IMPLEMENTING A 'EUROPEAN' APPROACH TO MATHEMATICS EDUCATION IN INDONESIA THROUGH TEACHER EDUCATION

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ABSTRACT
This paper reports on the results of a four-year study called CASCADE-IMEI that is a learning environment (LE) in the form of a face-to-face course and a web site (www.clix.to/zulkardi) which aims to introduce Realistic Mathematics Education (RME), Dutch approach to mathematics education, as an innovative teaching methods in Indonesia trough prospective mathematics teachers in initial teacher education. It also presents the background of mathematics reform in Indonesia by adapting RME as a promising approach. Then, the paper describes the process of a development research approach in which three prototypes of the LE have been developed and evaluated both by prospective mathematics teachers in Indonesian Educational University in Bandung and several experts in the Netherlands. Finally, it will discuss the changes on the prospective mathematics teachers after they followed the LE program with a more detailed on their teaching performance in junior secondary mathematics classroom.

Key words : mathematics learning environment, www, RME, development research

Introduction

Up to now, the teaching process in mathematics classrooms in Indonesia is still conducted mainly with a traditional (or mechanistic) approach. Teachers actively explain the material, provide examples and exercises, whereas the students act like machines, they listen, write and perform the tasks initiated by the teacher. Group or whole class discussions are seldom present and interaction as well as communication is often missing. Likewise, mathematical goals and curriculum materials used in the classrooms are still based on 'mathematician' mathematics not on student mathematics with a focus on real life application (de Lange, 2001). This is in contrary to the needs of the information society in which mathematics literacy is an important goal. In summary, it is clear that goals, content and teaching and learning approaches in the mathematics classroom need to be reformed.

Since the last three years, the CASCADE-IMEI study is tied to the current reform of mathematics education in Indonesia. In an attempt to combat the low achievement in mathematics of students on national exams, the Indonesian government has attempted to identify probable reasons for this problem. Research cites various causes, including inaccurate learning materials, inadequate mechanistic teaching methods, poor forms of assessment and the anxiety of students to mathematics. One of the promising approaches toward the teaching and learning of mathematics that is thought to address these problems is realistic mathematics education (RME). RME is a theory of teaching and learning mathematics that has been developed in the Netherlands since the early 70's (cf. de Lange, 1987; Freudenthal, 1991; Gravemeijer, 1994). Contrary to the current mathematics education in Indonesia, RME uses realistic and interdisciplinary materials as a source as well as a starting point for mathematics teaching.

This study aims to introduce RME to (prospective) mathematics teachers in teacher education in Bandung, Indonesia, by developing a learning environment in the form of a face-to-face RME course and web site support. In this learning environment (prospective) teachers are encouraged to build up their background knowledge as well as to develop knowledge regarding (Selter, 2001): the mathematical component (overview of RME theory, doing mathematics); the didactical component (how to design and teach RME lessons); the practical component (how to manage RME classroom during classroom practice); and the psychological part of RME (how do pupils in the school learn and understand RME lessons).

This paper will focus on the impact of the learning environment on (prospective) mathematics teachers and teacher educators as well as on pupils in the classrooms with regard to RME as an innovation in mathematics education in Indonesia.

Theoretical Framework

The learning environment, including both the course and the web site, is based on the RME philosophy and principles. The philosophy of RME is mostly determined by Freudenthal's view on mathematics (cf. Freudenthal, 1991). Two of his important points of view are: (1) mathematics must be connected to reality and (2) mathematics should be seen as a human activity. First, in order to start from reality that deals with phenomena that are familiar to the students, *Freudenthal's didactical phenomenology*, i.e. the view of learning as starting contextual experience is used. Second, by the *guided reinvention* principle through *progressive mathematizations*, students are guided didactically and efficiently from one to another level of thinking. These two principles and the concept of *self-developed models* (Gravemeijer, 1994) are

used as design principles both in developing the course materials and the web site. Furthermore, these principles are operationalized into five basic characteristics of realistic mathematics education or five tenets of RME (Gravemeijer, 1994). In short those are:

(1) *Use of contextual problems* (contextual problems figure as applications and as starting points from which the intended mathematics can come out).

(2) *Use of models or bridging by vertical instruments* (broad attention is paid to development models, schemas and symbolization rather than just offering the rule or formal mathematics right away).

(3) *Use of students' contribution* (large contributions to the course are coming from student's own constructions, which lead them from their own informal to the more standard formal methods).

(4) *Interactivity* (the social live in the classroom including explicit negotiation, intervention, discussion, cooperation and evaluation among pupils and teachers are essential elements in a constructive learning process in which the student's informal strategies are used as a lever to attain the formal ones).

(5) *Intertwining of learning strands* (the holistic approach implies that learning strands can not be dealt with as separate entities; instead, an intertwining of learning strands is exploited in problem solving).

Research Methodology

This study uses a development research approach (van den Akker, 1999). With this method, the learning environment is developed and evaluated in three main phases: preliminary study, prototyping phase and assessment phase. In this paper the focus is on the research process up to the prototyping phase in which the three prototypes of the learning environment were designed and evaluated in the Netherlands and in Indonesia. In the Netherlands, eight experts from four different expertises (curriculum development, professional development, RME and web site development) were involved as evaluators of the learning environment. After being revised and adapted to the Indonesian context, these prototypes were evaluated and implemented to the target group in teacher education in Bandung.

Development phase

This section provides a brief description on both components of the learning environment (see also Zulkardi & Nieveen, 2001): the course and the web site as illustrated in Figure 1.
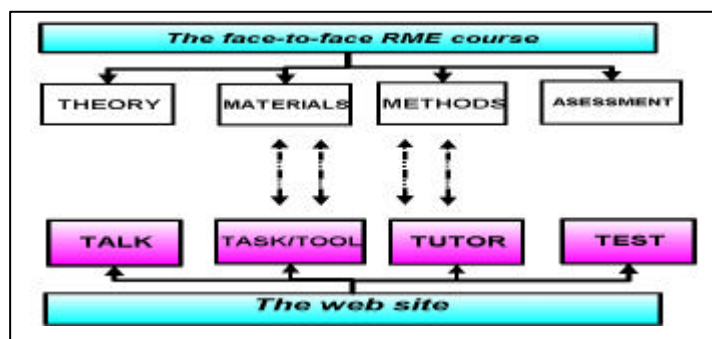

Figure 1. *The components of the learning environment*

The course

The RME course is a part of the learning environment that is developed in order to make (prospective) mathematics teachers understand what RME is and how to implement RME in the classroom. The main contents of this course include: (1) overview of the RME theory; (2) learning what are RME materials and how to redesign them; (3) learning how to teach using the RME approach in the classroom; and (4) learning how to assess the pupils in the RME classroom.

The web site

The web site, www.clix.to/zulkardi, is developed in order to support the course participants in a sustainable way. In order to do so, the following options are available:

(1) Online Info-base or task. The online info-base is the main component of the web site and consists of exemplary RME materials such as student materials and teacher guide; student productions from RME classes, applet programs and mathematical games, links to web sites that have relationship with mathematics education in general and RME.

(2) Online Tutor. In order to inspire (prospective) mathematics teachers before they conduct teaching practice in the school, an online tutor was designed. At his moment, the online tutor consists of theory on how to use RME materials in the classroom. In the future, a number of video clips that illustrate critical moments of teaching using RME materials in the classroom will be made available. For example, how to start the lesson, how to organize and to manage discussions.

(3) Online Talk. In order to provide (prospective) mathematics teachers with opportunities to discuss their problems and experiences, the web site provides an online talk element including e-mail facilities, a message board and a mailing list.

(4) Online Test. In order to facilitate (prospective) mathematics teachers with a number of RME problems, an online test called *problem of the month* was developed. It contains not only an example of RME problems but also a guide on how and when to use them in the classroom practice.

Research phase and questions

The results of the implementation and evaluation of the learning environment are discussed in the remainder of this paper based on the following questions:

- *What changes in (prospective) mathematics teachers as well as in pupils in schools in Bandung are reflected in their attitude towards RME?*
- *What changes in (prospective) mathematics teachers in Bandung are reflected in their knowledge of RME as the content of the learning environment?*
- *What are the effects of the learning environment with respect to the mathematics education society in Indonesia?*

Participants

In Indonesia, the main participants of the formative evaluation cycles of the learning environment (held in the period September 1999 to January 2000, May 2000 to August 2000, January 2001 to May 2001 and September 2001 to November 2001) were 27 (prospective) mathematics teachers at the Department of Mathematics Education, the Indonesian Educational University in Bandung. All of them had no teaching experiences except four of them, who were in-service teachers. About 480 pupils participated from 15 secondary school classrooms. In addition, six teacher educators were involved as supervisors of their students, and 15 school mathematics teachers were involved as observers in the classroom.

Instruments

The instruments that were used during the evaluation of the course are an entry and a final questionnaire, an end of unit test and a guideline for interviewing participants. The instruments that were used in the school are a final questionnaire, end-of-unit test and observation form. Furthermore, the instruments that were used in evaluating the web site are an observation form, a logbook and e-mails for collecting data from the (prospective) mathematics teachers.

Procedure

The course was implemented in the teacher education institute within a time frame of three to five blocks of four-hours. The course started by giving the participants information about the basic principles of RME and its characteristics. Then some examples of realistic mathematics problems were given and discussed in groups to get the idea of each characteristic of RME. Next, the participants were given a number of RME problems in various topics (such as linear equation system, symmetry, side seeing, statistics and matrices). After they solved the problems, they were guided in discussing the various strategies and in several cases they were invited to present their answers in front of the class. Finally, at the end of the course they were tested to see their performance in solving the problems. They were followed when they implemented the RME lessons in school classrooms. These activities took the longer time of the research period. They developed the lesson materials in collaboration with the researcher, who also observed their lessons.

The web site was evaluated using a cooperative evaluation, during which the (prospective) mathematics teachers performed as users and were asked to work aloud. Moreover, during the whole program, they discussed and reflected on their experiences using e-mails and a mailing list.

Results and Discussion

We present the results and discuss them based on the basis of the questions that were stated in the research methodology part.

- *What changes in (prospective) mathematics teachers as well as in pupils in schools in Bandung are reflected in their attitude towards RME?*

The sample reactions of participants that were gathered by a similar questionnaire are summarized in table 1.

Table 1. The results of final questionnaire of 29 student teachers in teacher education (TE), 36 senior high school students (SMUN) and 24 junior high school students (SMPN) after they followed the RME instruction process.

Items	TE			SMUN			SMPN		
Reactions overall	+	+/-	-	+	+/-	-	+	+/-	-
Learning process of RME is interesting	27	2	0	32	1	3	24	0	0
RME materials are interesting	28	1	0	32	2	2	23	0	1
Interactivity make me easy to understand	29	0	0	36	0	0	23	0	1
The role of teacher is helpful for me	28	0	1	35	0	1	24	0	0
Assessment materials challenge me	26	0	3	33	3	0	24	0	0
Motivates me to learn mathematics	28	1	0	33	1	2	24	0	0
Learning other's strategies is new for me	28	1	0	36	0	0	24	0	0

Note for reactions: '+': yes, '+/-': neutral, and '-': no

In general, the results in table 1 illustrate that the participants are very interested in the RME teaching approach both in the teacher education institute and in the schools. These positive reactions from participants are a necessary prerequisite to higher-level evaluation results. The items refer to the characteristics of RME. For instance, from the results on the second item 'RME materials are interesting', it can be concluded that the materials that were used are real to their situation (the first characteristic of RME) and integrated to other strands or subjects (the fifth tenet of RME). Further, they found 'a nuance of democracy' in learning mathematics such as the interactivity and a chance to learn other's strategies during the discussion (the fourth characteristic of RME).

- *What changes in (prospective) mathematics teachers in Bandung reflected in their knowledge of RME as the content of learning environment?*

In order to answer this question three kinds of results are used. The first kind of result consists of (prospective) mathematics teachers solutions on a test at the end of the course. Here, their understanding of RME either theoretically or mathematically were assessed. Overall, the results show that the participants were able to write down the philosophy and the characteristics of RME and solve RME typical problems in the sense of mathematization. However, the results are not discussed here because this falls somewhat beyond the theme of this conference. Second, the knowledge of (prospective) mathematics teachers in developing lessons based on the RME tenets was taken into account when answering the question. All of participants developed their lessons based on the RME materials, which were provided by the researcher. As a result of this, all of them were able to develop their own lessons in collaboration with the researcher. Of course, the results are not as good as truly RME materials. Nevertheless, as (prospective) mathematics teachers they have got a valuable experience in designing the lessons. Finally, the researcher observed the teaching skills of (prospective) mathematics teachers. An overall impression was that they were able to teach realistic materials in an interactive manner. They used their knowledge from teacher education such as how to start the lesson, how to make groups of students and how to guide group and class discussions. However, they also encountered some problems such as how to motivate the students to get involved in the discussion and how to conclude the lesson.

- *What are effects of the learning environment (the web site) to the mathematics education society in Indonesia?*

As the web site of the CASCADE-IMEI has been online since last three years, thousands of users, most of them from the mathematics education society from many countries (dominantly from Indonesia), have accessed the web site. On the basis of data that were gathered from user's feedback either through forms, e-mails, or a mailing list it can be concluded that this first mathematics web site in Indonesia has positive effects in:
- providing information, learning opportunities and communication facilities concerning mathematics education to not only mathematics education people but also parents and policy makers; and
- functioning as a dissemination tool of RME to other (prospective) mathematics teachers all over Indonesia.

Conclusion

Based on the results in the previous section we can concluded that:

- Changes in (prospective) mathematics teachers as well as pupils in schools in Bandung reflected in their attitude to RME have shown that they are interested in RME as an innovation as well as 'a nuance of democracy' in mathematics classroom (such as the interactivity and a chance to learn other's strategies during the discussion) has been accessed not only in the undergraduate (teacher education institution) level but also in the secondary school level.
- Changes in (prospective) mathematics teachers in Bandung reflected in their knowledge of RME theory have shown that they could perform better as RME teachers in classroom practice.
- The learning environment (the web site part), as the first web site of mathematics education in Indonesia has   positive effects in supporting a traditional course in teacher education. Hopefully, the web site will be a nice dissemination tool for an innovation to mathematics society in Indonesia.

Nevertheless, these tentative changes have only been found mainly in the research locations of the CASCADE-IMEI study in Bandung. As Indonesia is a big country with about 225 million people, of course, the issues of scaling up and dissemination become of paramount importance. In this process we need to learn from experiences of mathematics education in Indonesia and in other regions all over the world.

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