zulkardi, 2012) have been conducted by the PMRI team as follows: (1) PMRI textbooks writing; (2) PMRI magazine; (3) Designing

International Master program on Mathematics Education (IMPoME) in collaboration with Unsri, Unesa and Utrecht University since 2009; (4) Giving training for PGSD lecturers; (5) Training of Character building via mathematics; (6) PMRI in the international forum; (7) PPPPTK and SEAMEO Regional Centre for QITEP in Mathematics; (8) Design research task force; (9) designing web in using Information Communication and Technology; (ICT) as dissemination tool; and (10) Mathematics literacy contest and workshop PISA for mathematics teachers since 2010.

The Intersections between New Curriculum and PMRI

It has been discussed earlier that some new components in the new curriculum are similar to the characteristics of PMRI. First, in the content and the use of context or theme is an important point for both, as is how to integrate the strands of mathematics and how to integrate mathematics and science. One of the characteristics of PMRI is intertwining of the strands in mathematics with other subject matter. Moreover, an approach that is proposed in the new curriculum is a thematic integrated approach while in PMRI it is called design research. They seek to achieve similar goals such as: to produce good instructional learning materials that use of context; or the use of themes as a starting point of learning mathematics.

New competences that are related to assessment are also stressed in the new curriculum that is problem solving, reasoning, communication and modelling. Open-ended problems are also focused upon in the new curriculum. These competences are used in the three levels of assessment in PMRI (Zulkardi, 2002).

In brief, there are similarities between PMRI characteristics and some components of the new curriculum. Therefore, one can say that PMRI is now institutionalized in the curriculum 2013. This is an indicator of sustainability of PMRI for the future (Sembiring, Hadi, Zulkardi, & Hoogland, 2010).

Concluding Remarks

The Indonesian curriculum 2013 makes extensive use of thematic or contextual problems. Our experiences show that context can lead to a joyful and meaningful mathematics learning of concepts. Yet, it is not an easy task to find a good context that is relevant for all mathematics concepts. Also, a mathematics teacher has to design instructional materials that can guide students in learning the concepts of mathematics from informal to the formal mathematics. In order to do so, PMRI, its standard and design research method can be used (Hadi, Zulkardi, & Hoogland, 2010).

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