New School Mathematics Curricula, PISA and PMRI in Indonesia

By Zulkardi Zulkardi

Chapter 3
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Zulkardi and Ratu Ilma Indra Putri

Abstract This chapter discusses and analyzes the development of the new school mathematics curriculum in Indonesia. The curriculum is a part of the National Curriculum 2013 that has already been implemented since July 2013. About 6000 schools all over Indonesia were selected. The implementation began at grades 1, 4, 7, and 10. In 2014, the implementation was extended to all grades. Some reasons behind the change in the curriculum are discussed. Furthermore, this implementation of the new curriculum drew on the experience of a team in implementing an innovation in mathematics education, known as the Indonesian version of Realistic Mathematics Education, the Pendidikan Matematika Realistik Indonesia (PMRI). This chapter also presents some activities of mathematics curriculum development in the context of PMRI. The implementation process of the PMRI materials in schools using an Educational Design Research (EDR) method is also presented. This chapter concludes with some remarks on the new school mathematics curricula, the Programme for International Student Assessment (PISA) and PMRI.

3.1 Introduction

When PISA 2012 results were released by OECD in December 2, 2013, the performance of students in mathematics, science, and reading from various countries topped the headlines of many newspapers all around the world. Many of these papers recognized the rising performance of East Asian countries, since the top seven then were Shanghai-China, Singapore, Hong Kong-China, Chinese Taipei, Korea, Macau-China, and Japan. Three ASEAN countries, Thailand, Malaysia, and Vietnam, were ranked 50th, 52nd, and 17th, respectively. In comparison, Indonesia was ranked 64th among the 65 participating countries. In other words, based on this international com-

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Table 3.1 Development of school curriculum in Indonesia since 1945 (MoEC, 2012)

No.	Year	Name
1	1947	Lesson plan
2	1964	Education plan for primary education
3	1968	Primary school curriculum
4	1973	Curriculum project for development school
5	1975	Primary school curriculum
6	1984	1984's curriculum
7	1994	1994's curriculum
8	1997	1994's revised curriculum
9	2004	Prototype of competency-based curriculum
10	2006	KTSP (curriculum level of education entity)
11	2013	Curriculum 2013

parative study, the performance of Indonesian students in mathematics was among the lowest of the participating countries. This result led to the printing of the following headline by Tempo, one of the most critical newspapers in Indonesia: "*Quality of education in Indonesia the worst in the world*" (Tempo, 2013). In contrast, Indonesian students were ranked first among the 65 participating countries as the happiest students in schools (OECD, 2013).

Since the first PISA in 2000, Indonesian students' performance in the test has always been low. In PISA 2009, Indonesia was ranked 61st among the 65 participating countries. More information about PISA in Indonesia can be found in the studies by Stacey (2011) and Stacey et al. (2015). Besides the PISA results, the performance of the grade 8 Indonesian students in mathematics in the Trends in International Mathematics and Science Study (TIMSS) was also low. In TIMSS 2011, Indonesia was ranked 38th among the 42 participating countries.

Based on the low achievement of students in PISA and TIMSS results, the Indonesian government revised her school mathematics curriculum in 2012. The new school curriculum was called "Curriculum 2013." Table 3.1 shows that Curriculum 2013 was the tenth revised curriculum since the independence of Indonesia in 1945.

This chapter presents the rationale, implementation, and the practices related to the new mathematics curriculum in Indonesia, known as Curriculum 2013.

3.2 Why Curriculum 2013?

Data from the international comparative studies was one main impetus for a curriculum revision in order to address the education problems of Indonesia. What was equally pressing was for education reforms in Indonesia to prepare their students and become future-ready. This was reflected in a speech by the Minister of Education and Culture, Muhammad Nuh, who stated four main reasons behind the change in the school curricula (MoEC, 2012).

(1) Future challenge
The school curriculum should adapt and respond to the future challenges of the Indonesian citizen, particularly in relation to globalization. The most immediate challenge facing Indonesia at that time was the anticipated ASEAN integration in 2015. With this looming change across the region, the Indonesian citizen had to thrive in a highly competitive situation along with all other ASEAN countries. Another future challenge was the fast development of the information and communications technology (ICT) sector that presented many possibilities including the utilization of ICT as media for learning. In this sense, the old curriculum needed to be revised. Finally, with the international comparative studies TIMSS and PISA setting the tone for the future of mathematics and science education and the continuous low performance of Indonesian students in TIMSS and PISA, the content material of the mathematics curriculum needed to be aligned to the framework of TIMSS and PISA.

(2) Future competencies
Indonesia needed her students to be equipped with competencies and develop characteristics in order to be future-ready. These include communication skills, critical thinking, good attitudes, ability to work in a team, and smart citizenship. These skills and characteristics had to be included as some of the main goals of learning in the new curriculum.

(3) Societal phenomena
Developments in society and social realities make it imperative to study the kind of education that the students are getting. It is hoped that students' attitudes and character would improve with the new curriculum. It is believed that social phenomena such as corruption and dishonesty can be reduced or even eliminated, given radical improvements in the quality of education and development of better attitudes among students.

(4) Perceptions by society
According to many critics, the mathematics curriculum prior to Curriculum 2013 was deemed to be too content-heavy for the students. Besides the heavy content, the previous curriculum had been perceived by the society as only focusing on cognitive knowledge. Ideally, the three learning outcomes of education, namely cognitive, attitude, and psychomotor skills, must be balanced. This was addressed in Curriculum 2013.

Although the above four reasons for the curriculum revamp seemed logical, many criticisms were published and discussed in the newspapers and were ultimately addressed to the Minister of Education. The criticisms covered broad categories of concerns that include the following: (1) the new curriculum was implemented too quickly without being tested; (2) the published textbooks were not research-based; and (3) the teachers were not trained to use these resources.

3.3 Changes Effected in Curriculum 2013

There were four important broad categories of changes that took effect in Curriculum 2013.

1. Mathematical competencies
   There was an effort to balance the three key competencies in the learning outcomes: Attitude (religious, democratic, responsible, self-confident, and polite); Knowledge (understanding concepts of mathematics); and Skills (creativity and innovativeness). It was also emphasized that new knowledge and skills need to be mastered through mathematical processes that emphasize and put premium on logical thinking, critical thinking, steadfastness, divergent thinking, innovation, creativity, and teamwork. These competencies were identified as necessary in getting, managing, and using information for better living in the competitive world. In addition, the knowledge and skills of problem-solving and communication were also underscored (MoEC, 2012).

   The following are the goals of school mathematics in the new Mathematics Curriculum 2013 (MoEC, 2012). Students are expected to be able to:

   (1) Understand and explain concepts of mathematics and use them in problem-solving. In the curriculum document, the use of realistic problems and media in instructional processes is suggested.
   (2) Learn to reason using patterns and to generalize based on the availability of data.
   (3) Solve mathematics problems, including problems in the real world, problems related to the sciences, and with technology. In solving problems, students are in particular able to understand the problem, develop mathematical models, manipulate the models, and use the mathematical results to interpret the real-life problems.
   (4) Communicate ideas, reason and justify or prove using full sentences, symbols, tables, diagrams, or other media.
   (5) Have a good attitude toward mathematics and use mathematics in their daily lives. Develop curiosity and confidence in solving problems.
   (6) Have good attitudes and habits that match the value in mathematics and its learning such as steadfastness, self-confidence, openness, discipline, and honesty.

2. Mathematical content
   The principle of content change of Curriculum 2013 is described below.

   (1) Curriculum materials were aligned to the PISA materials. Indonesian students were not able to solve higher-order thinking problems in PISA. The content of the school curriculum must prepare students to solve such problems.

(2) The mathematical content in Curriculum 2013 focused on the materials that foster students' development of reasoning, problem-solving skills, argumentation, modeling, and communication skills in mathematics.

3. Teaching and learning processes
The changes in emphasis on the teaching and learning processes are classified according to the following categories:

(1) Thematic integration. This approach involves integrating two or more subjects, or two or more strands in mathematics. This thematic integration for mathematics is only carried out in grades 1–6.
(2) Scientific method or inquiry/discovery learning. In this approach, mathematics learning begins with a task or a problem. Then, students carry out the steps in the inquiry-based learning, namely *observing, questioning, associating, experimenting, and communicating*. This approach is known as 5 M (in Indonesian language *Mengamati, Menanya, Menalar, Mencoba, dan Mempresentasikan*). During interaction after completing the task, students will discuss the task in a collaborative way.

4. Assessment strategies
Four assessment strategies were introduced in Curriculum 2013.

(1) Assessment of students' thinking at all levels (starting from *low-order thinking to high-order thinking*);
(2) Assessment of both processes and products of students' work;
(3) Use of students' portfolios as an alternative assessment strategy; and
(4) Use of open-ended tasks as assessment.

Table 3.2 summarizes the comparison between Curriculum 2013 and the previous curriculum.

3.4 Pendidikan Matematika Realistik Indonesia (PMRI)

3.4.1 The Theory

In order to implement Curriculum 2013, the framework of PMRI was adopted. PMRI, the Indonesian version of Realistic Mathematics Education, is a domain-specific instruction theory, which offers guidelines for instruction that aim at supporting students in constructing or reinventing mathematics in a problem-centered interactive environment (Gravemeijer, 1994). This theory can be traced back to the ideas of the well-known mathematician and mathematics educator Hans Freudenthal. He argued that students should engage in "mathematics as a human activity" instead of being taught mathematics as a "ready-made product." According to Freudenthal (1991), students should be given the opportunity to reinvent mathematics using well-chosen tasks and with the help of teachers. This point of departure, for some decades, formed

Table 3.2 Analysis of changes in school mathematics curricula (MoEC, 2013)

No.	Previous curriculum	New curriculum
1	Students only used rules for solving problems	Students have to know both the history of rules and how to use the rule (higher-order thinking and low-order thinking)
2	Mathematics problems were only associated with numbers	Mathematics problems use both numbers and other non-numeral cues [e.g., images, graphics, patterns]
3	Mathematics learning began directly at the abstract level	Mathematics learning begins with a problem in the real-world context, which paves the way for semi-concrete and finally moving to abstract or formal mathematics
4	Students were guided to use procedural approach in solving mathematics problems which focused on exact mathematical solutions	Students are guided to use critical thinking in a creative way in solving problems, including open-ended problems, and they may use estimation and approximations in solving the problems

the basis of design research in the Netherlands and elsewhere, which resulted in the development of a range of local instruction theories.

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

3.4.2 History of PMRI

The story of PMRI began in 1994 when Sembiring, Professor at the Department of Mathematics from ITB Bandung, met Jan de Lange, Director of Freudenthal Institute Utrecht University, at the second ICMI-China Regional Conference in Mathematics Education in Shanghai. Professor Sembiring learnt from Professor Jan about the success of Realistic Mathematics Education (RME) in the Netherlands. Then, in 1998, they both agreed to send six Ph.D. candidates from different teacher education institutions in Indonesia to study RME in the Netherlands. The recruitment process was through a seminar in ITB Bandung, where candidates were selected for a Ph.D. in mathematics education at the University of Twente (UT) in cooperation with the

Freudenthal Institute of Utrecht University (FI UU). The selection was conducted by Professor Tjeerd Plomp (UT) and Professor Jan de Lange (FI). Four selected students obtained their Ph.D. from that program and became professors in mathematics education and leading agents in the PMRI movement in Indonesia.

Furthermore, in 2001, Sembiring invited a group of Dutch educators, some from the FI UU to initiate a project that aimed to adopt RME as an innovation in mathematics education in Indonesia. The project was supported by the Netherlands through NUFFIC/NESO (Netherlands Education Support Office) and Indonesia through the DGHE. The project stretched to 2010 and included the main goals of implementing and disseminating realistic mathematics in Indonesia to the primary schools via the teacher education programs. It is now known as PMRI, namely Pendidikan Matematika Realistik Indonesia or the Indonesian version of Realistic Mathematics Education. For a formal introduction to PMRI, see an article on PMRI in ZDM international journal posted online (Sembiring, Hadi, & Dolk, 2008). In addition, a book that described the success of PMRI after a decade of implementation in Indonesia was published (Sembiring, Hooglands, & Dolk, 2010). Over the last decade, the PMRI team, with the support of a group of Dutch mathematics educators, created a new image of mathematics education, especially in primary schools. With the cooperation of teachers, lecturers, deans, and stakeholders at the Department of Education, they implemented a series of workshops, carried out design research in classrooms, designed learning materials, produced standards for mathematics education, and educated master's and Ph.D. students.

In 2001, the PMRI project was initiated in 12 primary schools (SD), 4 Madrasah Ibtidaiyah Negeri (MIN), in collaboration with 4 LPTKs, namely Universitas Pendidikan Indonesia (UPI), Universitas Negeri Yogyakarta (UNY), Universitas Sanata Dharma (USD), and Universitas Negeri Surabaya (UNESA). This activity was conducted by the PMRI team with a small budget funded by the Indonesian DIKTI (DGHE) and the Dutch government (see also Sembiring & Zulkardi, 2012). Over the years, 23 LPTKs have been involved, each LPTK working with thousands of schools that are either SD/MIN or SMP/MTs.

3.4.3 Curriculum Development in PMRI

The curriculum development activities of PMRI refer to all activities that relate to the implementation of PMRI in the schools. The following activities are the products of the project.

Curriculum materials development The PMRI team agreed that teachers have to develop their own lessons based on the theory of RME. There are two main activities of curriculum development in the context of PMRI, namely the task of developing school textbooks and exemplary lesson materials. The former is usually held by a team of teacher educators and teachers who implement PMRI in their region. The latter is conducted by researchers and graduate students. In order to guide the developer in making a lesson and learning materials, the PMRI team developed a standard for a PMRI lesson and a standard for learning materials based on PMRI that can be used as guidelines (Hadi, Zulkardi, & Hoogland, 2010).

Teacher development: Seminar and workshop for teachers The PMRI team conducts at least twice a year professional development programs for in-service mathematics teachers in the form of a workshop. Most of the workshops focus on developing lesson materials and simulating the use of the materials in the classroom. The PMRI team also guided their communities who wanted to conduct a PMRI workshop following a workshop standard (Hadi et al., 2010).

Assessment: Mathematics literacy contest The PMRI team has been conducting an activity called Kontes Literacy Mathematics (KLM) since 2011. This activity is categorized as assessment activity by the PMRI team. It was initiated by the Center of PMRI at the Sriwijaya University in Palembang. After three years, the KLM has been joined and conducted in the 16 big cities in Indonesia such as Banda Aceh, Medan, Padang, Palembang, Jakarta, Jogjakarta, Surabaya, Makassar, Manado, and Kupang. The purpose of the KLM is to familiarize students of age 15 years at junior high school level to PISA-type mathematics items. Furthermore, the mathematics teachers who accompany their students during mathematics competitions are given the opportunity to attend a PISA workshop. This workshop helps mathematics teachers understand the principles of PISA assessment items. Detailed information about PISA and KLM activities is documented in the blog of PISA Indonesia at the following address: http://pisaindonesia.wordpress.com/. This website publishes news about activities of all KLMs, PISA items released by OECD, and PISA-like items developed by the PMRI team.

Center of PMRI (P4MRI) and its website The P4MRI, which stands for Pusat Penelitian dan Pengembangan PMRI, is also called the center of excellence for researching and developing PMRI. The P4MRI serves as the center of information as well as a meeting point for teachers, teacher educators, and student teachers. It has a website that links all the supplementary websites of the P4MRI from 32 teacher education programs that implement the PMRI in schools within the region. The website http://www.p4mri.net serves as a portal that links all the P4MRI websites from all over the provinces in Indonesia. In order to guide teacher education development and manage the center of the PMRI or the P4MRI, the PMRI team developed standards for establishing centers for the PMRI (see Hadi et al., 2010).

International master program on PMRI The IMPoME (International Master Program on Mathematics Education) program was founded in 2009 as an integral part of the dissemination of the PMRI to schools. Through this program, the teacher education programs are able to recruit new graduates of the program from all over Indonesia to become new staff in mathematics education. The IMPoME is a collaboration of the State University of Surabaya (UNESA), the University of Sriwijaya (UNSRI), as well as Utrecht University (UU). The program starts with an intensive four months of English training, followed by a semester of graduate mathematics education courses. During this period, a team from UU would come to Indonesia to select students who are qualified to continue their study in UU for a year. The selection is strict; usually, only half or less than half of the students are qualified. Those students who are not eligible to go to UU continue their study at UNESA or UNSRI.

After their return to Indonesia, besides taking more courses, each student has to conduct research based on their accepted proposal, usually in schools using Design Research or Educational Design Research (EDR). They also need to present their findings in a special seminar attended by representatives of UU. The local seminar has grown into a regional seminar called South East Asian Design Research (SEA-DR) Conference in 2013 at UNSRI Palembang. The purpose of the conference is to build a community of design researchers in mathematics education.

The fourth batch of the IMPoME program finished in 2014. Most of the alumni of the first three batches were working as teacher educators in their teacher education programs. Their master's theses have been published online at http://www.fisme.science.uu.nl/en/impome/. Some of their theses have also been published in journals such as the Indonesian Mathematical Society Journal on Mathematics Education (IndoMS-JME) that can be accessed freely at http://ejournal.unsri.ac.id/index.php/jme/. Furthermore, three of the theses have been published in international journals (see Bustang, Zulkardi, Darmawijoyo, Dolk, & van Eerde, 2013; Risma, Putri, & Hartono, 2013; Sumarto, van Galen, Zulkardi, & Darmawijoyo, 2014).

3.5 Conclusion

Some new components in Curriculum 2013 are similar to the characteristics of PMRI. First, in the content material, the use of contexts or themes is an important point both in Curriculum 2013 and PMRI. Second, how to integrate among strands of mathematics topics and how to integrate mathematics with other subjects were valuable concerns. The integration of more than one strand of mathematical topics and of mathematics with other subjects is one of the characteristics of PMRI. This idea is similar to producing good instructional learning materials that make use of contexts or themes as a starting point in learning mathematics. Third, in relation to assessment, new competencies are also emphasized in Curriculum 2013, namely problem-solving, reasoning, communication, and modeling. Open-ended problems are also stressed in the new curriculum. These competencies are used in the three levels of assessments in the PMRI (Zulkardi, 2002).

To conclude, the main reason for developing Curriculum 2013 was to address the problem of the poor performance of Indonesian students in PISA and to prepare Indonesian students to be future-ready. There are some changes in emphasis on the competencies, content material, method, and assessments. These changes have created a new set of problems for teachers during the implementation phase. Problems such as how to design thematic integrative contents, how to teach using the scientific method, and how to design high-order thinking problems or open-ended problems arose. Guidelines were needed in order to address these new problems. The PMRI is an innovation in mathematics education in Indonesia that has been implemented over the last decade. Following the best practices of RME, the PMRI has become a vehicle for implementing Curriculum 2013 and, in particular, improving the quality of mathematics education in Indonesia in the future.

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