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Developing RME-based lesson study for learning community in the learning environment of high school mathematics teachers

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Abstract

Teachers' academic and professional competencies significantly improve the quality of their learning. An ongoing process is needed to support and develop their quality. This study developed a learning environment through the Realistic Mathematics Education (RME)-based Lesson Study for Learning Community (LSLC) for high school mathematics teachers. The model is valid and practical and potentially affects the learning quality of high school mathematics teachers. The research employed a design research method of development studies was conducted in three stages: the preliminary stage, the development or prototyping stage, and the assessment stage. Prototyping development is a formative evaluation in which the phases include self-evaluation, expert review, one-to-one, small group, and field tests. The research subjects were 15 high school mathematics teachers from four schools in Palembang. Data was collected through questionnaires, observation, and documentation. The research has resulted in a valid and practical teachers' working group-learning community-class model that potentially affects high school, mathematics teachers. The learning environment is in the form of training in working groups for mathematics teachers, teacher mentoring in learning communities in schools, and teacher assessment learning processes in the classroom. The learning tools were produced using the RME-based LSLC system. The data analysis shows that the learning environment using the RME-based LSLC model can make high school mathematics teachers significantly understand learning, design learning tools, carry out learning, and evaluate learning. Consequently, the teachers' academic competence and professionalism significantly improve their learning.

Keywords: Design Research, Development Studies, Learning Environment, Lesson Study for Learning Community, Realistic Mathematics Education

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Improving the quality of education is still a significant challenge for Indonesian education. Although the government has made various efforts to overcome this problem, there have not been any encouraging results; for example, Indonesia's PISA trend from 2000 to 2018 is always below the OECD average (OECD, 2019). Apart from student performance, the results of the Teachers' Competency Test (TCT) in 2018 are also still below the standard, as shown in Table 1.

Indonesian students' PISA results and TCT results are related. Kayange and Msiska (2016) argue that the quality of education in a country is primarily influenced by individuals who implement curriculum programs and, in this case, are teachers.

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Table 1. 2018 TCT Results for Palembang City Teachers

No.	Region	Province	PS	MS	HC	VS	Academic	Professional	Mean
234	Palembang	South Sumatra	50.89	54.73	59.93	54.15	50.71	55.91	54.35

Based on the Law of the Republic of Indonesia No. 14 of 2005 Article 10 Paragraph (1), a teacher has four mandatory competencies: academic, personal, social, and professional competencies. Moreover, Podkhodova et al. (2020) argue that teachers must effectively apply the values of knowledge, life experience, expertise, personality, and professionalism. The results of the TCT in 2018, which are still below the standard, show that teachers have low competence. The Law of the Republic of Indonesia No. 14 of 2005 Article 7 Paragraph (1) concerning Teachers and Lecturers stipulated that getting the opportunity to develop professionalism is one of the principles of teachers to be considered professional. Consequently, a forum is necessary to support the development of teacher competencies. This article focuses on discussing academic and professional competencies.

In Japan, the development of teacher professional competence is oriented toward improving the quality of teaching and learning practices and is carried out through a Lesson Study (LS) (Giannakidou et al., 2013; Robutti et al., 2016). LS is described as a classroom inquiry model that requires teachers to work collaboratively to design lessons, implement lessons, observe the learning process, analyze student activities while studying, and improve classroom learning with a reflection process to improve teachers' teaching practices (Ogegbo et al., 2019). Since LS is related to collaborative attitudes between teachers, a teacher community can be established to share learning materials, design lessons, carry out teaching experiments, collect data for assessment, and discuss the results of the implemented learning (Lesson Study for Learning Community) (Robutti et al., 2016; Sato, 2014a, 2014b). In addition, in terms of academic competence, Zulkardi (2002) has revealed that the academic competence of mathematics teachers can be developed using RME.

Soleas' research (2022) states that there is a need to integrate approaches that promote innovation across disciplines, organizations and learning contexts in educational programs. Based on the description above, this research will develop a forum for high school mathematics teachers to develop pedagogical and professional competence. This development forum will form an RME-based LSLC learning environment with the teachers' working group-learning community-classroom (TLC) model consisting of three stages: the training phase, mentoring phase, and assessment phases. The IHT activities, workshops, LSLC training, and RME training are available in Indonesia but have not been followed- up and resulted in teachers' progress (Wulandari & Iriani, 2018; Mulbar et al., 2020; Khotimah, 2017). Therefore, the purpose of this study is to produce an RME-based LSLC learning environment with a valid and practical TLC model that potentially affects high school mathematics teachers' academic and professional competencies.

METHODS

This study employed a developmental research type of design research to develop the RME-based LSLC learning environment with the TLC model. This method enables this research the preliminary design stage and the formative evaluation stage (Gravemeijer & Cobb, 2013; Bakker, 2018). Figure 1 describes the flow of the developed learning environment.

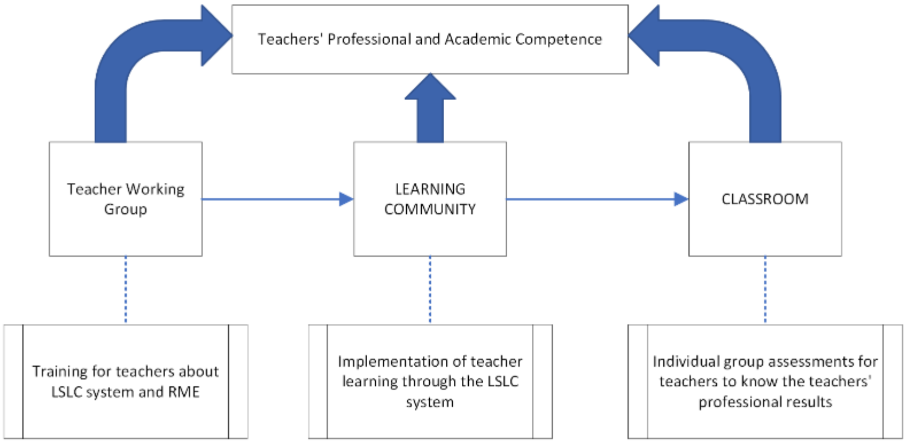


Figure 1. The flow of the TLC Model Learning Environment with Stages of Training, Mentoring, and Assessment (Rusiyanti et al., 2020)

Preliminary Design

At this stage, the researcher determined the research site, research subject, and research schedule. The research was conducted in four different high schools in Palembang City, namely SMA Negeri 1 Palembang, SMA Plus Negeri 17 Palembang; SMA Negeri 22 Palembang, and SMA Negeri Sumatera Selatan. The subjects of this study were 15 mathematics teachers from these four schools.

Formative Evaluation

To develop a valid and practical learning environment, the researchers conducted a formative study in the form of self-evaluation, expert and one-to-one reviews, small groups, and field tests (Zulkardi, 2002). The instruments of this research are presented in Table 2.

Table 2. Instruments in the Developed Learning Environment

Learning Environment	Phases	Instruments
Teachers' Working Group	Training	Questionnaire of initial concepts of LSLC and RME knowledge Questionnaire of satisfaction with training stage
Learning Community	Mentoring	Observation sheets of teacher learning planning Observation sheets of teacher learning implementation Questionnaire of satisfaction with assistance stage
Classrooms	Assessment	Observation sheet of teacher learning planning Observation sheet of teacher learning implementation Questionnaire of satisfaction with assistance stage

The instruments from a valid and practical learning environment were then implemented in the research subjects, namely 15 mathematics teachers at SMA Negeri 1 Palembang, SMA Plus Negeri 17

Palembang, SMA Negeri 22 Palembang, and SMA Negeri Sumatera Selatan.

Self-Evaluation

At this stage, the researcher reviewed the literature to improve the teachers' academic and professional competencies using RME-based LSLC. Moreover, this study investigated the implementation of this model in the learning process in the research sites. The researchers also examined the essential competencies in the 2013 curriculum to select appropriate content to develop a learning environment with the TLC model. This model developed the academic competencies of high school mathematics teachers. In addition, the researcher prepared the instruments needed at the training, mentoring, and assessment stages.

Expert Review

The expert validation process investigated the content, construct, and language of the prepared instruments referring to the TLC model. The results of the expert review were then used to revise all instruments.

One-to-One Review

Along with the expert review process, a one-to-one review was carried out, to individually test teachers' learning tools. The results of the one-to-one review were also used to revise the product. The expert review and one-to-one review aim to determine the validity of the learning environment.

Small Group

The prototype of this learning environment was then proposed at the small group stage by involving a small number of teachers (6-8 people) who were not the subject of the actual research. They were mathematics teachers who were not research subjects and came from different schools from the research subject. This stage determined the practicality of the designed learning environment. If the learning process in the learning environment could run effectively and produce good outcomes, the learning environment would be practical. Afterward, the learning environment was revised based on the results of the small group trial and the teacher's comments on the instrument for the training, mentoring, and assessment stages.

Field Test

The learning environment was then tested as the last stage in developing the learning environment. This stage was carried out at four high schools in Palembang City and involved 15 high school mathematics teachers from four schools. They were as the actual subjects of this study. In addition, the researchers involved students as the research subject during the research at school. This stage explored the potential effects of the learning environment using the TLC model on high school mathematics teachers.

RESULTS AND DISCUSSION

This study has developed a TLC model learning environment using an RME-based LSLC system for high school mathematics teachers. The implementation of the TLC model learning environment consists of three phases: training, mentoring, and assessment (TMA). The research results are described in two major stages: preliminary design and formative evaluation. Meanwhile, the formative evaluation comprises five stages: self-evaluation, one-to-one review, expert review, small group, and field test. Each phase will be described as follows.

Preliminary Design

The research was carried out in four different high schools in Palembang; they are SMA Negeri 1 Palembang, SMA Plus Negeri 17 Palembang, SMA Negeri 22 Palembang, and SMA Negeri Sumatera Selatan. The subjects of this study were 15 mathematics teachers from these schools. In the preliminary stage, the researcher reviewed the literature to improve the teachers' academic and professional competencies, including the literature on the LSLC learning system, RME, and various implementations in previous studies. Based on the results of the literature review, the researcher made an initial design of the prototype instrument to design a TLC model learning environment using the TMA stage. The results of the initial design were discussed with colleagues. The researchers developed the initial design of the TLC learning environment instrument through the TMA stage.

At the training stage, the researchers designed an initial questionnaire to determine the teachers' knowledge about the learning process using the RME-based LSLC system, their understanding of the system, and the implementation of the 2013 Curriculum. Afterward, the researchers prepared an observation sheet to plan and implement the learning following the RME-based LSLC at the mentoring stage. This instrument was used to determine the progress of each research subject towards the LSLC stages (planning, seeing, and redesigning). Meanwhile, the phase was only carried out by a model teacher and other research subjects as observers. Finally, the researcher prepared an observation sheet to assess the planning and implementation of learning following the RME-based LSLC stage for teachers and students at the assessment stage. This instrument was used to determine each teacher's academic and professional competencies and the students' performance at the LSLC stage. The researchers also prepared an instrument to assess the satisfaction of research subjects and students with the TLC model learning environment at the TMA stages. These data sources have enabled researchers to address teachers' pedagogical reasoning (Amador et al., 2022)

Formative Evaluation

The researchers conducted formative studies in the form of self-evaluation, expert review, one-to-one review, small groups, and field tests to develop a valid and practical learning environment (Zulkardi, 2002). The researchers also conducted a literature review to improve the teachers' competencies. Moreover, the implementation of the RME-based LSLC TLC model learning environment using the developed TMA stages helps the teachers become more professional.

Self-Evaluation

In the self-evaluation process, the researcher considered colleagues' suggestions to turn the 2013 Curriculum knowledge questionnaire into an observation sheet at the assessment stage. This step investigated the teacher's academic and professional competencies.

Expert Review

The learning environment instrument was evaluated by the experts. This process validated the content, construct, and language of the prepared instruments by referring to the TLC model learning environment. This study involved RME and LSLC experts, namely Dr. Meryansumayeka, M.Sc., a postgraduate program lecturer at Universitas Sriwijaya and Dr. Marheny Lukitasari, M.Pd who is a lecturer in the PGRI Madiun University.

One-to-One

Besides the expert review, prototype one was tested using the one-to-one review. This review was conducted by two mathematics teachers at SMA Negeri 8 Palembang in January 2019. Some parts from the expert review were changed by the one-to-one review. These parts include a questionnaire on initial concepts of RME and LSLC knowledge at the training stage as well as a questionnaire of academic and professional competency of teachers at the assessment stage.

Small Group

The valid learning environment instrument was tested on a small group of four teachers from SMA Negeri 8 Palembang in January 2019. Some changes were made based on the results of the small group. These changes added several statement points to the initial concept of RME and LSLC knowledge in the training phase

Field Test

The learning environment instrument used in the field test is the result of the revision from the small group stage. This instrument is considered valid and practical. The followings are the results of the valid and practical instrument. The TLC model learning environment employed in this research is as follows.

The training phase begins with distributing a questionnaire to assess the teachers' initial understanding of LSLC and RME. Table 3 describes the statement items in positive statements.

Table 3. Statement Items of Questionnaire of Teacher's Initial Understanding of LSLC and RME

Aspects	Indicators	Item Number
LSLC (A)	1. The concept of LSLC learning system	1, 2, 7, 8, 9, 10
	2. LSLC in mathematics learning	3, 6, 11
	3. LSLC in 2013 Curriculum	4
	4. LSLC in 21st century learning	5
RME (B)	1. RME concept	12, 13, 14
	2. RME in mathematics learning	15, 18
	3. RME in 2013 Curriculum	16
	4. RME in 21st century learning	17

Figure 2 shows that the teachers still do not understand the LSLC and RME. For this reason, teachers should have a common perception of LSLC and RME at the training stage.

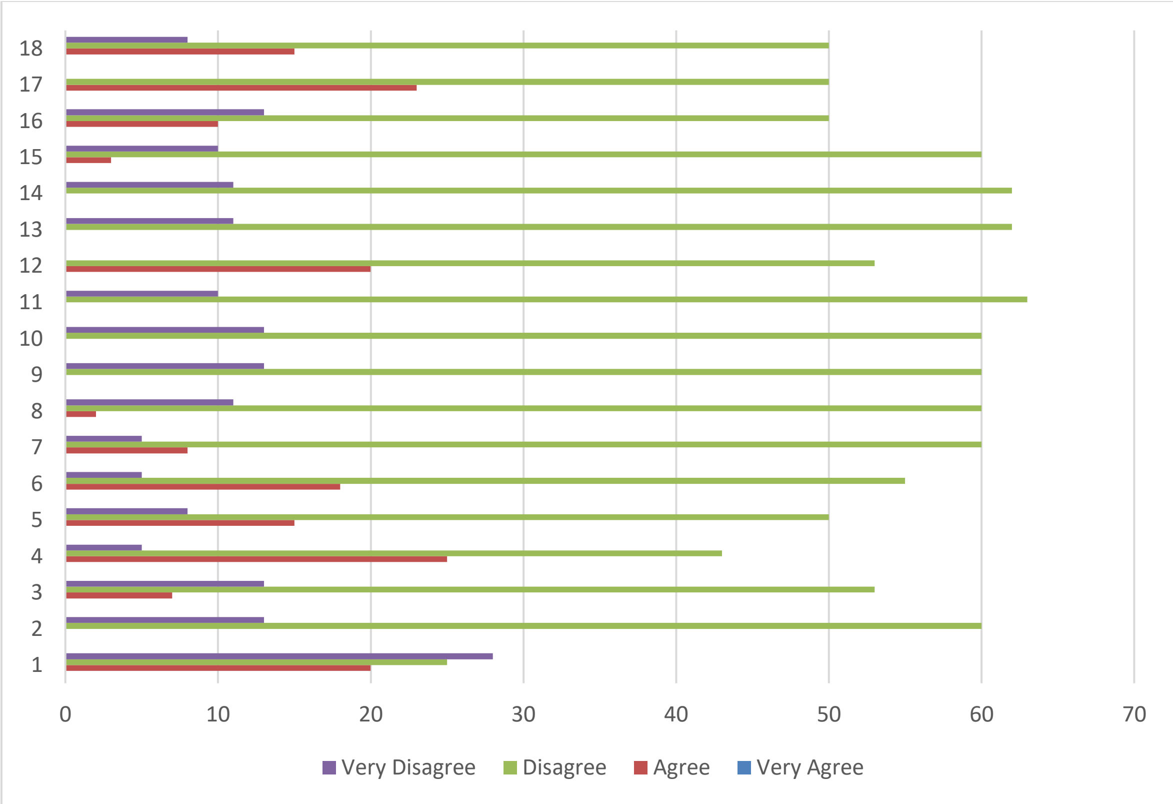


Figure 2. Results of the Teacher's Initial Understanding Questionnaire about LSLC and RME

After implementing training, the teachers' satisfaction with the given training was measured using a questionnaire. The statement items in the questionnaire on post-training satisfaction are in the form of positive statements, as summarized in Table 4.

Table 4. Statement Items in Questionnaire of Training Satisfaction

Indicator	Item Number
Training attractiveness	1, 5, 6, 7
Training Innovation	2
Training usefulness	3, 8, 9, 10
Training continuity	4

Figure 3 shows that most teachers agree that the provided training is new to them, and it is engaging, valuable, and sustainable. The mentoring stage is a follow-up stage from the training stage and is carried out for one year. The mentoring stage is conducted for teachers to simulate the RME-based LSLC learning system.

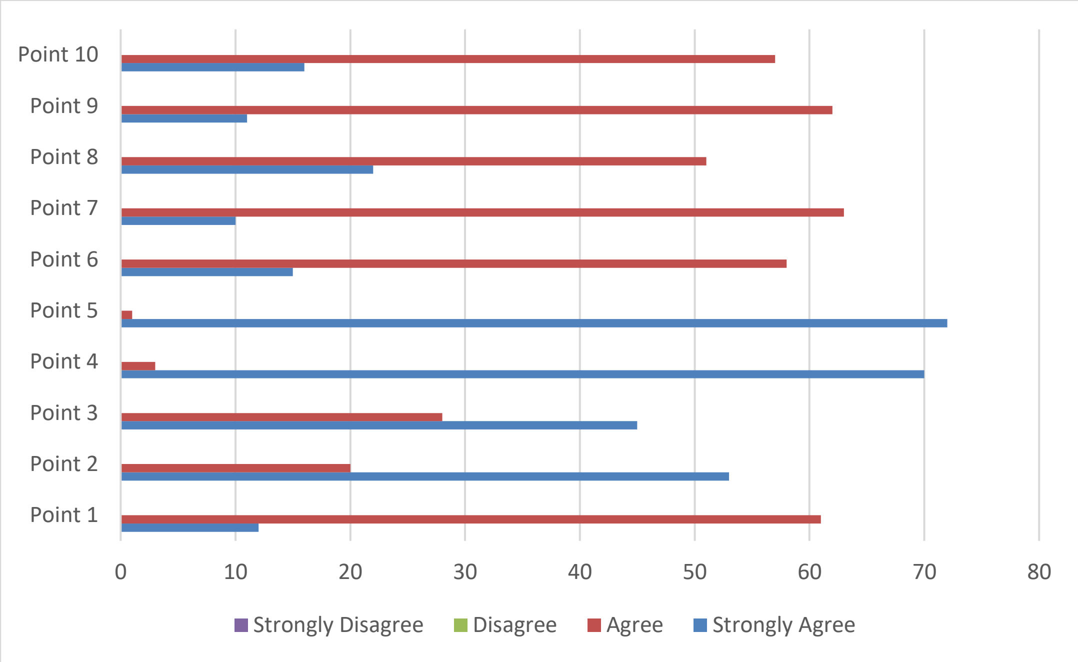


Figure 3. Results of Training Satisfaction Questionnaire

Samuelsson et al. (2022) state that simulation training helps teachers to prepare teaching material and become confident more effectively. The consideration of a one–year research refers to the results of Moser et al. (2022) who discover that during a one-year teacher professional development program, students' class participation can be enhanced. Meanwhile, the mentoring stage for the research subjects follows the LSLC phases: planning, doing, seeing, and redesigning. In each mentoring cycle, the teachers discuss the design of learning activities that will be carried out (plan) at the planning stage. One of these activities is preparing learning activities that will be presented to students. Learning activities will be in the form of student worksheets, consisting of sharing tasks to improve students' weak competencies and jumping tasks to help students think more critically and challenge overall learning improvement (Asari, 2017). Besides, enough challenges with support could develop and apply students' self-regulated learning (Lahdenperä et al., 2022). Open class learning is implemented by a model teacher (doing), reflecting on learning outcomes (seeing), and redesigning the teaching to improve (redesigning) (Sato, 2014a, 2014b). Bakker et al. (2022) state that meaningful reflection could develop students' ability to focus on the teachers.

The mentoring phase was closed by distributing a questionnaire of satisfaction to the research subjects. This questionnaire measured the research subjects' satisfaction with the one-year mentoring session. Table 5 summarizes the statement items in the form of positive statements.

Table 5. Statement Items of Questionnaire of Teachers' Satisfaction from Mentoring Phase

Indicators	Item Number
Mentoring attractiveness	1, 2
Mentoring usefulness	3, 4

Figure 4 shows the research subjects' satisfaction with the one–year mentoring session. Since all statements are positive, the research subjects perceive that the mentoring session is helpful for future teacher learning.

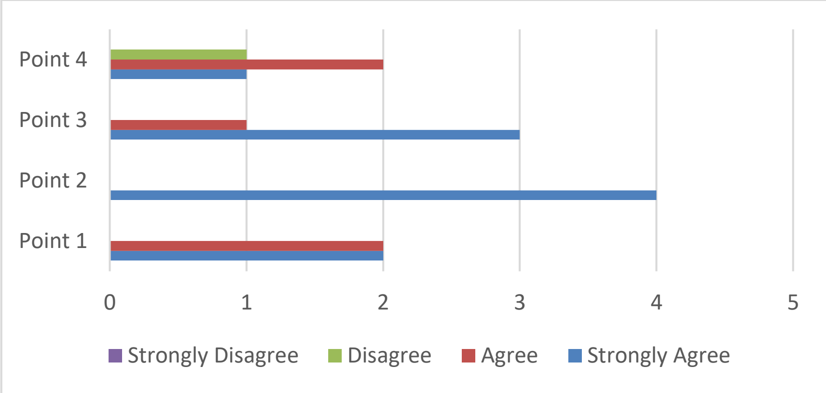
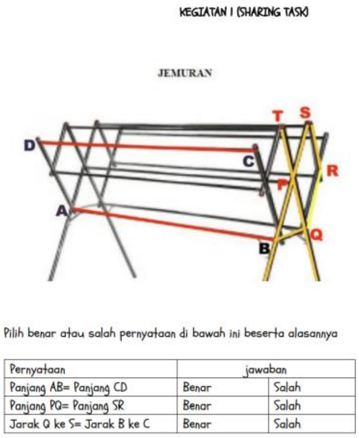


Figure 4. Results of Questionnaire of Research Subjects' Satisfaction with Mentoring Phase

At this stage, the teachers' progress, from designing, implementing, reflecting, to redesigning learning, was assessed. At the learning design stage (planning), the results of the teachers' lesson plans were assessed based on the component instrument of the learning planning assessment. Learning planning assessment is a tool to analyze lesson plans that fit the learning context. The researchers employed the Lesson Plan Analysis Protocol (LPAP) by Ndihokubwayo et al. (2022) to improve learning outcomes.



Choose true or false for the statements below and provide your reasons.

Statements	Reasons	
AB length = CD length	True	False
PQ length = SR length	True	False
Distance from Q to S = Distance from B to C	True	False

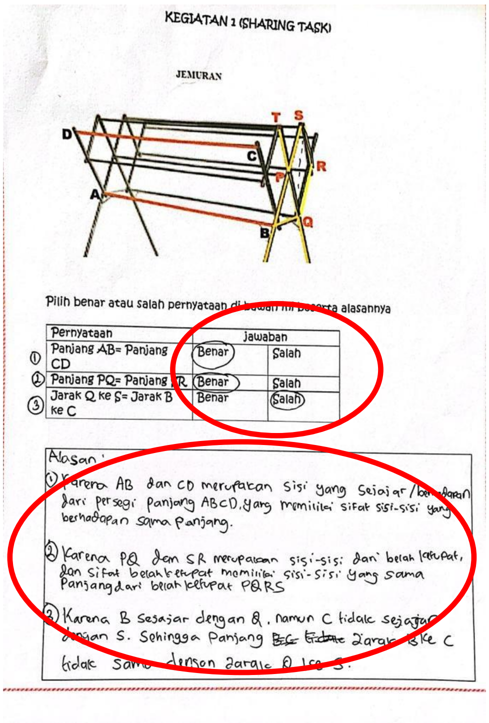
The picture of the roof terrace of a house, seen from the side, shows wooden pillars to support the roof of the building. These pillars connect one point of the building to another point of the roof plane. Determine the requirement of the minimum length of the wood and explain your reason!

Figure 5. Research Subjects' Worksheet Results for Topic of "Distance from a Point to a Plane"

The results are generally in a very good category with a score of 95. Furthermore, in the learning planning stage, the teachers have a very good category for formulating learning objectives with a score of 94. Moreover, they show a very good category of learning activities using essential competencies and achievement indicators, compliance with the RME-based LSLC learning system, and complete learning activities with a score of 92. In addition, the results of student worksheets and the student's answer sheets on the topic of "distance from a point to a plane" were designed by one of the research subjects.

Figure 5 explains the results of the share task worksheets that students do collaboratively and independently. Students succeed in answering correctly and giving the right reasons, marked by being able to analyze parallel lines in the given image.

However, in the jumping task, some students needed to understand that to determine the minimum length of wood to connect the sides of the building and one point on the roof plane, then the position of the wood must be perpendicular to the plane. It shows an understanding that it must be upright to determine the distance from the point to the plane much be perpendicular to the plane. One of the answers from students who succeeded in showing the achievement of the geometry learning indicators in three dimensions is represented in Figure 6.



Reasons:

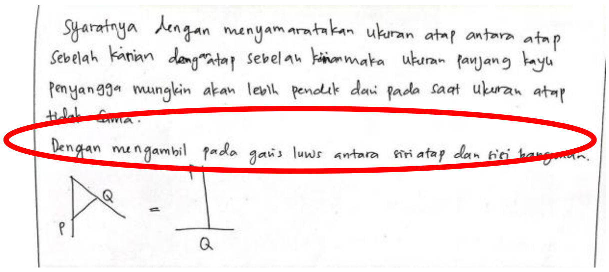
1. Because AB and CD have parallel sides or opposite sides of the rectangle, A, B, C, and D have opposing sides of similar lengths.
2. PQ and SR have sides of a rhombus. Moreover, the rhombus has a similar length of sides as those of the rhombus PQRS.
3. B is parallel to Q, but C is not parallel to S. Therefore, the distance from B to C is not the same as the distance from Q to S.

Students succeed in answering correctly and giving the right reasons

Figure 6. One Student's Answer for Sharing Task Worksheet

Furthermore, the problem of jumping task 2, which discusses students' understanding, is related to the building framework context to identify students' knowledge of learning parallel and perpendicular lines. One of the students' answers determined that students could show the properties and characteristics of parallel and perpendicular lines, as shown in Figure 7.

The researcher assessed how a model teacher implemented learning in an open class using the RME-based LSLC system. The assessment process was carried out based on three learning activities: preliminary, core, and closing activities. The initial action shows a very good category with a score of 95 and includes several activities, such as preparing students to learn, motivating them, conveying apperception, and conveying learning objectives to form groups consisting of four students sitting cross-legged. Furthermore, the core activities are categorized as very good with a score of 92 and include two activities: material mastery activities and learning conformity with the RME-based LSLC system. Finally, the closing activities have obtained very good results with a score of 100 and included actions to facilitate students to conclude learning, assessments, reflection, and follow-up.



The minimum length of the wood could be revealed by equalizing the right and left roof sizes. The length of the wooden pillars may be shorter than the roof sizes. The straight lines between the side of the roof and the side of the building are not equal.

Figure 7. One Student's Answer for Jumping Task Worksheet

The results of observing the learning process of the teachers and students were submitted at the seeing stage. Table 6 concludes the results of observing the learning activities of the model teachers and students. The results of the teachers' reflection from the seeing stage were then utilized to revise the material and redesign the learning. The observation results of this research are equal to those of Kager et al. (2022), who state that the lesson study group is significantly more profound in the reflection process.

Table 6. Conclusion of Observation on Students' Learning Activities

Observation Components	SMA Negeri 22 Palembang	SMA Negeri Sumatera Selatan	SMA Plus Negeri 17 Palembang	SMA Negeri 1 Palembang
Positive activities	Students perform excellent collaboration.	Students help each other in group discussions, especially when group members have difficulty.	Students help each other in group discussions, especially when group members have difficulty.	The model teacher appreciates the students who actively express their ideas and opinions.
Negative activities	The teacher does not make a learning agreement so that the discussion is noisy.	Some students still copy the work of their group mates	The jumping task worksheet takes a long time.	Some students just wait for the answers of their group mates.
Pedagogic Competence of Model Teachers	There is no visible component of potential development to overcome students' deficiencies.	There is no visible component of potential development to overcome students' deficiencies.	There is no visible component of potential development to overcome students' deficiencies.	There is no visible component of potential development to overcome students' deficiencies.
Pedagogic Competence of Model Teachers	All components are visible.	There is no component to develop learning materials from various references and improve the use	There is no component to develop learning materials from various references and improve the use of learning assessment	There is no component to develop learning materials from various references and improve the use of learning

	of learning assessment results for remedial and enrichment.	results for remedial and enrichment.	assessment results for remedial and enrichment.

Figure 8 discusses student activities when collaborating in groups to complete the share task worksheet, in which some students still need clarification about understanding the questions. Next, the student asks for help from her group of friends to re-explain the question, and then the student understands her friend's explanation until she looks enjoyed and can continue the jumping task.

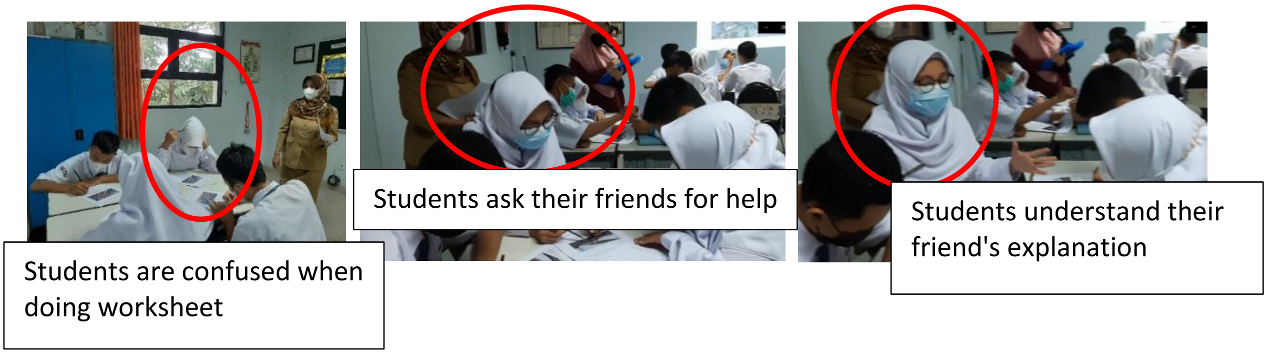


Figure 8. Students Learning Observation

In general, the training and mentoring stages are beneficial for teachers' future learning. This finding indicates that this learning environment has met the first level of evaluation development of Guskeys (2016), namely participant satisfaction. The teacher's learning plans, and students' worksheets have denoted that the teachers could design and implement learning using the RME-based LSLC system with the second level of development evaluation of Guskeys (2016), namely participant learning. The development of this learning environment is also supported by each school, which has fulfilled the third level category of development evaluation of Guskeys (2016), namely organizational support and changes.

During the implementation of learning, the teachers applied the obtained knowledge to plan the lesson, implement and observe learning, reflect the learning, and redesign learning. The results of observing learning planning assessment, evaluation of learning implementation abilities, and pedagogical and professional competencies of teachers show that the developed learning environment using the RME-based LSLC TLC model has met the fourth level of development evaluation of Guskeys (2016), namely the use of participants' new knowledge and skills.

The students' answers on the worksheet signify that they have reached indicators of competency achievement for the topic of distance from a point to a plane. In addition, after the learning, the model teachers conducted short interviews with the students regarding learning reflections, and their excitement with the learning. They deliver that they could easily understand the learning because it links to daily life. These results indicate the fulfillment of the fifth level 5 of the evaluation of Guskeys (2016), namely student learning outcomes. This result is also supported by Carmona-Medeiro et al. (2021) and Gargrish et al. (2020), who discover that learning geometry that actively involves students gives satisfactory results. In addition, students do not experience significant problems when learning using the RME-based LSLC learning system because they have been accustomed to this system during the mentoring phase for one year. This finding is in line with de Vries et al. (2022), who have revealed that teachers' professional development positively impacts students' learning outcomes.

The TLC model learning environment with the developed RME-based LSLC system has met valid and practical criteria and potentially affects high school mathematics teachers. This study developed the learning environment model using a developmental research design. This research method enabled this study to conduct the preliminary design stage and the formative evaluation stage (Gravemeijer & Cobb, 2013). At the preliminary design stage, the researcher determined the research site, research subject, and schedules for conducting the research and the literature review to improve teachers' academic and professional competence. Based on the results of previous studies, the researchers conclude that the academic and professional competence of teachers could be strengthened using the LSLC system and RME approach (Giannakidou et al., 2013; Robutti et al., 2016; Zulkardi, 2002). Based on the analysis results, the researchers proceed to the design stage. The researchers have designed the learning environment instruments following the TMA stages.

At the self-evaluation stage, the researchers independently evaluated the learning environment instruments design. The independent evaluation results, called prototype one, were validated at expert review and one-to-one stages.

Prototype one was then validated by the experts of the LSLC learning system and the RME approach. Meanwhile, in the one-to-one stage, prototype one was tested to gain readability. The result of validation by experts and one-to-one stages shows that the instruments are suitably used for the revisions. Some parts changed, including a questionnaire on initial concepts of knowledge RME and LSLC at the training stage and a questionnaire on teachers' academic and professional competencies at the assessment stage. The researchers improved prototype one by considering comments and suggestions. The results of upgrading prototype one is considered valid, and these results are called prototype two, which were tested to gain practicality data at the small group stage.

In the small group stage, the instruments of the TLC model learning environment in prototype two were tested by four teachers from SMA Negeri 8 Palembang to explore the practicality of prototype two. Some changes were made based on the results of the small group. These results added several statement points to the initial concept of RME and LSLC knowledge in the training phase. Afterward, the researchers improved the comments at the small group stage. The result of improving prototype 2 is called prototype 3 and has been declared valid and practical.

The instruments of the TLC model learning environment in prototype 3 were tested by 15 subjects at the field test stage. At the field test stage, the subjects participated in the TMA training. At the beginning and end of the training phase, the teachers were given a questionnaire to measure their initial knowledge of LSLC and RME (beginning) and assess their satisfaction with the training phase (end). Furthermore, teachers' learning plans and students' worksheets were assessed during the mentoring phase. In addition, the teachers' learning was also observed. Finally, in the assessment phase, the teachers' learning plans, the students' worksheets, the teachers' teaching results, and the students' learning results were assessed and observed. Then, all data on the instruments were employed to determine potential effects of the learning environment.

CONCLUSION

This research has produced a TLC model learning environment using a valid, practical RME-based LSLC system that potentially affects mathematics teachers and high school students. The TLC model of the learning environment consists of three systematic phases: training, mentoring, and assessment phases. The stages are implemented to equalize the teachers' perceptions of the LSLC and RME learning system concepts. Furthermore, a mentoring stage is conducted for one year to help mathematics teachers learn using the RME-based LSLC system. Finally, an assessment is carried out to explore the progress and development of the teachers' academic and professional competencies.

These results provide alternative solutions to the RME-based LSLC system for teacher training activities. These results potentially affect mathematics learning activities carried out in post-training by teachers. This training was conducted to make the learning activities more contextual and closer to daily life. These learning activities are proven effective and have increased mathematics teachers' academic and professional competencies to apply the curriculum in Indonesia.

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Declarations

Author Contribution	:	RHR: Conceptualization, Writing - Original Draft, Formal analysis, Editing and Visualization; and Writing - Review & Editing Z: Writing - Review & Editing, Validation, and Supervision RIIP: Writing - Review & Editing, Formal analysis, Validation, and Supervision S: Validation and Supervision
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Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	Additional information is available for this paper.

REFERENCES

Amador, J. M., Rogers, M. A. P., Hudson, R., Phillips, A., Carter, I., Galindo, E., & Akerson, V. L. (2022). Novice teachers' pedagogical content knowledge for planning and implementing mathematics and science lessons. *Teaching and Teacher Education, 115*, 103736. https://doi.org/10.1016/j.tate.2022.103736

Asari, S. (2017). Sharing and jumping task in collaborative teaching learning process. *Didaktika: Jurnal Pemikiran Pendidikan, 23*(2), 184-188. https://doi.org/10.30587/didaktika.v23i2.28.

Bakker, A. (2018). *Design Research in Education*. In Design Research in Education. https://doi.org/10.4324/9780203701010

Bakker, C., de Glopper, K., & de Vries, S. (2022). Noticing as reasoning in Lesson Study teams in initial teacher education. *Teaching and Teacher Education, 113*, 103656.

https://doi.org/10.1016/j.tate.2022.103656

Carmona-Medeiro, E., Antequera-Barroso, J. A., & Domingo, J. M. C. (2021). Future teachers' perception of the usefulness of SketchUp for understanding the space and geometry domain. *Heliyon*, *7*(10), e08206. https://doi.org/10.1016/j.heliyon.2021.e08206

de Vries, J. A., Dimosthenous, A., Schildkamp, K., & Visscher, A. J. (2022). The impact on student achievement of an assessment for learning teacher professional development program. *Studies in Educational Evaluation, 74*, 101184. https://doi.org/10.1016/j.stueduc.2022.101184

Gargrish, S., Mantri, A., & Kaur, D. P. (2020). Augmented reality-based learning environment to enhance teaching-learning experience in geometry education. *Procedia Computer Science, 172*, 1039-1046. 10.1016/j.procs.2020.05.152

Giannakidou, E., Gioftsali, K., & Tzioras, E. (2013). The reflective action of prospective teachers when implementing an appied version of the lesson study model. *Hellenic Journal of Research in Education, 1*, 30-58. http://ejournals.epublishing.ekt.gr/index.php/hjre/article/view/8791/9012.

Gravemeijer, K., & Cobb, P. (2013). *Educational Design Research*. Netherlands Institute for Curriculum Development: SLO, 1–206. http://www.eric.ed.gov/ERICWebPortal/recordDetail?accno=EJ815766

Guskeys, T.R. (2016). Gauge impact with 5 levels of data. *JSD The Learning Forward Journal, 37*(1), 32-37.

Kayange, J. J., & Msiska, M. (2016). Teacher education in China: Training teachers for the 21 st century. www.tojned.net

Kager, K., Jurczok, A., Bolli, S., & Vock, M. (2022). “We were thinking too much like adults”: Examining the development of teachers’ critical and collaborative reflection in lesson study discussions. *Teaching and Teacher Education, 113*, 103683. https://doi.org/10.1016/j.tate.2022.103683

Khotimah, R. P. (2017). Pakom pelatihan dan pendampingan penyusunan perangkat pembelajaran matematika berbasis lesson study [Pakom training and assistance in the preparation of lesson study-based mathematics learning tools]. *Warta LPM, 20*(1), 24–31. https://doi.org/10.23917/warta.v19i3.2854

Lahdenperä, J., Rämö, J., & Postareff, L. (2022). Student-centred learning environments supporting undergraduate mathematics students to apply regulated learning: A mixed-methods approach. *The Journal of Mathematical Behavior, 66*, 100949. https://doi.org/10.1016/j.jmathb.2022.100949

Moser, M., Zimmermann, M., Pauli, C., Reusser, K., & Wischgoll, A. (2022). Student's vocal participation trajectories in whole-class discussions during teacher professional development. *Learning, Culture and Social Interaction, 34*, 100633

Mulbar, U., Minggi, I., & Zaki, A. (2020). Meningkatkan kompetensi profesional guru dengan pelatihan pembelajaran matematika realistik [Improving the professional competence of teachers with realistic mathematics learning training]. *Dedikasi, 22*(1), 85–89. https://doi.org/10.26858/dedikasi.v22i1.13828

Ndihokubwayo, K., Byukusenge, C., Byusa, E., Habiyaremye, H. T., Mbonyiryivuze, A., & Mukagihana, J. (2022). Lesson plan analysis protocol (LPAP): A useful tool for researchers and educational evaluators. *Heliyon, 8*(1), e08730. https://doi.org/10.1016/j.heliyon.2022.e08730

OECD. (2019). *PISA 2018 Results* (Volume I): Vol. I. https://doi.org/10.1787/5f07c754-en

Ogegbo, A. A., Gaigher, E., & Salagaram, T. (2019). Benefits and challenges of lesson study: A case of teaching physical sciences in South Africa. *South African Journal of Education, 39*(1), 1–9. https://doi.org/10.15700/saje.v39n1a1680

Podkhodova, N., Snegurova, V., Stefanova, N., Triapitsyna, A., & Pisareva, S. (2020). Assessment of mathematics teachers' professional competence. *Journal on Mathematics Education, 11*(3), 477–500. https://doi.org/10.22342/jme.11.3.11848.477-500

Robutti, O., Cusi, A., Clark-Wilson, A., Jaworski, B., Chapman, O., Esteley, C., Goos, M., Isoda, M., & Joubert, M. (2016). ICME international survey on teachers working and learning through collaboration: June 2016. *ZDM - Mathematics Education, 48*(5), 651-690. https://doi.org/10.1007/s11858-016-0797-5

Rusiyanti, R. H., Zulkardi, Z., & Putri, R. I. I. (2020). The 3P model with lesson study for learning community (LSLC) in the professional development of mathematics teachers on three-dimensional shape material. *Journal of Physics: Conference Series, 1663*(1), 012026. https://doi.org/10.1088/1742-6596/1663/1/012026

Samuelsson, M., Samuelsson, J., & Thorsten, A. (2022). Simulation training-a boost for pre-service teachers' efficacy beliefs. *Computers and Education Open, 3,* 100074.

Sato, M. (2014a). *Dialog dan Kolaborasi Sekolah Menengah: Sebuah Praktek Komunitas Belajar [Middle School Dialogue and Collaboration: A Learning Community Practice]*. Jakarta: Pelita-JICA.

Sato, M. (2014b). *Mereformasi Sekolah: Konsep dan Praktek Komunitas Belajar [Reforming Schools: The Concept and Practice of Community Learning]*. Jakarta: Pelita-JICA

Soleas, E. K. (2022). Conditional knowledge and debugging strategies help overcome creative endeavours' costs: Can we use successful innovators' tactics for innovation education?. *Journal of Creativity*, 100028. https://doi.org/10.1016/j.yjoc.2022.100028

Wulandari, M. R., & Iriani, A. (2018). Pengembangan modul pelatihan pedagogical content knowledge (PCK) dalam meningkatkan kompetensi profesional dan kompetensi pedagogik guru matematika SMP [Developing pedagogical content knowledge (PCK) training modules in improving professional competence and pedagogic competence of middle school mathematics teachers]. *Kelola: Jurnal Manajemen Pendidikan, 5*(2), 177–189. https://doi.org/10.24246/j.jk.2018.v5.i2.p177-189

Zulkardi. (2002). Developing a learning environment on realistic mathematics education for indonesian student teacher. *Doctoral Dissertatio*n. Enschede: University of Twente.