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DEVELOPING PMRI LEARNING ENVIRONMENT THROUGH LESSON STUDY FOR PRE-SERVICE PRIMARY SCHOOL TEACHER

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Abstract

Teachers' pedagogical ability contributes significantly to their process and learning performance. To improve it, a development process is needed as long as they are still having their process of education or they are still teacher students. This study aimed to develop a valid and practical PMRI learning environment through lesson study which had a potential effect on improving the pedagogical abilities of pre-service primary school teachers. A design research method of development study type was used in this study consisting of three phases, namely the preliminary, development or prototyping phase, and assessment phase. The research subjects were 32 students of Primary School Teacher Education of Sriwijaya University. The data were collected using walkthrough, observation, documentation, questionnaires, interviews, and tests. The study produced a learning environment with a valid and practical Campus-School (CS) model and had a potential effect on improving teacher students' pedagogical ability. The learning environment was in the form of training on campus and implementation in schools. Based on the data analysis, the learning environment was able to produce pre-service primary education teachers understanding the PMRI through lesson study and design PMRI learning tools through a lesson study.

Keywords: Learning environment, *Pendidikan Matematika Realistik Indonesia*, Lesson study, Pedagogical ability

Abstrak

Kemampuan pedagogik guru memiliki kontribusi yang signifikan dalam proses dan kinerja pembelajaran. Untuk meningkatkannya, proses pengembangan diperlukan sepanjang guru tersebut masih menjalani proses pendidikannya atau masih berstatus pada guru. Penelitian ini bertujuan mengembangkan lingkungan belajar PMRI dengan lesson study yang valid dan praktis serta memiliki efek potensial untuk meningkatkan kemampuan pedagogis mahasiswa calon guru sekolah dasar. Penelitian menggunakan metode design research tipe development studies. Penelitian ini terdiri dari tiga tahap, yaitu tahap preliminary, development atau prototyping phase dan assesment phase. Subjek penelitian adalah 32 orang mahasiswa Pendidikan Guru Sekolah Dasar Universitas Sriwijaya. Pengumpulan data dilakukan dengan cara walkthrough, observasi, dokumentasi, angket, wawancara dan tes. Penelitian menghasilkan lingkungan belajar dengan model Kampus-Sekolah (KS) yang valid dan praktis serta memiliki efek potensial dalam meningkatkan kemampuan pedagogis mahasiswa. Lingkungan belajar tersebut berupa pelatihan di kampus dan implementasi di sekolah. Berdasarkan analisis data, lingkungan belajar mampu menghasikan calon guru yang memahami PMRI melalui lesson study serta mampu mendesain perangkat pembelajaran PMRI melalui lesson study.

Kata kunci: Lingkungan belajar, *Pendidikan Matematika Realistik Indonesia*, *Lesson study*, Kemampuan pedagogik

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Shulman (1986) states that the dimension of professional knowledge important for teachers and prospective teachers to teach is the Pedagogical Content Knowledge (PCK) covering the Pedagogical Knowledge (Pedagogical Competence) and Content Knowledge (Professional Competence). It is the knowledge possessed by a teacher or prospective teacher of a material so that learning objectives can be achieved based on an understanding of things that make the material easy or difficult for students to understand (Shulman, 1986). In other words, a teacher who already has PCK will be able to

develop effective teaching strategies and have the ability to identify student errors and deal with them well. Likely, the most vulnerable competency or ability of teachers lies in pedagogical competence (Susanto & Agustina, 2019; Brandt et al., 2019). This is because the pedagogical competence is the ability of teachers to manage learning (Rahman, 2014; Kunter et al., 2013). It includes the ability for the students to understand and develop, the planning and implementation of learning, and evaluation of learning (Dirgantoro, 2018).

However, in reality, the pedagogical competence or ability of teachers in Indonesia is still low. The teacher competency test results in 2014 and 2015 showed that the national average still did not reach the target, namely 42 and 53.05 respectively (Rahman et al., 2015; Bhakti & Maryani, 2016). Whereas the desired target to be achieved by teachers was 55. If further classified specifically for pedagogical abilities, the national average obtained was 48.94 which is below the minimum standard of 55. In addition, several studies relating to the teacher pedagogical abilities still show unsatisfactory results (Rahman, 2014; Syahruddin et al., 2013; Febrianis et al., 2014; Bhakti & Maryani, 2016). Bhakti & Maryani (2016) state that the unsatisfactory results of the competency test put the Teacher Education Institute (TEI) to be the most responsible due to its providing the prospective teacher education. This is because the pedagogical ability is not possessed by a teacher suddenly but through continuous and systematic learning efforts, both for pre-service and in-service teachers (Asari et al., 2018). Consequently, a development process is needed to improve the pedagogical ability of the teachers as long as either they are still in their education training process or they are already teachers. The curriculum needs to be redesigned according to the need to prepare pre-service teachers who have competencies to be professional, especially pedagogical competencies.

To improve the pedagogical abilities of these students, a collaborative learning process is needed (Asari et al., 2018). Lesson study is a learning system that uses a collaborative system (Sato, 2014a; Sato, 2014b). Lesson study is a learning system first carried out in the education system in Japan (Darra & Kanellopoulou, 2019) and shows good results on improving the quality of teaching and learning process (Kusumah & Nurhasanah, 2017; Wessel, 2018). This Lesson Study has four main steps in the form of a Plan-Do-See-Redesign cycle, namely (1) Plan, aiming to produce a design of learning tools, made collaboratively, (2) Do, aiming to carry out learning that has been designed at the Plan stage, (3) See, aiming to find the strengths and weaknesses of the implementation of learning and finally, (4) Redesign, aiming to make improvements to the learning design if there is anything needing to be improved based on the results at the see stage (Sato, 2014a).

Pendidikan Matematika Realistik Indonesia (PMRI) is one of the approaches that become innovations in learning and can reform mathematics education in Indonesia (Sembiring et al., 2010). PMRI is the Indonesian version of RME, in the Indonesian and cultural context, which has five characteristics, namely (1) using the real world context as a starting point for learning, (2) using the model as a bridge between abstract and the real world, (3) using results or strategies of the students themselves, (4) interaction as an important element in learning mathematics, and (5) the connection of

each learning strand (Zulkardi & Putri, 2019). In the process of its development in Indonesia, the Primary School Teacher Education became the spearhead (Sembiring, 2010).

Research on professionalism development devoted to improving the pedagogical competence of mathematics teachers has been carried out in Indonesia using PMRI (Zulkardi, 2002; Putri et al., 2015; Ekawati & Kohar, 2016; Jannah & Prahmana, 2019) or lesson study (Kusumah & Nurhasanah, 2017; Asari et al., 2018). However, the use of both PMRI and lesson study in the professionalism development specifically pedagogical abilities in the form of a learning environment in pre-service primary school teacher which has never been done before. What is more, the result of preliminary observation conducted by the researchers on pre-service primary school teacher showed that they were not familiar with PMRI and lesson study. For this reason, the researchers developed a PMRI learning environment through lesson study applied in the teaching and learning process (Zulkardi, 2002). This learning environment is understood as a condition where the learning process runs under objective factors that influence learners and determine the achievement of new experiences and attitudes towards learning (Kirillov et al., 2016). This learning environment will be a means for pre-service primary school teacher to learning about PMRI through lesson study, practicing preparing and designing learning tools, using learning tools, and learning to manage classes using PMRI through lesson study. Thus, the process of developing a PMRI learning environment through lesson study to pre-service primary school teacher was expected to make these teacher students have an understanding of PMRI and lesson study and be able to design learning tools which would be useful for them later when becoming teachers. The researchers expected that this development model would help improve the quality and professionalism of teachers in the future.

Therefore, there were two aims of this study, first, to find out the characteristics of a valid and practical of the PMRI learning environment through lesson study to improve the pedagogical abilities of primary school teacher candidates; and second, to find out the extent of the effectiveness of the PMRI learning environment through lesson study towards improving the pedagogical abilities of primary school teacher students.

METHOD

This study used design research method with development study type. This research consisted of three phases, namely the preliminary phase, the prototyping phase and the assessment phase (Plomp, 2013). At the prototyping phase, the researchers conducted a formative study of the devices used and produced by the learning environment by conducting self-evaluations, expert, and one-to-one reviews, small groups, and field tests (Zulkardi, 2002). The number of the subjects was 32 students of Primary School Teacher Education of Sriwijaya University.

The data were collected using walkthroughs, documentation, observation, interviews, questionnaires, and tests. The data of the walkthrough were in the form of comments and suggestions provided by the expert validators documented along with the comments and suggestions derived from colleagues and students. The observational and interview data were obtained during the one-to-one, small

group, and field test phases. The questionnaire was given to the research subjects during their education and training on campus in the form of initial questionnaire, perception questionnaire, and satisfaction questionnaire. Meanwhile, the test was given to the subjects after the field test phase at school. The documentation, observation, interview, questionnaire, and test data were analyzed qualitatively presented in a narrative form and images and the percentage of each indicator in tabular form. The satisfaction questionnaire and tests were given to find out the potential effects of the learning environment model on improving student teachers' pedagogical abilities related to PMRI through lesson study.

RESULTS AND DISCUSSION

Preliminary research was conducted to get an overview of the learning of *Pendidikan Matematika Realistik Indonesia* (PMRI) to pre-service primary school teacher. At this stage, it included the literature review and try out of PMRI learning related to the topics of angles. Then, the researcher had students' perceptions of PMRI learning through questionnaires and interviews. The preliminary research was conducted on six primary school teacher students. At the beginning of learning it was discovered that the pre-service primary school teachers never knew PMRI at all. The results of this preliminary research were published by the researcher in previous article, that is relating to the perception by Fauziah et al. (2017). Based on the literature review, results of preliminary research and discussions with lecturers of Primary School Teacher Education, lecture designs and initial prototype of learning environment were designed.

The prototyping stage was divided into two, namely 1ˢᵗ prototype and 2ⁿᵈ prototype. The prototype of the learning environment consists of PMRI through lesson study training prototypes and learning tools prototype. The 1ˢᵗ prototype of learning environment focused on the purpose of testing the validity of the design of PMRI through lesson study training and the learning tools. The design of PMRI through lesson study training was discussed with the experts. The comments and suggestions were given on the 1ˢᵗ prototype of the phases of training. After that, the learning device was prepared in conjunction with the teaching team of lecturers because the system used was lesson study (plan). During this plan phase, the researcher and team teaching discussed the choice of learning material, context and media based on the student characteristics. The topics chosen as materials for the simulation were the polygon (Grade 4) and direct proportion (Grade 5). The results of the discussion of the researcher and team teaching produced a learning plan, student worksheets, teacher's Instructions, test questions for higher order thinking skill (HOTs) which was the 1ˢᵗ prototype of learning tools. The 1ˢᵗ prototype of learning tools was tested by PMRI expert and two colleagues. Then, the researchers also validated it on three students (one-to-one) who were not the subjects of the study with the aim to solicit student responses and comments related to the readability of the lesson plans and test questions. The researchers also asked the three students their opinions about the difficulties they encountered in understanding the learning device. The results of the expert review, peer review, and one to one summed up that the content and construct of learning environment in the form of training and lesson tools were valid. However, some suggestions were given

relating to the learning device in PMRI learning simulations to be more easily understood and in accordance with the characteristics of PMRI.

Based on the results of the review, the 2nd prototype was tested by teaching experiments on the 8 pre-service primary school teacher of Sriwijaya University. The focus on 2nd prototype was to test the validity and practicality of PMRI with lesson study training and the lesson tools. The validity was re-investigated because the results of developing the 1st prototype showed that the prototype needed to be improved. The findings of small group classroom experiments at this phase indicated that the training of PMRI through lesson study and lesson tools of direct proportion and polygon met the content and construct validity criteria and could be used to develop pedagogical abilities of primary school teacher candidates. The content validity meant that all interventions in this subject were in accordance with the state of the art knowledge, while the construction validity meant that the various components of the subject were connected to each other (Bakker, 2018). At this stage, the practicality of the results of the design of learning environment was obtained from the results of questionnaires and interviews conducted to small group students after the training was completed. This means that students and lecturers (or other experts) consider each session in this lecture interesting and could be used in normal conditions (Bakker, 2018).

The results of the teaching experiment on the 2nd prototype helped to develop the final version of learning environment. The lecture process added the implementation of the design results made to the lesson study model school. The final version or class experiment at the field test phase was carried out on 32 students of primary school teacher education of Sriwijaya University who took the high-grade mathematics learning subject. Here are the results of the final version as shown in Figure 1.
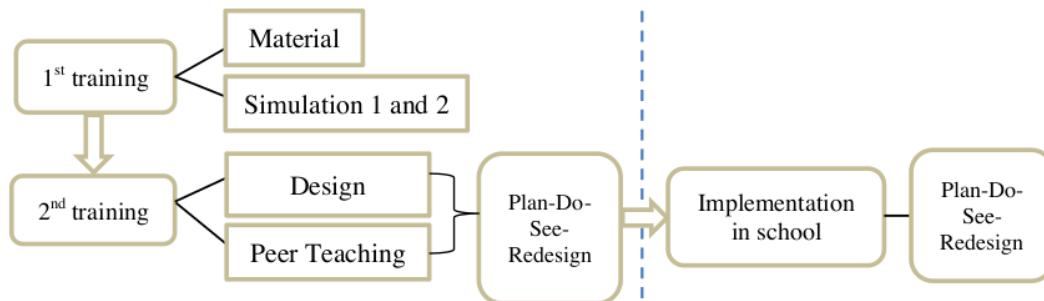

Figure 1. Final version of learning environment

At the first and second meetings, the students were given PMRI material relating to the background, principles and characteristics of PMRI as well as the material of lesson study learning community (LSLC) in a row. It was carried out since based on the preliminary studies the students were not familiar with PMRI and lesson study. Furthermore, the students were given PMRI learning simulation of direct proportion and polygon through lesson study. This simulation was provided by two lecturers of primary school teacher education who were the team-teaching researchers. The

students were given two worksheets in which the Student Worksheet I contained a sharing task and the Student Worksheet 2 contained a jumping task. According to Sato (2014a), a collaborative method consists of two worksheets: sharing task and jumping task. The former is a task that students can still reach it or do it and the latter is a bit more difficult task (Asari, 2017). Figure 2 shows the context and answers of students in learning simulation on the topic of direct proportion carried out in one of the meeting sessions in lectures.

Kereta Api	Berangkat	Datang	Durasi	Harga
BUKIT SERELO (S5) Ekonomi	09:30 18 Dec 2018	17:00 18 Dec 2018	7j 30m	Rp 32.000 Subclass C
SINDANG MARGA (S3) Eksekutif	20:00 18 Dec 2018	03:30 19 Dec 2018	7j 30m	Rp 150.000 Subclass A
SINDANG MARGA (S3) Bisnis	20:00 18 Dec 2018	03:30 19 Dec 2018	7j 30m	Rp 120.000 Subclass B

Figure 2. Train ticket prices as sharing task context used on Student Worksheet I

On this worksheet I, students were asked to determine the travel costs of Mr. Iwan commuting every week in a month using the train at night and help Mr. Iwan to choose which train by stating his reasons. All of the students were able to answer this problem well because this problem was classified as sharing tasks. Figure 3 shows the student's answer.

The business class round trip cost of taking Sindang Marga train
= 8 x Rp. 120.000 = Rp. 960.000
The executive class round trip cost of taking Sindang Marga train
= 8 x Rp. 150.0000 = Rp. 1.200.000
Mr. Iwan should use the Sindang Marga business train because it is cheaper than the Sindang Marga executive train

Figure 3. Student's answer on Student Worksheet I

The researcher also confirmed the student's answer. The following excerpts of student conversations and team teaching:

Researcher : why multiplied by 8?

Student   : because in a month Mr. Iwan traveled 4 times and went home 4 times. So, Mr. Iwan did 4 + 4 trips, which is 8.

Next, the students were given the Student Worksheet 2 containing a jumping task with the *Maksuba* context shown in Figure 4.

If Mrs. Rima has 200 duck eggs, 2 kilograms of butter, 9 cans of sweetened condensed milk and 3 kg of sugar, how many baking pans of *Maksuba* cakes can Mrs. Rima bake? Explain your answer!

Mrs. Rima received a cake order. On the Eid Day, *Maksuba* cake is the favorite cake most ordered by customers. The following ingredients are needed by Mrs. Rima to make *a Maksuba* a baking pan of Maksuba cake :

Figure 4. *Maksuba* as jumping tasks context used on the Student Worksheet 2

The following is the student's answer related to the problems on Student Worksheet 2 given in Figure 5. When working on the student worksheet 2, if students had difficulties, they were given the opportunity to ask their friends by first saying "please teach me" (Sato, 2014a). Here are their answers related to the problems in Student Worksheet 2 in Figure 5.

No.	Jumlah loyang	Telur	Susu	Mentega	Gula
1.	1 loyang	1 ×24 = 24 butir	1×1 = 1 kaleng	1× 250 = 250	1×300 = 300
2.	2 loyang	2 ×24 = 48 butir	2×1 = 2 kaleng	2×250 = 500	2×300 = 600
3.	3 loyang	3 ×24 = 72 butir	3×1 = 3 kaleng	3×250 = 750	3×300 = 300
4.	4 loyang	4 ×24 = 96 butir	4×1 = 4 kaleng	4×250 = 1000	4×300 = 1200
5.	5 loyang	5 ×24 = 120 butir	5×1 = 5 kaleng	5×250 = 1250	5×300 = 1500
6.	6 loyang	6 ×24 = 144 butir	6×1 = 6 kaleng	6×250 = 1.500	6×300 = 1800
7.	7 loyang	7 ×24 = 168 butir	7×1 = 7 kaleng	7×250 = 1750	7×300 = 2100
8.	8 loyang	8 ×24 = 192 butir	8×1 = 8 kaleng	8×250 = 2000	8×300 = 2400
	Sisa	200 −192 = 8 butir	9−8 = 1 kaleng	2000−2000 = 0	3000−2400 = 600 gram

Jadi, banyak loyang kue yang dapat dibuat adalah 8 loyang.
Karena jika ingin membuat 9 kue bahan-bahannya tidak mencukupi.

No.	Number of baking pans	Eggs	Milk	Butter	Sugar
1	1 baking pan	1x24 =24 items	1x1=1 can	1x250=250	1x300=300
2	2 baking pans	2x24=48 items	2x1=2 cans	2x25=500	2x300=600
3	3 baking pans	3x24=72 items	3x1=3 cans	3x25=750	3x300=900
4	4 baking pans	4x24=96 items	4x1=4 cans	4x250=1000	4x300=1200
5	5 baking pans	5x24=120 items	5x1= 5 cans	5x250=1250	5x300=1500
6	6 baking pans	6x24=144 items	6x1=6 cans	6x250=1500	6x300=1800
7	7 baking pans	7x24=168 items	7x1=7 cans	7x250=1750	7x300=2100
8	8 baking pans	8x24=192 items	8x1=8 cans	8x250=2000	8x300=2400
	Remains	200-192=8 items	9-8=1 cans	2000-2000=0	3000-2400 = 600

So, the number of cakes that can be made is 8 pans.
because if you want to make 9 baking pans, the ingredients are not enough

Figure 5. Student's answer on Student Worksheet 2

Because student worksheet 2 was classified as a jumping task, some students could not directly work on the problems. Initially, the students were confused because the material needed to make a *Maksuba* cake was only in the form of picture without a hint of size and number. After asking a friend for help by first saying please teach me, asking for an explanation and discussing it together, finally the problems in Student Worksheet 2 could be resolved properly. Consequently, this jumping task is able to create active learning among students, such as dialogues, interactive and collaborative activities (Sato, 2014b; Putri & Zulkardi, 2019)

After doing the simulation, the students were given a questionnaire containing perceptions of the learning that already took place. The questionnaire was used to evaluate the simulation carried out whether it was in accordance with the principles of learning contained in PMRI. The indicators in this questionnaire was based on the principles put forward by Van den Heuvel-Panhuizen (2000), namely reality principle, activity principle, level principle, intertwinement principle, interaction principle and guidance principle. This questionnaire was previously used by researchers in the front-end analysis phase to look at students' perceptions of PMRI after initial learning with angular topics on different subjects (Fauziah et al., 2017). The questionnaire was made with a 1-4-point Likert scale. Table 1 explains the results of the questionnaire calculations on the subject of field tests on learning PMRI simulation 1 of direct proportion topics as follows.

Table 1. Result of questionnaire of learning

Indicator	N	Mean
Reality principle	30	3,45
Activity principle	30	3,28
Level principle	30	3,01
Intertwinement principle	30	3,06
Interaction principle	30	2,90
Guidance principle	30	3,2

The results of the questionnaire showed that the learning that took place was in accordance with the principles contained in PMRI learning (average score 3). They agree if the learning used everyday life contexts, the learning required them to be active and collaborative; the learning was made with levels interrelated, and leading them to understand the topic well.

In addition to the questionnaire, the researchers also conducted interviews and discussions related to the learning simulations in order for students to better understand about PMRI. At the next meeting, the researchers and students held discussions relating to PMRI learning device through lesson study system and assigned them to make learning device in the form of learning plans, student worksheets, HOTs test questions and teacher instructions with different materials in groups. This plan phase produced eight sets of PMRI learning device. The materials produced by the students were circumference of squares and rectangles, area of squares and rectangles, angles, surface area of cubes and cuboids, statistics (Grades 4 and 5), scales, nets of cubes and cuboids.

At the next meeting, the students were asked to do their peer teaching with fellow students related to the learning device that had been designed. Peer teaching was conducted using a collaborative method in lesson study (do and see phase). Of the 4 group members, one member functioned as a 'model teacher', the other three served as observers of the learning process. The other student group members were the 'model students'. The students then discussed their observations and experiences during peer teaching. The learning tools displayed by each group were commented and suggested by other students so that they became input for redesigning the devices (re-designing phase).

The meeting continued with asking students to implementation their design results in the lesson study model school. The researchers choose the IBA Foundation SD Palembang and SD Negeri 111 Palembang as the schools for students to do the open classes because the two schools had received training related to lesson study. The students and teachers planned the process together, tried out the designed student worksheet to several students (one-to-one), revised it, and then applied it in the learning in class. The initial learning device used as materials for planning with the teachers of the model schools was the one that was previously designed by the students on campus during the training. This device was then adjusted to the student's condition based on the results of discussions with the teachers and validated it to several pupils. Then, the students together with the school teachers conducted the open classes. The Open Class was conducted in two different classes in each school. During the open classes, the students observed and analyzed the learning that was taking place (do and see phase in lesson study). Activities at this model schools were closed by conducting a joint reflexion among the researchers, students, and teachers.

Finally, the next meeting was continued on campus by conducting a final discussion and preparing an observation report. The training closed with a final test, questionnaire, and interview. The researcher concluded the development model produced as a Campus-School (CS) model as shown in Figure 6.

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┌─────────────────┐        ┌─────────────────┐
│     Campus      │        │      School     │
│   (Training)    │───────▶│ (Implementation)│
└─────────────────┘        └─────────────────┘
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Figure 6. Campus-School (CS) model

Learning environment of PMRI through lesson study has a potential effect if it has a positive impact on students in order to improve their pedagogical abilities. Table 2 shows the results of measurements on the questionnaire of student satisfaction with the learning environment.

Table 2. Result of the questionnaire satisfaction on the learning environment

Indicator	Statement	Average	Sd
PMRI lecture	1-4	3,382	0,410
PMRI learning device	5-8	3,195	0,299
Lecture	9-10	3,25	0,361

Table 2 shows that on the average the student agreed that PMRI learning environment through lesson study was interesting, useful, and new to them. Likewise, the used learning device included context, worksheets, sharing tasks and jumping tasks that made the students eager to participate in the learning. The results of this questionnaire were later confirmed by conducting interviews with students showing that all of the students felt that the lectures that were going on were interesting and very useful for them. Here is one of the results of the questionnaire in Figure 7.

1. Perkuliahan tentang Pendidikan Matematika Realistik Indonesia (PMRI) dengan sistem *Lesson Study Learning Community* yang telah diberikan secara umum menarik bagi saya
   a. Sangat Tidak Setuju   b. Tidak Setuju   c. Setuju   ☒ Sangat Setuju

Penjelasan :

Karena sebelumnya belum pernah mendapat pembelajaran PMRI pada perkuliahan maka saat di beri kesempatan untuk mempelajarinya maka sangat menarik bagi saya Sendiri.

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1. Lectures about PMRI using Lesson Study Learning Community system that have been given in general are interesting to me
   a. Strongly disagree   b. Disagree   c. Agreed   ⓓ Strongly agree
   Explanation:
   because I have never been taught the PMRI learning so when given the opportunity to learn it is very interesting for me myself.

Figure 7. Results of questionnaire of learning environment satisfaction 1

The PMRI learning environment through lesson study made students understand it. Most students were able to make the PMRI learning device well covering the learning plans, student worksheets 1 and 2, HOTs test questions, and teacher instructions that contained the hypothetical learning trajectory. Here is one of the results of the questionnaire in Figure 8.

3. Saya merasa perkuliahan Pendidikan Matematika Realistik Indonesia (PMRI) dengan sistem *Lesson Study Learning Community* sangat bermanfaat
   c. Sangat Tidak Setuju   b. Tidak Setuju   c. Setuju   *d.* Sangat Setuju

Penjelasan :

Saya merasa perkuliahan PMRI dengan sistem Lesson study sangat bermanfaat dan membuat siswa menjadi aktif

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3. I find the *Pendidikan Matematika Realistik Indonesia* (PMRI) lecturing with the lesson study learning community system very useful
   a. Strongly disagree   b. Disagree   c. Agreed   (d) Strongly agree
Explanation:
I feel that PMRI lectures with the lesson study system is very useful and makes students active

Figures 8. Results of questionnaire of learning environment satisfaction 2

Figure 9 shows one of the contexts in student worksheet prepared by the students, namely *Loyang* Brownies. This context was used in Student Worksheet on the topic of determining the area of a rectangle where learning began by asking the students to draw a divider on a baking sheet and determining the number of dividers on the top and sides of a baking sheet and the total number of trays. The learning was continued by finding the relationship between the number of dividers on the top and sides with the total number of the trays.

Figure 9. *Loyang* brownies as learning aid, one of the contexts produced by the students

In PMRI, the context plays an important role in learning because it helps students understand the topic (Haris & Putri, 2011; Fauziah et al., 2019; Risdiyanti et al., 2019). Therefore, when designing learning, choosing a context becomes the pressure point to do (Risdiyanti & Prahmana, 2020). Initially the students found it difficult to choose contexts relevant to the topic of the material. After the discussion process among students, and students and researchers, most students were finally able to determine the context, although there was one group that until the end of learning, according to the researchers, the context chosen was not appropriate with the principles and characteristics of

PMRI, or often known as camouflage context. The camouflage context (dress-up) is the context used in learning but it is not meaningful or less compatible with actual conditions or with the topic (Zulkardi & Putri, 2006).

Similar to the lesson study, in addition to getting a theory, the students also immediately felt the learning process with the system during the simulation session, design learning in the design session, trying it out during the peer teaching session, and its application to model schools. The students and teachers at school implemented the stages of lesson study well, starting from planning learning (plan), doing the learning and observing it (do), and doing the reflection (see). The students were able to become good observers during the open classes on campus and schools. This can be seen from the results of reflections and reports that were prepared by them. Based on the observations, most of the primary school students' responses to the learning conducted by the model teacher showed their enthusiasm, though some felt it was difficult because when working on the student worksheet, they had to answer the questions by expressing the reasons and they were not used to doing this. Likewise, the primary school students understood the learning more easily because the problems were given using real contexts in everyday life (Bustang et al., 2013; Putri & Zulkardi, 2017; Risdiyanti et al., 2019).

In connection with the pedagogical abilities of pre-service teachers, the researchers assessed the results of learning device prepared by the students in groups to find out their ability in planning the learning using the PMRI approach with the lesson study system. Table 3 shows the recapitulation of the assessment results. There were 86.25 % of the students being able to plan the learning well as follows: 100% of students were able to make the learning goals complying with the indicators of competency achievement, 85% of students in both categories in preparing the learning materials that are in accordance with the basic competencies and indicators to be achieved, conformity with the steps in PMRI principles and lesson study as well as the completeness of the stages of learning activities.

Table 3. Recapitulation of the assessment of the ability to plan learning

Component	Average score	Percentage
Learning objectives	5	100%
Learning material	4,25	85%
Learning media	4	80%
Evaluation	4	80%
Average total		86.25%

Similarly, in the use of instructional media, 80% of students could adjust the context used in student worksheet with the objectives and learning material. And when making evaluations, 80% of students could also make the evaluations using test questions requiring the higher-order thinking skills (HOTs). Furthermore, Table 4 shows the students' ability to carry out the learning based on the results of observations and assessments during the students having their peer teaching. All students could

open the lesson very well which included preparing pupils, motivating them, expressing apperception and conveying the learning objectives. 80 % of the students were also good at conducting the core learning activities including the mastery of the material, suitability of the implementation of learning with the principles and characteristics of PMRI and lesson study, use of language, social sensitivity and personality.

Table 4. Recapitulation of the result of evaluation of conducting the learning

Component	Average score	Percentage
Initial activity	5	100%
Core Activity	4	80%
Ends Activity	4,25%	85%
Average total		88.3 %

Finally, 85% of the students were able to close the learning well, including concluding the lesson together with the pupils, having assessments with HOTs test questions, and conducting reflexes and follow up. Thus, 88.3% of the students already had a good ability to carry out learning.

The level of understanding of the students related to PMRI through lesson study was also evaluated by the researchers by conducting a final test. The students were given questions related to the understanding the PMRI principles and characteristics. They were also asked to tell in their own language about the lesson study and prepare a PMRI learning plan through lesson study in brief, individually. As a result, 87.5% of the students were able to answer the tests well.

The process of developing this learning environment could improve the pedagogical abilities of the pre-service primary school teacher. There were 86.25% of the students having the ability to plan the learning well and 88.3% of the students having the ability to carry out the learning well too. Likewise, 87.5% of the students understood PMRI and lesson study. Students could prepare the PMRI learning tools and implement these devices in class. The implementation of the design of the student learning devices in schools also showed good results. The use of lesson study as a learning system in this learning environment greatly helped the process of developing a learning environment get better results. This is because the lesson study ensures that every student gets the same opportunity in learning (Sato, 2014b). Students work in teams to create collaborative learning tools and each step in the lesson study helped them improve their pedagogical abilities (Coenders & Verhoef, 2019). Therefore, the researchers expect that the PMRI learning environment with lesson study can become part of the curriculum for the education of pre-service primary school teachers, especially in high-class mathematics learning course in order to improve the pedagogical knowledge of pre-service primary school teachers.

CONCLUSION

The development process in this study produced a learning environment with a Campus-School model (CS). The learning environment was in the form of the 1st training and 2nd training in campus

and implementation in school. The training consisted of PMRI and lesson study materials, two PMRI learning simulations through lesson study, discussion and making of learning tools, peer teaching, application of learning to lesson study model schools, final discussions, and tests. The PMRI learning environment through lesson study is valid, having practical criteria, and having a potential effect on improving pedagogical abilities of the pre-service primary school teachers.

ACKNOWLEDGEMENTS

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