CHAPTER 5
SUMMARY AND DISCUSSION

The CASCADE-IMEI study was started to explore the role of a learning environment (LE) in assisting mathematics student teachers learning RME as a new approach in mathematics education in Indonesia. Using a development research approach, the LE has been developed and evaluated. This chapter starts with a brief summary of the study, followed by the design guidelines gained as a scientific contribution of the study. Then, the discussion and reflection on the learning environment, the development research approach and the main findings that relate to RME are presented. Finally, based on the discussion, some recommendations are offered to the Indonesian government, Department of mathematics education in Indonesian teacher education, and further research of the study.

5.1 INTRODUCTION

The main problem of mathematics education in Indonesia - especially in the arena secondary schools - are both low achievement of pupils in mathematics and their poor attitude toward mathematics. Research cites various potential causes, including inaccurate learning materials, inadequate mechanistic teaching methods, and poor forms of assessment. Indonesian government through the PGSM project had an idea to improve the quality of mathematics education in Indonesia by introducing RME.

The CASCADE-IMEI study was initiated in order to support that idea. Contrary to the teaching approach that is common in Indonesia, RME uses contextual problems or applications as a source as well as a starting point for mathematics teaching. In this study RME is assumed to be a promising approach to improve mathematics education in Indonesia. However, based on the four-year experience dealing with RME and the results of the literature study, introducing
RME as a new approach is not an easy task. As described in Chapter 1, there are three warnings that should be considered. First, RME curriculum materials are not easy to be designed and learned by teachers because RME materials focus on middle-level and high-level order thinking instead of the low level only. Second, teachers need to be educated how to use RME materials in their classroom. As de Lange (1991) mentioned the role of teachers in RME changes from teaching to 'un-teaching'. Their roles more focus as a guide or a facilitator rather than a teacher. Finally, the implementation of RME is not a short-term program or project, but it needs many years to be institutionalized.

This study used some strategies in introducing RME in Indonesia that try to give justice to these challenges. First, by choosing teacher education as a research context and prospective teachers as target users, RME is introduced not only to the student teachers but also to the pupils in the schools through teaching practice that is conducted by student teachers. Second, by using web technology in combination with classroom based activities, the student teachers are supported in terms of resources and tools for communication and collaboration about the complexities they encounter while they are learning and teaching RME in the schools. Finally, by using the ideas from the CASCADE line of study, the computer is viewed as a tool that may support teachers and curriculum developers dealing with curriculum (exemplary lesson materials) development and implementation activities.

The aim of this study was to explore the role of a learning environment (LE) in assisting mathematics student teachers in UPI Bandung learning and teaching RME as a new approach. At the beginning of the study and throughout the development of the LE, guidance was sought from literature relating to RME, curriculum development and implementation, teacher learning in teacher education, exemplary lesson materials, and web-based performance support. Understandings from these sources helped to shape the structure of the study as well as the LE itself. More detailed information about the context and origins of the study can be found in Chapter 1 and about the literature can be found in Chapter 2.

The CASCADE-IMEI study used a development research approach aiming at exploring the potential of a valid and practical learning environment on RME for Indonesian student teachers. In so doing, the study was guided by the following main research question:
What role can the CASCADE-IMEI learning environment play in assisting student teachers in UPI Bandung, Indonesia who learn RME as a new instructional approach in mathematics education in Indonesia?

Using the development research approach, this study deals with designing and evaluating both an intervention and guidelines for the design and development of such interventions. In this study, the intervention is the learning environment with three main components: 1) web support, 2) course, and 3) exemplary lesson materials. The design guidelines cover the theoretical outcomes of the development and evaluation process.

The LE has been developed and evaluated in three main phases: 1) preliminary investigation stage, 2) prototyping stage, and 3) assessment stage. Throughout the first two phases, five prototypes of the LE have been designed and formatively evaluated both in the Netherlands and Indonesia. At the end, the final version of the LE was field-tested in Indonesia. The design and evaluation of the prototypes can be found in Chapter 3.

The development activities of the prototypes were mainly conducted at the University of Twente and the LE was tried out several times at the Department of mathematics education at the University of Indonesian Educational (UPI) Bandung and 12 selected secondary schools. During a 4-year time period, a total of 34 mathematics student teachers (pre-service and in-service) at the Department of mathematics education in UPI Bandung were involved. In addition, about 800 pupils from 12 secondary schools in Bandung, 6 mathematics teacher educators, 12 school teachers and 6 experts with different expertise (RME, computer support curriculum development, web design, course development and teacher learning in teacher education), were involved.

During the assessment stage, the final version of the LE was field tested empirically in order to find out the potential impact of the LE in assisting the professional development of student teachers learning and teaching RME as a new approach in mathematics education in Indonesia. In order to study the potential effects of the LE, the five effectiveness levels of a professional development program were used (Guskey, 2000). Based on these levels, five sub-research questions were stated:
1. What is the perception of student teachers with respect to the LE?
2. What knowledge, skills and attitudes did the student teachers learn after
they followed the LE?

3. What effects did the CASCADE-IMEI LE have on the organization at the Department of mathematics education in UPI Bandung?

4. To what extent do student teachers apply their RME’s knowledge and skills in the classroom?

5. What is the reaction of pupils after they experienced the RME teaching-learning process?

The results of the formative evaluation and empirically field test in Indonesia are described in Chapter 3 and 4 subsequently. Based on that, design guidelines for developing such learning environment as a scientific contribution of the study is concluded.

5.2 DESIGN GUIDELINES: A SCIENTIFIC CONTRIBUTION

Van den Akker (1999, 2002) suggests that knowledge gained from development research can be presented in the form of ‘design principles’, which are usually heuristic statements of a format such as:

'If you want to design intervention X [for the purpose/ function Y in context Z],
then you are best advised to give that intervention the characteristics C1, C2,...,Cn [substantive emphasis],
and to do that via procedures P1, P2,...,Pn [procedural emphasis],
because of (theoretical/ empirical) arguments A1, A2,...,An.

Relating to the CASCADE-IMEI study a principle can be represented as follows. If you want to design a valid, practical, and effective learning environment for supporting mathematics student teachers learning and teaching a new approach (e.g. RME) in the context of (e.g. Indonesian) teacher education then you are best advised to give the learning environment the following characteristics:

- use as the main content exemplary lesson materials (that consists of learner materials, assessment materials, and teacher guide) with clear guidelines on how to use the materials;
- use a face-to-face course (which is integrated in one of the method courses in the teacher education) with several activities related to learning the new theory, materials, teaching method and assessment strategy based on the new approach (e.g. RME); and
• use web support for the course participants that provides additional information, training facilities, advice and communication tools for collaboration and reflection; and to do that via the following procedures:
  • adapt and develop the lesson materials from the available (RME) lesson materials that were derived from both theory and practice into the context of (Indonesian) teacher education and (Indonesian) schools;
  • design and develop the learning environment (course and web support) by starting subsequent prototyping cycles until a satisfying LE has been reached; and
  • improve the quality of the content, support and structure learning environment by conducting formative evaluation activities with the involvement of experts and target users and make revisions at the end of each prototyping cycle;
  • assess the potential effects of the LE by conducting a summative evaluation activities via a field test in the real practice; because of the following arguments:
    • by using lesson materials, student teachers can decided to use the materials as the learning resources during the course, as examples when they learn how to redesign lesson materials, and as additional materials when they conduct teaching practice;
    • by following the course, student teachers could overcome the obstacles as new teachers and they might learn not only the content and pedagogical knowledge of the new approach but also learn how to teach with the new materials using the new approach either in a peer teaching situation or with the pupils in the schools;
    • by using the web support, student teachers (other web users as well) could easily learn the new approach (e.g. RME) whenever and wherever they want either during the course (short-term) or afterward (in the long term);
    • by using a prototyping approach with several cycles the intervention was designed easily and effectively;
    • by conducting formative evaluation activities with experts and target users the validity and practicality of the intervention were improved and the content became rich; and
    • by conducting a summative evaluation via a field tested the potential effects of the intervention were empirically assessed.
5.3 REFLECTION ON MAIN CHARACTERISTICS OF THE LEARNING ENVIRONMENT ON RME

In this study, the intervention is a learning environment for student teachers who are learning RME as a new instructional theory in mathematics education. The LE consists of both a web-based and a classroom-based component. The main content of these two components consisted of RME exemplary lesson materials. This section summarizes the main characteristics of the web site, the course and the exemplary lesson materials.

5.3.1 RME Web support

As stated in the sections 1.3.1 that the use of a web support in the teacher education is a promising tool for a big country with so many islands such as Indonesia. As a result, a web site support as a part of the learning environment (LE) has been designed and evaluated. This section discusses the main characteristics of this web site with its three main components: content, support and user interface.

The content of the web site refers to the philosophy and characteristics of RME. During the development of the web site, the validity and practicality of the content evolved to a large extent. Based on synthesizing the definition and theory in the literature study as well as evaluation feedback, the following aspects of RME are emphasized in the web site support:

- the background information of RME as well as its characteristics in order to give users general views on what mathematics is, how pupils learn mathematics, and how mathematics should be taught from the RME perspectives;
- flexible ready-made exemplary learner and teacher materials in various topics in the sense that the student teachers can adapt the materials to or directly use them in their own classes;
- a number of computer simulation and game programs in which the users could visualize and simulate a mathematical phenomena (e.g. function graphics, geometry concepts) by changing the variables or moving the figure by using the mouse;
- examples of student's production or solutions to the lesson materials, so the student teachers or users could learn from the learning process of pupils in solving mathematics problems;
• guidelines for developing lesson materials, for teaching in RME classroom and for assessing pupils in the classrooms; and
• examples of assessment problems at all school levels, so the users could learn or practice or use the problems in the classrooms.

In the web site, various types of support are provided. Some of them naturally came from the web such as tools for communication (e-mails facilities and the mailing list) and links to other resources about RME and mathematics education in general. Others were specifically designed and developed by the developer including:
• a tool for designing lesson plans or templates;
• a number of Java applet simulation programs on several mathematics topics, a number of mathematical games;
• a tutor component; and
• a number of video clips on how to teach using realistic approach.

During the prototyping stage special attention was given to its validity and practicality of the support component.

The user interface of the web site was designed in order to accommodate users so they can easily navigate and access information from the web site. The main characteristics of the web site interface are listed below:
• menu and submenu have several screen areas, located consistently throughout the web site;
• buttons and texts that use two languages, English and Indonesian, are easy to read;
• graphics, text and background colors are clear and simple;
• some screens of simulation and game programs are interactive meaning that users could simulate the phenomena by only changing the variables;
• some documents and information are provided in Word document files to make it easy to retrieve or print from the web;

The programming language that was used mainly HyperText Markup Language (HTML). Besides, some mathematical parts were programmed using Java applet and Java script programming languages.

Based on the results of the prototyping and assessment stages, the web site was
evaluated both by experts (on web design, CSCD, RME) and by target users as being valid and practical. More detail about the characteristics of the LE and the formative evaluation activities and results can be found in Chapter 3.

5.3.2 RME course

As explained in the section 1.3.1 that teacher education in Indonesia is a place to start an innovation in education. One of the reasons, the innovation can be accelerated to the pupils in the schools by student teachers through teaching practice. This study used this idea in introducing RME instructional theory as an innovation in mathematics education in Indonesia. This sub section discusses the content, support and structure of the course.

The content of the course also refers to the philosophy and characteristics of RME. Both were also used in the learning process of the course. Based on synthesizing the definition and theory in the literature study as well as evaluation feedback, the aspects of RME (content and support) that are emphasized in the course are listed below.

- **Theoretical background.** This aspect focuses on the background information of RME as well as its five characteristics. For instance, what are the roles of context in the learning and teaching mathematics and how to use the context in the lesson materials.

- **Doing mathematics.** This aspect focuses on the learning process with a RME approach. Here, student teachers were treated as pupils. They are not only learning mathematics (content knowledge) but also learning the way pupils in the schools get to understand mathematics (pedagogical knowledge).

- **Support in lesson redesign.** This aspect refers to the process of applying the characteristics of RME when designing RME lesson materials. Ideally, all of the RME characteristics are used. As this is not an easy task, student teachers were supported in learning how to adapt the available materials for other relevant contexts and use the materials in their teaching practice. As a result, they mainly focused on two tenets of RME: the use of context and the intertwining among strands of mathematics.

- **Teaching method.** This aspect refers to the use of interactivity (one of the RME tenets) in the teaching process in the classroom. Several critical moments of teaching were given and discussed. The critical moments usually consist of interaction, individual work, group work, classroom discussion, student presentation, and teacher presentation. Moreover, a
RME-teaching video was shown and discussed. Finally, they were invited to apply their knowledge and skills in the teaching practice in the school.

- Assessment strategy. In RME, the assessment should get attention not only at the end of the instruction (summative evaluation) but also during the instructional process (formative evaluation). While the former focuses on the pupils' achievements in the form of scores, the latter focuses on the improving the learning of pupils. In this course, assessment problems are a part of exemplary lesson materials. During doing mathematics session, for instance, a sequence of assessment problems were given to the student teachers. These problems were designed in such way that could guide and enhance the student teachers in getting to a mathematics concept. In RME, the assessment problems usually cover all three levels of student's thinking: low, middle, and high level order thinking. Therefore, in some cases students could not directly get the formal solutions, instead they have to discuss their informal solutions in a pair of a group.

The course was organized based on the main activities such as doing mathematics, redesigning lesson materials, teaching practice, and reflection. In the final version of the course, the meetings required six weeks (each meeting about two-hour courses or 100 minutes) and two weeks for teaching practice in the school. Results from the prototyping and assessment stages show that the RME course was perceived valid, practical and have some potential effects to the participants. More details about the RME course can be found in the Chapter 3.

5.3.3 RME exemplary lesson materials

Exemplary lesson materials play an important role in this study. The materials included learner materials, assessment materials, and a teacher guide. The teacher guide contains procedural specifications, a very clear guidelines and specific direction in using the materials and focuses on the essential of the innovation in this case the RME approach. For instance, how to deal with RME lessons (start, manage, and close) and how to deal with the assessments in RME. Five mathematics topics have been developed and adapted to the Indonesian context: linear equation system, symmetry, matrices, side seeing, and statistics. These materials were used in the doing mathematics session and used as a guide for student teachers in developing or adapting their own materials. The materials were provided and used in the course, in the schools and in the web
site. Findings from the expert appraisals and try-outs during prototyping and assessment stages show that the RME course was perceived valid, practical and have some potential effects to the student teachers. More details about the RME exemplary lesson materials can be found in the Chapter 3.

5.4 REFLECTION ON THE DEVELOPMENT RESEARCH APPROACH

The CASCADE-IMEI study used a development research approach. As described in Chapter 1, this study aimed at developing a valid, practical and effective learning environment (the intervention) and generating design guidelines (process development) for such an intervention. This section reflects on the knowledge gained and lessons learned with regard to this research approach.

Prototyping approach and formative evaluation

The prototyping approach appeared to be effective in improving the quality and the richness of the learning environment when it is combined with formative evaluation activities. For example, the initial prototype of the LE only consisted of a web site. Although the web site itself seemed to be valid, it was not practical for learning about how to apply the RME approach in practice. Then, based on literature findings, context and problem analysis, and suggestions from experts in the subsequent prototypes of the LE, the web site was combined with a course-based learning environment in which the web site functioned as a support tool for the course participants.

During the development process, the ideas and intentions of the developer dynamically evolved based on the state-of-the art of the components that are used in the LE as well as based on the suggestions, comments, and needs from both experts and target users. For instance, experts suggested including several Java applet simulation programs so the users can visualize realistically the concepts of several mathematics topics on the web site. Also, they suggested to include several short video-clips to show the users the idea of how to teach using a RME approach. In the course, moreover, users showed their needs to learn redesigning RME lesson materials. Based on these, and other suggestions, the revision decisions were drawn and the LE was revised. Hence, the quality and the richness of the LE improved.
Roles of the researcher

One of the benefits of the development research approach was that it fosters the researcher to learn and perform a number of new roles. In this study, for example, the researcher was also perform as a designer (web site, course), a developer (exemplary lesson materials, video clips), a web-programmer (web site, Java applet, and Java script), a trainer (course trainer), and observer (in the Internet cafe and classrooms). These roles were needed in order to develop and evaluate the intervention (the learning environment). As a result, on one hand, the development researcher gained much knowledge and skills and rich learning experiences from those roles. On the other hand, it was not an easy task because the intervention usually an innovation in a research domain that may did not have an example before. It that situation it seemed that working as a development researcher was difficult and spent a lot of time. In contrast, after the researcher developed and evaluated the intervention, the difficulties of the development of the intervention were paid back by the short line between the formative evaluation and the revision decision and by the successfulness of that intervention in reaching the aim of the research. For the CASCADE-IMEI study, although it was over, the web site as a part of the intervention is still used by the web users and alive for unlimited of time.

5.5 DISCUSSION OF THE EVALUATION FINDINGS

This section summarizes and discusses the main findings of the CASCADE-IMEI study that were represented in five levels of effectiveness. These findings show the potential role of the learning environment (LE) in assisting student teachers in UPI Bandung learning and teaching RME.

The final field test was conducted in the Department of mathematics education in UPI Bandung from September 2001 to December 2001. The working group consists of 10 student teachers that were selected from 33 student teachers that took the Seminar course participants. A number of instruments were used. In addition, about 400 pupils from 5 different schools were involved. More detail of research design of the field test can be found in section 4.1 of Chapter 4.

5.5.1 Student teacher' satisfaction to the LE

The effects of the LE on the student teacher’ satisfaction were indicated based on the data from questionnaires and interviews. Results show that the
participants were satisfied with the content, support, interface and the organization of the LE. First, related to the content, they perceived the content of the LE to be practical. They agreed that the content of LE (RME exemplary lesson materials and examples of pupil's solution) was useful for helping them in learning RME. They also agreed that the content was consistent with their expectations as well as interesting from the mathematical point of view.

Second, results show that student teachers were also satisfied with the support offered by the LE. The most valuable support offered via the web site that satisfied the student teachers were the video clips (Tutor part). Then, they also appeared to be satisfied with other parts such as the problem of the month, RME papers, and Java applet simulation programs.

Moreover, the student teachers were content with the RME course, especially with the didactical component. They were impressed when treated as learners in the doing mathematics part of the course. Being the learners, they could perceive lively and directly the teaching methods that belong to the RME and they could remember several critical teaching moments. Also, the RME-video display gave them a vivid idea of how to manage the RME classroom, guide the discussions and assess the pupils formatively.

In addition, they were also satisfied with the interface of the web site. As new web users, they were even proud of the fact that the web site was developed mainly for them as Indonesian mathematics student teachers. Moreover, they were happy due to the fact that some of their activities and pictures were recorded and put online. Finally, they were also satisfied with the organization of the course. Most of them agreed that the course was rich with the support (exemplary lesson materials, video, etc.) and the activities (doing mathematics, peer teaching, teaching practice, group discussion, and seminar).

Up to now, the web site still gains about 15 hits per day. Most of users are student teachers from Indonesia, while others come from all over the world. Some of the student teachers from the working groups are still working on their final projects on RME. Most of them return to the web site for finding additional information and for asking questions. This is also seen as an indicator of their satisfaction to the LE. In addition to that, some new student teachers and pupils from Indonesian junior secondary schools stopped by and used the web site in order to use the simulation and game programs as well as
practice with RME problems. In summary, although the CASCADE-IMEI study was finished, the aim of the LE, to assist Indonesian student teachers learning RME, is still alive.

5.5.2 Student teachers' learning RME

The knowledge, skills and beliefs that have been learned by the student teachers in the CASCADE-IMEI learning environment can be summarized as follows.

- Knowledge of RME theoretical background as a new approach to teaching and learning in mathematics education, including its philosophy and tenets.
- Content and pedagogical knowledge of RME that they learned when they were treated as learners in the doing mathematics session and when they were shown the RME-video.
- Knowledge and skills on how to redesign RME lesson materials on a mathematics topic that they want to teach in the school. By using the available materials and guided by the five tenets of RME, they designed their teaching materials that consist of sequences of problems in different meaningful contexts. Although the quality of their lessons is far from the standard of RME materials, they have tried to include at least two tenets of RME in their materials (the use of context and the integration of mathematics strands).
- Knowledge and skills on how to use the web site and communication tools for finding additional resources and as a way of communicating, collaborating and reflecting on RME. For instance, through e-mails all student teachers reflected their experiences. They believed that they learned a lot from this way of reflection.

In addition, based on their reflections, they believed that they would use all knowledge and skills in their daily job either as student teachers or teachers. In other words, there are indications that there are changes in the beliefs or attitudes of student teachers toward mathematics and their jobs after they followed the LE.

5.5.3 Organizational support and change

Results from informal discussion with some teacher educators, interviews with the Head of the Department of mathematics education in UPI Bandung and with a member of the RME-team, provided insights in the following changes
that have happened in the Department of mathematics education in UPI Bandung.

- Soon after the developer gave a seminar in the Department of mathematics education in the beginning of the research in September 1999, 'a RME-team' with 6 teacher educators as members was formed in the Department. During a number of try-outs of the LE, the team members were formally involved in supervising the student teachers.

- The Dean of faculty and the Head of the Department of mathematics education supported facilities and gave permission to all activities that were related to the evaluation of the LE during the four tryout periods (October 1999 until December 2001).

- The LE offered a new model to the Seminar course by providing a number of activities during the course and integrating the course with the web support. By using the web support, the number of weekly meeting for the course is reduced from 16 times to 8 times (including 2 weeks for teaching practice).

- The LE could increase the number of student teachers who take the final project. Before the LE was launched in the Department of mathematics education in UPI Bandung, there were only a small number of student teachers who took the final project (research) in which they have to write a final report or thesis (skripsi). Instead, they were used to take only the Seminar course with an additional mathematics course before they would graduated. After each round of tryout of the LE in UPI Bandung, fortunately, almost all of the student teachers that were involved in the LE also took the final project. They were inspired to take a RME related topic for their research project.

**5.5.4 Student teachers' use of knowledge and skill in teaching RME**

Results from observational notes, the teaching profile, and video show that participants used their knowledge and skills both in the peer teaching and teaching practice in the schools. The results show that they have good performance on the basic critical moments of teaching in RME classroom such as at the start of lesson; during the lesson; and at the end of lesson. All of them were able to teach and manage their classroom in an appropriate way. In general, they could use their knowledge and skills that they learned from the LE. However, they also encountered several technical problems such as use of time (most of them ran out of time) and use of volume of speech (almost half
of them, especially female, had low volume). These problems seem to be typical for novice teachers and could be solved by practice and coaching.

5.5.5 Pupils' experiencing the RME instruction

The teaching profiles, questionnaires, interviews, and video provided indications that pupils in the schools who participated were satisfied with the RME teaching process that was taught by student teachers. They perceived that the exemplary materials were interesting due to the use of daily applications that are real to them. They liked their roles both as an individual in learning mathematics problems and as a member of a group discussion. They experienced the new ways in learning mathematics. For example, they could freely discuss the adequacy and the efficiency of their solutions. They learned from others' strategies. Finally, they learned that a mathematics problem can have multiple solutions or multiple strategies. Although in some classes the student teachers provided end-unit tests, these results were used only for reporting either in their seminar course or for school teachers files. This study was limited to the experiences of pupils and their attitudes toward mathematics.

5.5.6 Conclusion of the evaluation findings

Based on the discussions on the section 5.4.1 to 5.4.5, it can be concluded that the LE could play a role in assisting mathematics student teachers in UPI Bandung learning and teaching RME as a new approach in mathematics education in Indonesia. The roles of the LE are outlined below.

1. The LE may make the student teachers be satisfied with the content (RME), support, interface and the organization of the LE. This seems to be mainly due to the consistency of the LE that the LE matches with their needs.

2. The LE could assists the student teachers learning the mathematical, didactical and practical part of the RME course. As a result, the LE could promote the student teachers' understanding about RME. The LE could also support student teachers learning how to redesign lesson materials for classroom level. In addition, student teachers also use the web technology in learning RME. This may provoke learning how to use e-mail facilities for instance for reflecting on their experiences. This way of teacher's learning could enhance their understanding of RME and change their beliefs toward mathematics as well as their jobs.

3. The LE may have impact on the organization and staff of the Department
of mathematics education as well as on the mathematics secondary teachers at the several practice schools. For instance, the LE could promote changes in that organization with respect to the activities of teacher educators and the process of Seminar and final project courses.

4. The LE may also have a positive impact on developing teaching performance of the student teachers. As a result of the LE, they may be able to perform as a real teacher in the school classroom using the RME approach.

5. The LE has also potential impact in changing the pupil's belief or in increasing the positive attitude of pupils in the secondary schools toward mathematics.

5.6 RECOMMENDATIONS ON MATHEMATICS EDUCATION IN INDONESIA

In this section, recommendations are given to the Indonesian government, to the Department of mathematics education in Indonesian teacher education, to the CASCADE-IMEI study, and to future researchers in the field of mathematics education. It includes the use of web technology in mathematics teaching and learning, professional development for mathematics teachers, curriculum development and implementation, and development research.

5.6.1 Indonesian government: The RME-pilot project team

Since 2001, the Ministry of National Education through DIKTI (Direktor Jenderal Pendidikan Tinggi or the Directorate General of Higher Education) and the PGSM project have been developing a team for implementing RME in Indonesia called PMRI (Pendidikan Matematika Realistik Indonesia, or Indonesian realistic mathematics education). This team has been conducting a RME pilot project in 12 Primary schools in three cities in Java that is Bandung, Jogyakarta and Surabaya (Sembiring, 2001). In addition to the 12 primary school teachers, the main members of this project are also mathematics teacher educators from four educational universities in three cities that are Universitas Pendidikan Indonesia Bandung, Universitas Sanata Darma Yogyakarta, Universitas Negeri Yogyakarta, and Universitas Negeri Surabaya. Moreover, Sembiring (2001), in the year 2002-2003, PMRI will still focus on the first grade of primary school, but they will extend the duration of the project time from a quarter to a full year. As this study started in order to support the idea of the
PGSM project and tried out during a workshop (third prototype of the LE) for the primary school teachers who are also members of the RME pilot project in Bandung, recommendations for the PMRI team are important. The recommendations for the team are outline below.

**RME exemplary lesson materials.** Exemplary lesson materials should be designed based on the RME characteristics. The materials usually consist of a sequence of contextual problems that guide the learners to understanding of a mathematics concept. It is recommended to get teachers be involved in developing the lesson materials. In addition, the materials should be evaluated formatively by the RME experts. The materials consist of learner materials, assessment materials, and a teacher guide. The teacher guide should provide procedural specification to the teachers on how to implement the materials. Gravemeijer (2001) pointed out that teachers or curriculum developers can use the available curriculum materials as a guide and then make their own adaptations based on the RME characteristics. This suggestion worked in this study in which the student teachers in UPI Bandung adapted the available materials provided in the LE to their own situations. Hence, the LE with its materials can be used as examples or resources for the curriculum developers and teachers that are involved in the PMRI pilot project.

**Teaching methods.** Based on the results of this study, it is recommended that the teacher should be trained how to teach using RME materials before they teach in their classroom. A promising way to train teachers is by using:
1. video display that consists of examples of a RME teaching and learning situation;
2. a teachers as learners strategy in which the teachers should be treated as learners by a RME teacher so they can directly see and experience the role of RME teacher in managing the classrooms; and
3. peer teaching and teaching practice activities followed by reflection in a focus group discussion.

**Assessment strategy.** In addition, teachers should be trained how to assess the pupils both formatively and summatively and how to score on the student's production or solutions. The formative evaluation focuses on the improvement of the instructional process as well as learning process of pupils while summative evaluation more focus on the production or solutions of the pupils. Finally, the assessment materials should cover all three levels of
thinking levels: low, middle and high.

Use of the LE. It is suggested to use the LE as follows. First, use the RME course in a similar framework and the materials of the LE such as the exemplary curriculum materials, the video, and the course program that have been proved to be valid and practical. Second, as the RME pilot project activities are placed in the three different cities, it might be helpful to use the web site as dissemination resources and a tool for communication and collaboration among the members of the pilot project. In this case, the designers and teachers from three cities can collaborate and communicate their experiences in teaching RME in their classrooms. In addition, their materials can be put on the web so they can learn from each other's experiences and materials. Therefore, while using this communication tool, they may able to sharpen their understanding of RME.

5.6.2 Department mathematics education in teacher education

This study started in order to support the idea of the PGSM project to improve the quality of mathematics education in the secondary level through teacher education. In addition to that, the CASCADE-IMEI study provided empirically proof on the validity, practicality and potential effectiveness of the LE in supporting student teachers in UPI Bandung. This university is one of the bigger teacher education institutions in Indonesia that provides a LE on RME as an innovative approach in mathematics education in Indonesia. Based on these results, it is suggested to other Department of mathematics education in Indonesian teacher education institutions, to use the LE program as a new model in supporting some method courses such as the Seminar course, Teaching and learning strategy, Evaluation methods, etc. Since RME is a new instructional approach in mathematics education, it can be a requirement topic to be learned by student teachers in those courses. In addition, by using the web site technology, student teachers or even teacher educators can use the Internet as a new technology in mathematics teaching not only about RME but also about other elements that related to mathematics that available on the Internet.

5.6.3 The future of the CASCADE-IMEI LE

This section describes how the LE can be extended and implemented in the future.
The RME exemplary curriculum materials may be extended not only the quality but also the quantity of the materials. For instance, with a number of development research cycles, the materials may be developed as a local theory of that topic in the Indonesian context. By the time this dissertation is finished, five mathematics topics have been adapted and developed both in English and Indonesian and used in the LE program. By adding more topics in the Indonesian version, the LE will be more helpful for the mathematics (student) teachers in Indonesia.

By the time this dissertation is ready to be published, the web site is the first and the only mathematics education web site in the world that uses the Indonesian language. As a result, it is visited by about 15 users daily from all over the world by the users who want to know more about mathematics education in Indonesia or want to learn about RME as a new approach. Figure 5.1 shows the number of users who used the web site since 17 August 2001. Since that time, the total number of users was more than four thousands.

<table>
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<tbody>
<tr>
<td>1. Netherlands</td>
<td>1240</td>
<td>27.3 %</td>
<td>2. Indonesia</td>
<td>1069</td>
<td>23.6 %</td>
<td>3. United States</td>
<td>268</td>
<td>5.9 %</td>
<td>4. Thailand</td>
</tr>
<tr>
<td>5. Germany</td>
<td>72</td>
<td>1.6 %</td>
<td>6. Hong Kong</td>
<td>71</td>
<td>1.6 %</td>
<td>7. Taiwan</td>
<td>62</td>
<td>1.4 %</td>
<td>8. United Kingdom</td>
</tr>
<tr>
<td>9. Australia</td>
<td>56</td>
<td>1.2 %</td>
<td>10. New Zealand</td>
<td>55</td>
<td>1.2 %</td>
<td>Unknown</td>
<td>618</td>
<td>13.6 %</td>
<td>The rest</td>
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<tr>
<td>Total</td>
<td>4537</td>
<td>100.0 %</td>
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Figure 5.1 The statistic page of the web (17 August 2001- 27 August 2002)

Therefore, it is important to start a new study or to get a research funding that may provide special time and attention to improve and maintain this web site.
in terms of its content, support and interface. For instance, the papers part can be extended to the online publication since up to now, there is no such journal on mathematics education both offline or online. Further, more examples on various topics might be added to the Java applet simulation pages. The same holds true for the 'problem of the month'. This component may be changed into 'problem of the week' so more examples of assessment problems at all school levels can be offered.

The LE may also be used as a part of regular method course in assisting mathematics student teachers to learn and to teach using RME approach in the Faculty of teacher training and education at the University of Sriwijaya, South Sumatera, in which the developer is currently working. With the new decentralize education system in Indonesia nowadays, the LE could function as a vehicle in supporting teachers in the South Sumatera learning and teaching RME as an innovation in mathematics education.

5.6.4 Further research on learning environment

The CASCADE-IMEI research was aimed at supporting Indonesian student teachers in learning RME as an innovation in mathematics education. More precisely, this study was developed in the domain of both realistic mathematics education and the use technology in curriculum and professional development of student teachers in the context of Indonesian teacher education. Thus, the further research of this study lies in both domain of researches and can be formulated as follows.

First, the RME exemplary materials that have been adapted to the Indonesian context and evaluated to be valid and practical for Junior secondary school level, can be used as initial exemplary lesson materials for a new development research study (e.g. at theoretical level of designing RME materials) at the same school level for other contexts either in Indonesia or other countries in the world (several contextual adaptations of course should be made). In addition, the research may be extended in a new mathematics topic in all school levels.

Second, the CASCADE-IMEI LE program appeared to be potentially effective in supporting student teachers in learning RME. By using five Guskey's levels of effectiveness the study did not cover the general effect on the learning outcome of pupils. Therefore, investigating to what extent the CASCADE-IMEI LE will improve the mathematics learning outcome of pupils after they being
taught by the (prospective) teachers that followed the CASCADE-IMEI LE could start a new development research project.

Finally, the CASCADE-IMEI study is in line with three previous CASCADE studies: CASCADE (Nieveen, 1997), CASCADE-SEA (Mckenney, 2001) and CASCADE-MUCH (Wang, 2001). Of course, there are similarities and differences. They are similar in the sense that all of them deal with the use of electronic tools to support teachers or curriculum developers in the domain of analysis, design, evaluation, and implementation of curriculum materials. The differences with CASCADE-IMEI study were all the previous CASCADEs used stand-alone computer while this study use the web site as platform. In addition, all of the contents and contexts were also different. Therefore, the new CASCADE research using web platform could be extended. For instance, by designing and evaluating a full web-based support system for a specific content in the new context that can play a role in supporting the curriculum developers or (prospective) teachers or professional developers? Of course this idea may work in the context that has full access to Internet. In relation with this study, for instance, how can a full web-support system that produce RME assessment materials on various school mathematics topics in the three levels of thinking (low, middle, and high)?

Finally, at the end of this dissertation, it seems easy to see and formulate all kinds of promising and challenging suggestions for further research. However, as Robert Frost (1874-1963) wrote in the last four lines of his poem "Stopping by the woods on a snowy evening":

...The woods are lovely, dark and deep,
but I have promises to keep,
and miles to go before I sleep,
and miles to go before I sleep.