INTRODUCING REALISTIC MATHEMATICS EDUCATION TO JUNIOR HIGH SCHOOL MATHEMATICS TEACHERS IN INDONESIA

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ABSTRACT

The study finds its basis on the emergent needs for improving mathematics education in Indonesia, that has for a long period experiencing many challenges. Since the time when the government changed the school subject from arithmetic to mathematics, many efforts to improve instruction have been done. Since 1977 the government has produced over 900 million copies of newly develop textbooks for the students and the teachers, carried out in-service training for most of the teachers, and provided teaching aids to schools. A diagnostic survey conducted by Ministry of Education and Culture in 1996 revealed that yet many mathematics teachers were still using the arithmetic based methods in their teaching.

This present study is called IndoMath (In-service Education for Indonesia Mathematics Teachers) and focuses on the introduction of Realistic Mathematics Education (RME) theory to the Junior High School (JHS) mathematics teachers. The RME theory is developed by some Dutch scholars. Its aim is to enhance the teachers' knowledge of mathematical content and RME pedagogy by means of workshops, instructional practices, and reflections. This introduction has been conducted from 1999 to the present in an effort to improve the teachers' competency. It involved 44 mathematics teachers.

This paper examines the effect of this introduction on the teachers' instructional practices in their respective mathematics class. The result indicated that a carefully planned program of professional development grounded in the principles of effective strategies can significantly impact teachers' understanding of the principles and practice of RME.

Key words: mathematics teaching, Realistic Mathematics Education, in-service training.

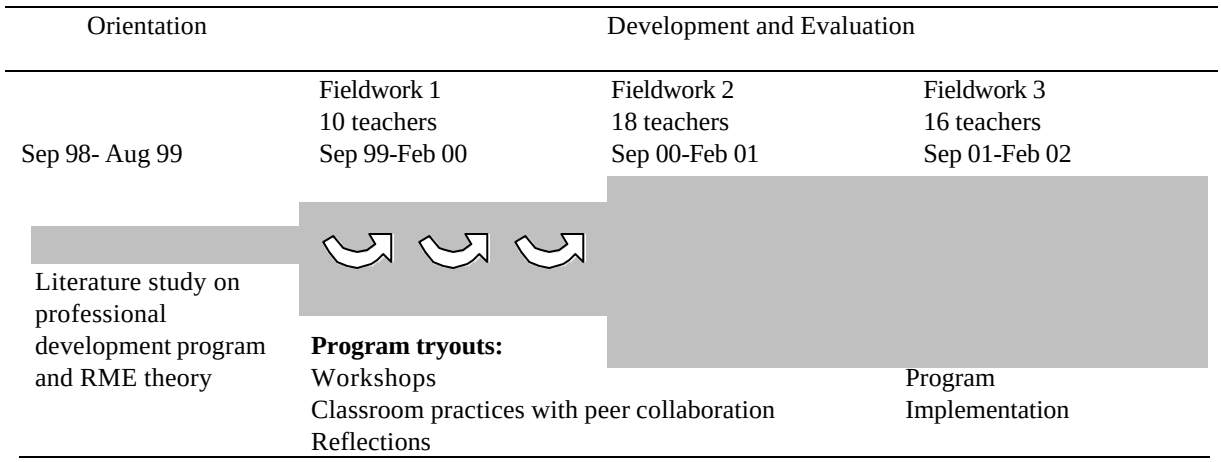
Introduction

The teaching of mathematics in the schools in Indonesia has been implemented since 1973 when the government replaced the teaching of arithmetic in the elementary school by the teaching of mathematics. Since then mathematics has become a compulsory subject in the elementary, junior high, and senior high schools. However, the teaching of mathematics has always raised problems, as is indicated by the ever-low achievement of the students on almost every examination, including the final year national examination conducted by the government. Issues of how to increase the students' understanding of mathematics and the students reasoning ability have always dominated the discussions on mathematics education in Indonesia. In response to the criticism of educational professionals and the society at large on the significance of school mathematics, the Indonesia government has lately revised the Curriculum of 1994. However, there is no information yet, about the effect of this revision on the students' performance in mathematics.

Realistic Mathematics Education (RME) seems to be a promising instructional approach that meets the Indonesia need for improving mathematics teaching. In the concept of RME, mathematics is a human activity and should be connected to reality. The concept of RME is characterized by students' activity to reinvent mathematics under the guidance of an adult (Gravemeijer, 1994), and the reinvention should start from exposure to a variety of "real-world" problems and situations (De Lange, 1995). Therefore, it is worthwhile to explore whether RME is an appropriate approach to tackle the problems of mathematics education in Indonesia.

General Research Design of IndoMath Study

The IndoMath study is aimed at designing and evaluating an instructional program to introduce RME to the JHS mathematics teachers. This 'development research' approach has been chosen with the purpose to document the development process, and to learn about the supporting conditions.



Notes: 1. Arrows indicate the cyclical character of development process
2. Increasing gray area means gradual upscaling of project

Figure 1: General design of the IndoMath study

The steps of the study are orientation, development, and evaluation (Fig. 1).

In the orientation phase an in-dept review of literature on professional development and RME was carried out. By doing this, one of the criteria of program quality, namely 'the state of the art knowledge' has been incorporated. For the purpose of understanding the context in program implementation, an analysis of the context was done as part of the first fieldwork in Indonesia during the period from September 1999 until February 2000. Based on the result of this orientation, procedural specifications have been formulated, i.e. specific guidelines on how to design RME based mathematics instruction. The specifications generated a methodological direction for the design and evaluation of the IndoMath program.

In the development and evaluation phases, two tryouts were conducted in Yogyakarta, Indonesia. In the first tryout (as part of the first fieldwork), 10 mathematics teachers of JHS in the Yogyakarta Province participated in the in-service training. This was carried out from December 30, 1999 to January 27, 2000. The second tryout was done as part of the second fieldwork in Indonesia, from September 2000 to February 2001.

The program evaluation was conducted as an integral part of the development process. Based on the results of the first tryout, some revisions were made to program components, RME exemplary curriculum materials, and program organization. The second tryout was focused was focused on the practicality of the program components and usability of the RME curriculum materials for the teachers. The third fieldwork period was conducted to evaluate the effects of the in-service training on the teachers' understanding of RME theory and practice.

Research Method in the Third Fieldwork

Since RME is so new for many people in Indonesia (teachers, teacher educators, curriculum developers, supervisors, and students) research is needed to investigate whether and how it can be translated and realized for the Indonesian context. Using the notion of 'think big start small' in education innovation efforts, it is important that a number of small experiments be carried out as a contribution to the curriculum reform in Indonesia. These experiments are needed to reveal the factors determine a successful implementation on both curriculum and teachers' level. According to Fullan (1991) a complex innovation is characterized by three dimensions, namely changing of teachers' beliefs, introducing new teaching and learning methods, and introducing new curriculum materials. The innovation we are talking about here pertains to all three dimensions. So, for Indonesia we are talking about a complex innovation if we want to introduce RME.

Within this analysis of the problems related to the introduction in Indonesia of the Dutch-based RME, the research problem is: *How can a professional development program be designed to make Indonesian mathematics teachers understand RME and prepare them for effective implementation of RME in junior high school mathematics?*

Within this general research question the focus of the evaluation in the third fieldwork was on the effect of the in-service program. For this purpose, three of the five levels of professional development effects as distinguished by Guskey (2000) were used for formulating the evaluation questions. This has led to the following effect categories:

- *Perception*: Participants' perceptions of the effectiveness and usefulness of program's aspects;
- *Learning effects*: Participants' understanding of RME theory and practice;
- *The use of RME exemplary curriculum materials*: The use of RME exemplary curriculum materials and approach in the participants' mathematics classes.

These in turn has led to the following sub-questions, and success criteria, concerning the effects of the inservice program:

- *Do participants perceive the program as relevant and meeting their expectation?*

  The teachers value the organization and components of in-service program positively, meaning that the program activities (workshops, classroom practices, and reflection meetings) meet their expectation, and are considered as instructive, useful, enjoyable, relevant and informative.

- *Do participants perceive the program activities as helping them to understand RME?*

  This would be indicated by the fact that participants: (a) gain knowledge of the RME theory; and (b) the participants perceive the RME approach, the in-service program activities, and the RME exemplary curriculum materials as positive and useful.

- *Do participants perceive the program activities as supporting them in implementing RME in their classes?*

  This would follow from a perceived change in the participants' confidence on the possible implementation of RME.

- *Do participants understand the RME theory?*

  This would be indicated by the participants' work and their scores on Realistic Contextual Problems Test (RCP-Test) before and after the program.

- *Can participants realize the characteristics of the RME approach in mathematics instruction?*

  This would be indicated by an observed change in participants' knowledge and skills in applying the RME approach in their teaching.

- *Do participants use after the IndoMath program the RME exemplary curriculum materials in their lesson?*

  This would be indicated if the participants use the RME exemplary curriculum materials in their actual lessons or as supplementary material to the governmental compulsory textbook.

- *Do what participants' learn inspire them to use RME method in their teaching for other mathematics topics?*

  An indicator for this would be participants' other mathematics lessons show characteristics of the RME approach (such as using contextual problems and students active learning).

This research (the third fieldwork in Yogyakarta) has been carried out in Yogyakarta with 16 teachers and used six kinds of data collection methods and instruments to evaluate the in-service program:

- *Questionnaires* were distributed to the participants at the end of each workshop session, and at the end of the whole program.

- *Realistic Contextual Problem (RCP) Test* was administered to the participants before and after the program. This test assessed participants' understanding about RME contextual problems and the relevance of the contexts to the current Indonesian Junior High School mathematics curriculum.
- *Classroom observation* was conducted during the program (in RME classes at the junior high schools) to get insight in the ways in which the teachers were implementing the RME exemplary curriculum materials.
- *Reflective reports*, during the reflection meetings, were provided by the teachers about the instructions they carried out in their classrooms using the RME exemplary curriculum materials.
- *Focus group discussion* took place of the researcher and participants after the program, about the program as a whole.
- Two months after the program, the researcher visited the participants' schools for several weeks to conduct *classroom observations* focusing on the effects of the program on the actual daily mathematics classes.

Implementation of IndoMath Program

The IndoMath program has been implemented by using the model of educational change that was based upon the principles of effective professional development (Fig. 2).

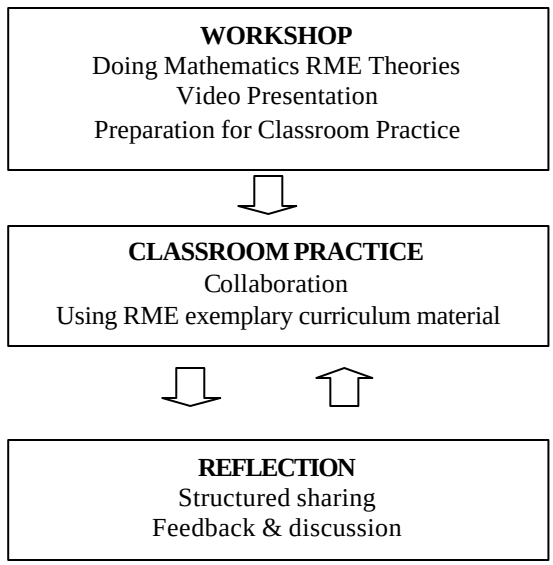


Figure 2: Teachers Development Model of the IndoMath Program

In this model the instructional practice is seen as being influenced by the teacher's subject matter and pedagogical content knowledge, the teacher's opportunity to experience new practices in a real setting, and with collaboration and reflection being the mediating factors between enhanced teacher's knowledge and the implementation of new practice (see e.g. Loucks-Horsley, et al., 1998;

Ball & Cohen, 1996; Borko & Putnam, 1996; Joyce & Shower, 1988, 1995; Van den Akker, 1988, 1998; Swafford, et al., 1999). So, the strategy of intervention in the IndoMath program was a combination of workshops, classroom practices, and reflections.

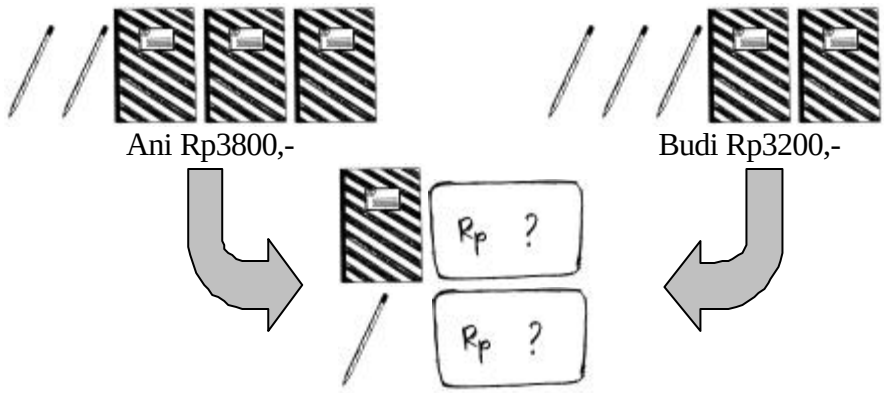
The IndoMath in-service program was held at *PPPG Matematika* (National In-service Training Development Centre for Mathematics Teachers) in Yogyakarta. The in-service course was conducted in period September 20 till October 10, 2001. The time spent for workshops, classroom practices, and reflection meetings was 25 hours (see Tables 1 and 2 for the example of program activities). So, the IndoMath Program can be categorized as an introductory in-service program about RME, as a preliminary effort to support teachers in the implementation of the RME approach to mathematics instruction.

Table 1: IndoMath Program Activities in Workshop I

Program Component	**Content and Procedure**	**Relevance to RME**
Session 1: Doing Mathematics (2 hours)	First, teachers work in a group to solve "the last card problem." Second, they learn how to approach a problem using "4-steps toward problem solving." Third, discussion of their findings.	In this activity teachers learn to find mathematics ideas by themselves, find procedure by themselves in interactive discussion among group member and share the findings with whole class.
Session 2: RME theories (1 hour)	Instruction on RME theories started from a general review of RME background and history. Trainer facilitates the discussion about *students' reinvention* and *interactivity* based on the results of doing mathematics.	In the previous session teachers learn how to find mathematics concepts by themselves. From this experience they get the idea of *students reinvention*. Since the activity is conducted in a group they experience the idea of *interactivity*.
Session 3: Video presentation (1 ½ hours)	Teachers watch the video on a lesson using RME material performed by a junior high school teacher.	It gives them visual support how to conduct the lesson, such as starting the lesson by giving students contextual problems that facilitate them to immediately engage in meaningful mathematical activity.
Session 4: Preparation for classroom practice (2 hours)	Teachers work individually and in a group to solve contextual problems on the topic of *Persamaan Belanjaan* (Shopping Equations).	By solving problems in the RME curriculum material that is being used in the classroom practice teachers will understand the content of the lesson. Teachers also understand *the use of contexts* as one of RME tenets. In this session the trainer acts as a teacher in a way that is typical for the RME approach, thereby participants can mirror from it as they intended to use it in their classroom lessons. In this regard the trainer should be able to be a good role model of RME teacher.

Sixteen mathematics teachers from 8 JHSs in Yogyakarta participated in the program. They were grouped in pairs, two teachers from each school. The day, after the workshop, each teacher wrote a lesson plan for teaching practice in collaboration with his or her partner. The material for the classroom practice was *Persamaan Belanjaan* (Shopping Equations, see Box 1). They performed teaching practice, by emphasizing the mutual observation (the teachers in each pair observed each other in their teaching practice). Teachers experienced important aspects of RME, such as the *lack of authority*, *interactivity*, and *student's free production*.

A student Store at *SLTP Realita* sells school supplies. Students prefer to buy their school supplies in the store because each supply has the same price. Each pencil, of different brands, is of the same price, so is each, etc. Ani bought 2 pencils and 3 books for Rp3.800,- whereas Budi bought 3 pencils and 2 books for Rp3.200,-



By using the above information find the price of a pencil and of a book.

Box 1: Sample of RME Curriculum Materials

After classroom practice teachers came again to the training centre to participate in the Reflection Meeting (Table 2).

Table 2: IndoMath Program Activities in Reflection Meeting I

Program Component	Content and Procedure	Relevance to RME
Session 1: Structured sharing (2 hours)	Each pair presents to other participants the results of their collaboration. They show the works of their students. They explain to the other participants the meaning of their students' free production.	In this session teachers learn that gaining understanding can be achieved by collaborating with their colleagues. This is the way that is also used in RME instruction emphasizing the *interactivity* and *intertwining* in mathematics concept building.
Session 2: Feedback and discussion (2 hours)	The trainer comments on the reports by paying special attention to the issues related to the aspects of RME. The trainer asks participants to share their experiences.	Students' work as the results of classroom practice will be discussed in this session. The discussion is directed to map the learning route of the students from which the teachers learn how to assess the process of students' mathematics learning.

There were two sessions in this meeting, namely *structured sharing* and *feedback and discussion*. This meeting facilitated participants to share their own experience in RME lesson and got information from other teachers as well as received comments and feedback from the trainer.

Participants' Understanding of RME

In order to know the participants understanding of RME, the RCP-Test[*)] was administrated to them before and after the IndoMath in-service course. The RCP-Test consists of four contexts in which some questions were embedded, namely a context of *pencils and books*, a context of *stacking chairs*, a context of *cars, viz. Kijang and Colt L-300* (see: box 2), and a context of *telephones and populations*.

Context 3: Kijang and Colt L-300

Second grade students from *SLTP Realita* are going to make a camping trip. There will be 96 people going, including the students and teachers. All the luggage, gear, and supplies are already packed into 64 equal-size boxes. The organizers want to rent the right number of vehicles to take everyone to the campsite. They can choose between two different types of vehicles from a car rental agency:

Kijang

Seats: 6 people
Cargo space: 5 boxes

Colt L-300

Seats: 8 people
Cargo space: 4 boxes

1. What combination of vehicles would you recommend to the camping organizers? (Use formal as well as informal mathematics procedure).
2. What mathematics concept, can be explained using the above context? Explain your answer (be more specific).
3. With which topic of the current SLTP mathematics curriculum does that context match? Explain your answer.

Box 2: Sample of Question in Realistic Contextual Problem (RCP) Test

The results of the test were used to find out the change of the teachers understanding of the RME on three aspects:

- teachers understanding of contextual problems (that is, solving the problem using informal as well as formal mathematics procedure);
- teachers understanding of the mathematical concept addressed in the contexts; and

[*)] The Realistic Contextual Problem Test (RCP-Test) has been tried out with the participants of the IndoMath program in Yogyakarta during the second fieldwork. 18 SLTP mathematics teachers participated in the tryout, and 17 teachers finished the test. Their results were used for the analysis of the content validity and reliability of the items (contexts) in the test. The test appears to be reliable (coefficient alpha .7544) and internally consistent (Pearson correlation is significant at the 0.01 level).

- teachers understanding of the relevance of the contexts to the current Junior High School mathematics curriculum.

All the problems in the test were judged as being on the level of JHS students' knowledge, and appeared to be quite simple for teachers (as concluded from tryout in the second fieldwork). Moreover, all the mathematical concepts in which the problems have their basis are relevant to the current JHS mathematics curriculum. So, for mathematics teachers those problems are solvable. However, the test does not merely assess teachers' ability to solve the problems by a formal procedure, but also their ability to solve the problems using informal procedures. Equally important, the test also explores teachers' knowledge about the concepts behind the contexts, and the relevance of the contexts to the current JHS mathematics curriculum. The results of the test for the participants in the third fieldwork period are presented in Table 4.

Fifteen participants stated that they had never heard about RME until they participated in the in-service course. The result of the pre test also indicates that they had little or no prior knowledge about RME. Particularly, they were not familiar with informal procedure for solving problems. For example, in the context of *Kijang and Colt L-300* most of the participants solved the problem using formal procedure: translating the problem into two linear equations of two variables, then solved the linear equation systems by elimination and substitution methods. Five participants gave no solution to the problem, had no idea about the mathematical concept addressed in the context, and had no idea of the relevance of the context to the current JHS mathematics curriculum.

Table 4: Participants' Scores on RCP-Test

No.	Teacher	Pre test*	Post test*
1	Suw	44	92
2	Sri	35	79
3	Sug	15	33
4	Wij	29	67
5	Kin	35	63
6	Wat	56	38
7	Sen	63	75
8	Wah	67	75
9	Sab	63	67
10	Har	63	79
11	Nug	35	67
12	Sud	27	50
13	Moc	25	54
14	Tut	46	83
15	Ton	25	67
16	Agu	33	75

* The scores are in percentage. Participants' work was also assessed independently by second evaluator. The Spearman correlation between the scores of the two evaluators are 0.789 (pre test) and 0.760 (post test). Correlation is significant at the 0.01 level.

Participants' scores on the post-test indicated that they gained knowledge about the importance of solution variation in solving contextual problems. In the context of *pencils and books*, 10 participants made use of two or more procedures using formal as well as informal procedures. Also, in the context of *stacking chairs* and the context of *Kijang and Colt L-300*, 8 participants made use of two or more procedures. The increase of participants' scores in the post-test are contributed mostly by their ability to solve the problems using different ways.

Teachers' understanding of the variety of possible answers to one contextual problem is important for RME mathematics teaching. Teachers should be aware of the different responses coming from their students in classroom lesson, and should be ready to facilitate discussions.

There were observed changes in teachers' mathematics lesson structure during and after the IndoMath in-service course. The results of the classroom observations during classroom practices indicated participants' ability to translate RME philosophy into classroom lesson. By the support of RME exemplary curriculum materials (student's book and teacher's guide) the teachers could perform instruction that was different from what they usually did (Fig. 3).

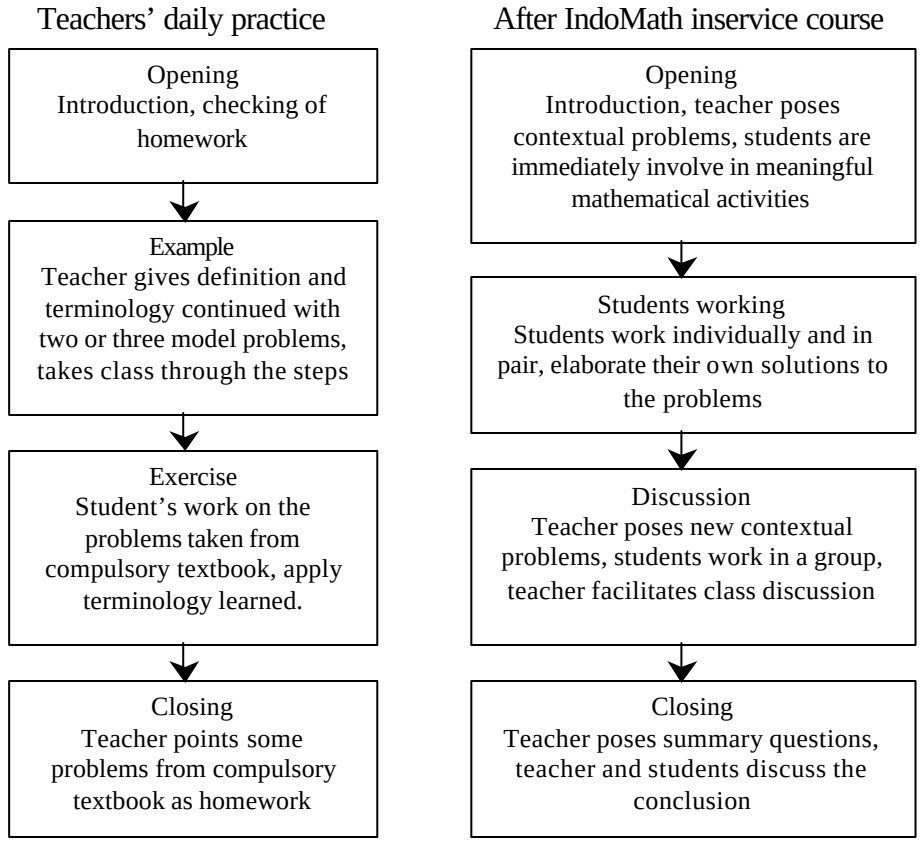


Figure 3: Teachers' Mathematics Lesson Structure

In their daily practice, teachers perform their instruction following the sequence: Opening – Example – Exercise – Closing. Their lesson structure was dominated by traditional "chalk and talk" that put intellectual authority in the hands of the teachers, and students' activities of note taking. Teachers have the tendency to 'spoon-feed' their students. This unfortunate nature of the

'traditional' learning process makes the students to become passive learners and with little responsibility for mathematical thinking and reasoning.

In the classroom practice during the IndoMath in-service course, teachers tried to structure their lessons by emphasizing the student's learning. Although it was rather troublesome because the students were used to being 'spoon-fed', the teachers always ask their students to explain their thought, or to comment on the other student's response, and facilitate discussion.

Conclusion

The IndoMath study used a development research approach which emphasized the design and evaluation of an in-service instruction program. This study has been conducted through a cyclic process of design-evaluation-revision. Now, the researcher (first author) is in the final stage of this development process that is visiting participants' schools. By conducting observation of participants' mathematics class daily, the researcher learns about program effects on the teachers' practical knowledge of the RME approach (developed in the Netherlands) and its feasibility to be implemented in Indonesia Junior High Schools.

The results of the analysis of the data that were collected during three fieldwork periods in Indonesia as well as the preliminary classroom observation indicated that the introduction of this innovation can be done by using a carefully planned program grounded in principles of effective professional development and supported by exemplary curriculum materials. The results also gave evidence that the use of adapted RME exemplary curriculum materials could reduce the difficulty of the introduction of the innovation to the teachers.

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