

Development of e-LKM for Elementary School Mathematics Learning as an Open-Ended Problem-Based Teaching Material using MiKIR Approach

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ABSTRACT

Active learning demands teaching materials that engage and motivate pupils. E-LKM is an active learning material because of this. This study develops e-LKM mathematics learning courses based on open-ended problems assisted by the LIMIT application using the MiKIR approach and describes the trial results. This e-LKM is developed using 4D models: define, design, create, and distribute. The study included University of Muhammadiyah Prof. Dr. HAMKA primary school teacher candidates. Students of UIN STS Jambi madrasah ibtidaiyah professors will test the product. Validation and practical instruments are utilised. The defined step produces the e-LKM's mathematical learning needs, including student indicators and targets. After the design stage, the mathematics learning e-LKM has a title, group name column, directions for use, lecture objectives and achievements, questions, answer columns, conclusions, and reflections. After development, the validation instrument for e-LKM was 77.33% material, 80.00% language, and 76.92% media, putting it in the correct category. Practicality instruments scored 83.76%, indicating e-LKM is practical. The distribution step will yield student and instructor opinions on e-LKM's practicality. This study suggests lecturers use LIMIT to create e-LKM and use it in learning. Research can also create an open-ended problem-based MiKIR e-LKM for additional materials.

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1. INTRODUCTION

There are so many problems in learning, including in learning mathematics, that it causes learning objectives to be challenging to achieve. (Bobyliiev & Vihrova, 2021) found several problems in learning, including errors in strategy selection, choosing learning approaches, availability of teaching materials and learning media, and inappropriate time effectiveness. The problem that is the root cause of the difficulty in achieving learning objectives is an error in choosing an approach or strategy in learning (Simbolon,

2014). The approach will be a reference or guideline for the learning process (Lutvaidah, 2016). Active learning is the process of making students the center of their learning (Peterson, 2001). A learning approach that can help achieve learning objectives is active learning.

Various studies have studied the application of various active learning models, including active learning designs with metacognitive strategies. Active learning collaboration and metacognitive strategies make students actively communicate and interact with peers and improve metacognitive skills in understanding and mastery of mathematical concepts (Abu Bakar & Ismail, 2020). Then, active learning research has been carried out using debate strategies. The research results allow students to develop knowledge acquisition skills, think and act strategically, understand the context and speak without preparation (Woods, 2020). Active learning stimulates higher-order cognitive processes such as reasoning, critical thinking, and analysis (Fatmawati et al., 2021). Active learning involves students' activities, stimulates higher order thinking, problem-solving, reasoning, and critical analysis, and provides teachers and students feedback about the learning process. The benefits of active learning are also related to exploring student attitudes, values, and habits and can increase students' motivation to learn and improve their abilities (Gleason et al., 2011). Active learning that is popular and growing in Indonesia is MiKIR.

MiKIR is an active learning approach initiated by the Tanoto Foundation in 2018. The creation of the MiKIR approach aims to put existing approaches into practice so that in learning the teacher has no difficulties in the active learning process (Muhammad F& Rusilowati, 2020). This approach invites students to learn creatively, work in groups, and be critical during the learning process (Prastyo E, 2021). MiKIR stands for Experiencing, Interaction, Communication, and Reflection (Prastyo E, 2019; Rusilowati A, Supriyadi, Pangestu MH, 2022). This MiKIR approach has also been widely studied in various studies, including research on needs analysis of student worksheets based on MiKIR on the theme of always being energy efficient, which describes the level of need for MiKIR-based LKS reaching 85% (suhandi, Pamela, Oktavia, Mubarok, & Amri, 2020). The "MiKIR" learning approach will add variations to learning that are more interesting and fun, involve students, increase student activity and cooperation, and when learning is given worksheets to find out how far students understand the material presented by the teacher.

In learning activities, the presentation of learning materials must be able to motivate students and lead to activities so that students play an active role in the learning process. Realizing active learning requires teaching materials that can activate students. Teaching materials are arranged excitingly and systematically, containing material content, methods, and learning outcomes to achieve the expected competencies to motivate students to study actively and independently (Mardia & Sundara, 2020). One of the teaching materials that can be used is student worksheets, which will be referred to as LKM in the future. LKM is a form of teaching material that can help students understand lecture material. According to (Danial & Sanusi, 2018), LKM is one of the learning media that contains guidelines for investigation or problem-solving activities. Based on this, it can be seen that the LKM has an important function and role in the learning process, which is in line with the function of the LKM. According to (Prastowo, 2011), the primary function of the LKM is teaching materials that can activate students and assist the role of educators in the learning process. Worksheets as a support in improving students' critical thinking skills and creative thinking abilities (Mardita M, Alim JS, Hermita N, Wijaya TT, 2022). Therefore, the design and content of the LKM must be considered and adapted to the function of its use.

Today, the presentation of LKMs continues to grow and can even be developed on an electronic or e-LKM basis. This e-LKM presentation is a problem that must be solved to stimulate students' thinking. Problems in e-LKM can be presented in two forms: open-ended and closed-ended. (Zan, Wu, Guo, & Yu, 2020) suggest that open-ended problems require much cognitive effort compared to closed-ended problems, which provide room for more information. (Nisa. R & Zulyanty, 2021) also stated that non-single methods or solutions could solve open-ended problems, and the solutions found can be varied (non-single solutions). This open-ended problem affects the students' ability to solve daily problems (Bahar & June Maker, 2015). According to (Lin & Lien, 2013), open-ended problems have the advantage

that in solving open-ended problems, students can show more and more complex abilities than solving closed-ended problems.

The fact that was found from the results of initial observations on mathematics learning courses at the PGMI Study Program, Faculty of Tarbiyah, and Teacher Training at UIN STS Jambi, showed that there were weaknesses in students' mathematical abilities. It can be seen in the inability of students to find patterns in solving mathematical problems, so it is not easy to draw conclusions related to mathematical ideas. From the test results, only about 22% of students can solve math problems, and the rest of the students have not been able to solve the problems well. Furthermore, based on further analysis related to learning media in mathematics courses at the PGMI Study Program, Faculty of Tarbiyah, and Teacher Training at UIN STS Jambi, which lecturers had used, it was found that only simple LKMs were used. The LKM is only in the form of sheets that tend to be informative, have simple illustrations, and only contain practice questions. So that students find it challenging to develop their knowledge.

This e-LKM is made using the LIMIT application, namely online Mathematical worksheets. This application is an application designed and created by researchers in this study. The advantage of this application is that mathematical tools can be used to write mathematical formulas in writing questions and answering questions. Of course, this e-LKM will be combined with MiKIR's active approach and questions in e-LKM based on open-ended problems.

Based on these observations, it is appropriate to research the collaboration of the MiKIR approach with open-ended problems in the form of e-LKM in mathematics learning courses assisted by the LIMIT application. This study aims to develop e-LKM for mathematics learning as teaching materials based on open-ended problems with the help of valid and practical LIMIT applications by utilizing the MiKIR approach. To achieve the research objectives, the discussion in this study is divided into two, namely:

- (1) How is the development of an e-LKM for mathematics learning as a teaching material based on open-ended problems assisted by the LIMIT application utilizing the MiKIR approach?
- (2) How is the e-LKM trial for mathematics learning courses as teaching materials based on open-ended problems assisted by the LIMIT application utilizing the MiKIR approach?

The innovation in this research lies in the e-LKM for learning mathematics, which includes components of the MiKIR stages on each question in the form of open-ended problems with the help of the LIMIT application. The findings of this kind of research will also further popularize MiKIR learning and the LIMIT application among educators in the world, especially in Indonesia.

2. METHODS

2.1 Research Design

This research was conducted using a research and development paradigm. It is because the research results are a product that is expected to be valid and practical. The research and development model used is 4D (four-D models). According to (Thiagarajan, Semmer, I, & Semmel, 1974), 4D models (four-D models) consist of the following: Define, Design, Develop, and Disseminate. The dissemination stage is carried out on a limited scale, namely other classes or universities, according to the needs of researchers. The university where the dissemination was carried out was Universitas Muhammadiyah Prof. Dr. HAMKA.

2.2 Participant

The subjects in this study were student candidates for elementary school teachers at Muhammadiyah University, Prof. Dr. HAMKA. However, before that, the product will be tested first on prospective students of Madrasah Ibtidaiyah teachers at UIN Sulthan Thaha Saifuddin Jambi.

2.3 Instrument

The instruments used in this study align with the research objectives, namely to produce valid and practical products. So that the instrument used in general consists of two things: the instrument of validation and the instrument of practicality. The validation instrument helps determine the validity of the designed e-LKM. The validation sheet contains assessment aspects which include content validity, construct validity, language, and e-LKM display. The practicality instrument is used to collect practicality data from the e-LKM; this instrument consists of a lecturer response questionnaire and a student response questionnaire to obtain lecturer responses and student responses to the practicality of using the developed e-LKM. Lecturers and students filled out this questionnaire after learning using e-LKM open ended.

2.4 Procedure

This research and development follow a 4D model consisting of four steps: define, design, develop, and disseminate, as shown in Figure 1. Define, in the define stage, the researcher establishes, understands, and defines all the requirements for designing the LKM and analyzing the lecture process. at this early stage, discussing with the research team and lecturers who teach mathematics courses in the Madrasah Ibtidaiyah teacher education study program at UIN Sulthan Thaha Saifuddin Jambi and Prof. University. Dr. HAMKA regarding the MiKIR approach in ongoing lectures, questions based on open-ended questions given by lecturers to students, and mathematical applications that lecturers have used in daily lectures.

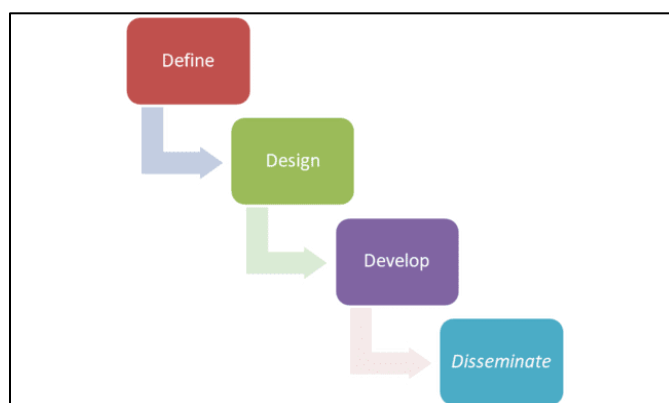


Figure 1. 4D model research steps.

At this stage, the researcher prepares an initial design for the e-LKM by choosing the format and production of the first version of the e-LKM based on the results of the discussion and analysis in the define phase. Develop at the development stage; it will produce an e-LKM product that has been revised based on the results of validators from material, language, and media experts. The step at this stage is validation by experts; experts have given suggestions, then the validation results are used as a guide to making revisions. Then, a limited group trial at UIN Sulthan Thaha Saifuddin Jambi will be carried out after revisions. At this dissemination stage, the e-LKM will be disseminated to other classes, namely classes at Prof. University. Dr. HAMKA. At this stage, it will produce responses from students and lecturers about the practicality of using e-LKM.

2.5 Data Analysis

Data from all instruments were analyzed using descriptive statistics to get the average percentage value. Data analysis techniques consist of validity data analysis and practical data analysis.

This data is obtained from the results of filling out the instrument, which is compiled using a Likert scale so that later a score will be obtained for each item. Finally, from the average value of the percentage, conclusions will be drawn for each analysis.

3. FINDINGS AND DISCUSSION

3.1 e-LKM Development

The results of the research and development of e-LKM using the open-ended problem-based MiKIR approach used in Mathematics learning are described based on the research and development syntax based on the 4D model. The PGMI study program's curriculum contained in the National Qualifications Framework-based Curriculum (abbreviated as KKN) states that the MI/SD Mathematics learning course is one of the courses that PGMI students must follow as prospective MI/SD teachers. This course should be about materials and concepts basics, mathematics, and integrating mathematics material (content) with its methodology while integrating it with ways of teaching mathematics for the MI/SD level. To fulfill the description of mathematics learning, lecturers must be skilled in practicing active learning in the classroom so that students are familiar with the habituation of the application of active learning. One of the active learning methods that can be applied in the classroom is the MiKIR approach. The MiKIR approach is able to provide learning meaning for students because it connects the knowledge acquired with the environment so that students' reasoning abilities can be improved (Mahmud Alpusari, dkk, 2020). With the MiKIR approach, each student is invited to be directly involved and more active in the teaching and learning process in class to develop their learning potential better (Jeanne Miera Mangangantung, 2021). MiKIR's approach can collaborate with the usual models or strategies in mathematics learning, for example, open-ended. It can be integrated into the form of an open-ended e-LKM based on the MiKIR approach in collaboration with open. Therefore, researchers developed an open-ended e-LKM based on Thinking, which resulted in e-LKM being easily accessible by students and could be used to solve open-ended problems in learning mathematics.

3.2 Define

The researcher with a lecturer in mathematics at the Madrasah Ibtidaiyah Teacher Education study program at UIN Sulthan Thaha Saifuddin Jambi and a lecturer in the Elementary School Teacher Education Study Program at the University of Prof. Dr. HAMKA discusses what is needed to design an e-LKM with an open-ended problem-based MiKIR approach as follows: analyzing the material and the objectives of the lecture, in the mathematics learning course consisting of a rhombus, kite, number operations, fractions, number recognition, presentation of data, squares, and rectangles, and units of weight. The needs of the e-LKM for learning mathematics that are discussed are the indicators and objectives students in the e-LKM achieve.

3.3 Design

In this design stage, the researcher designed an e-LKM for mathematics learning. The components in this e-LKM are the e-LKM title, group name column, instructions for use, lecture objectives and achievements, questions, answer columns, conclusions, and reflections. In this study, the use of e-LKM using the LIMIT application. The LIMIT app is an Online Mathematical worksheet app designed by the research team. The LIMIT application can now be accessed online based on a website. The advantages of the application compared to existing worksheets such as Liveworksheets, quizizz, Kahoot, etc. are that LIMIT can be used easily (user friendly), designs can be made according to the author's wishes without being limited, supporting files can be in the form of doc, pdf, and jpg. The application contains mathematical tools that can be used when writing questions and answering questions. The advantages of mathematical tools when answering questions are the central point for researchers to create this application because researchers find it difficult to find applications that

contain mathematical tools when answering questions. Most existing applications only have mathematical tools in the section for making questions. This is urgent because researchers create an open-ended problem-based e-LKM that requires students to answer questions by describing the correct answers and various forms of appropriate solutions.

The stages in designing this application are problems that arise when researchers want to use existing worksheets. However, researchers do not find mathematical tools to answer questions because the form of questions presented is in the form of essays. Then the researchers designed an application that contained mathematical tools for writing and answering questions. This application can also upload questions that the author has designed, or the author can write directly on the application. On the first page of this application, there is a username and password column, then log in, and users who have not registered can click on the words "Create an account."

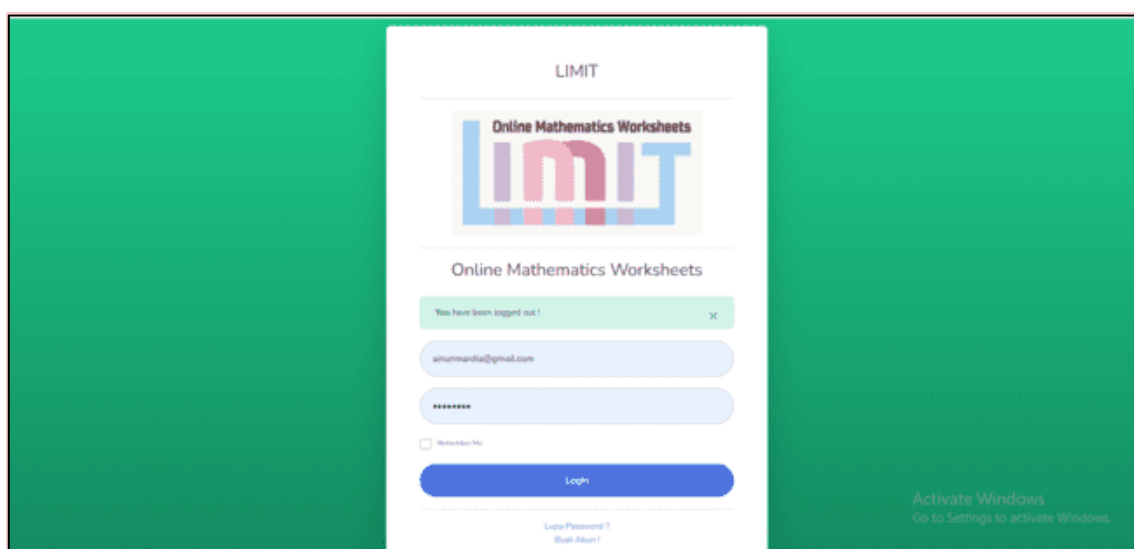


Figure 2. Login page view

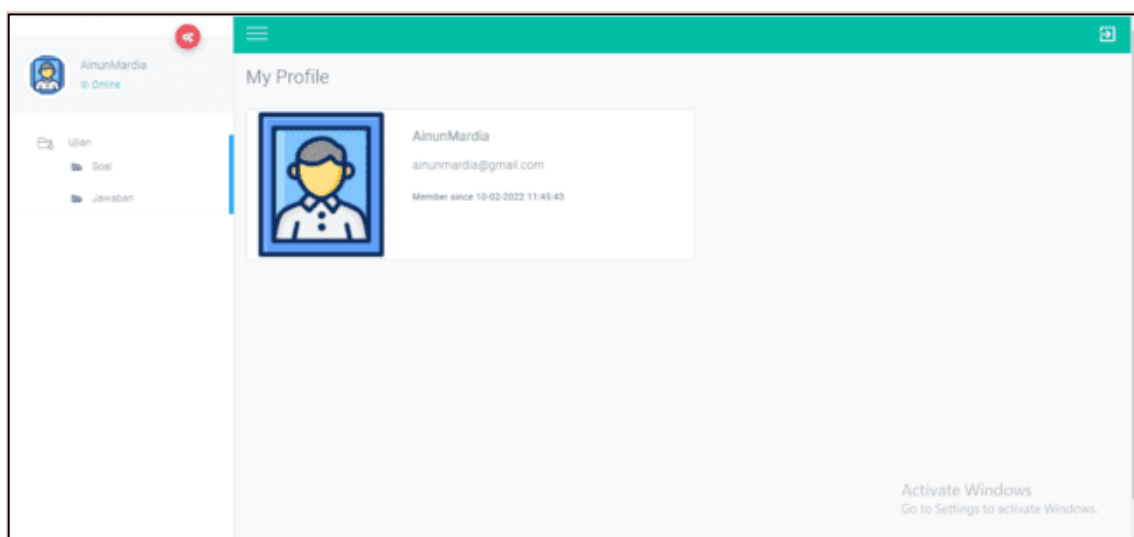


Figure 3. Main page view

On the next page, figure 3, it can be seen that there is a test menu and a question and answer sub-menu, and a user identity on the right side of the page. In the upper right corner are tools to log out of this application.

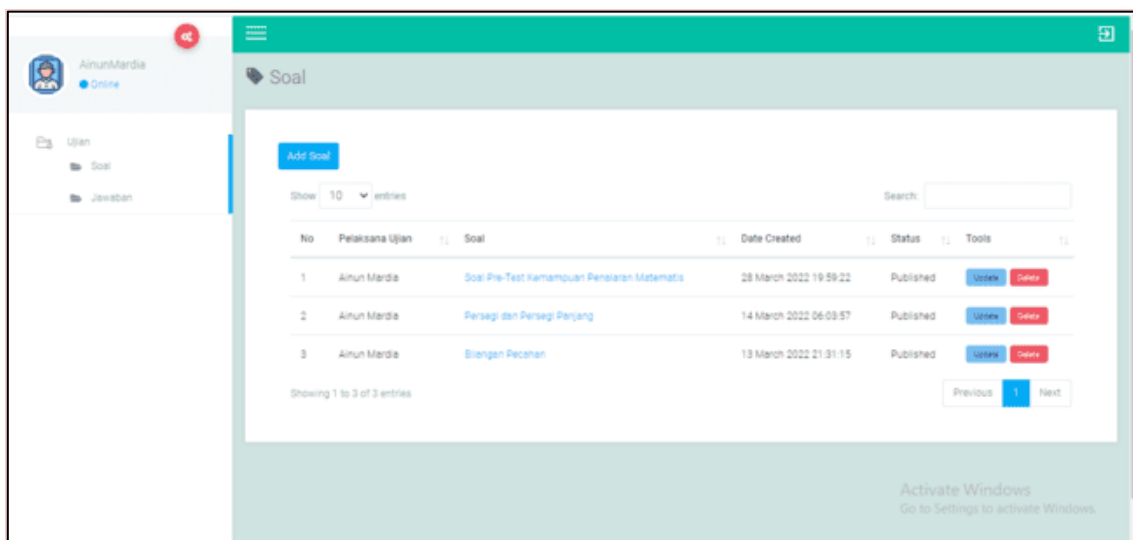


Figure 4. Question page view

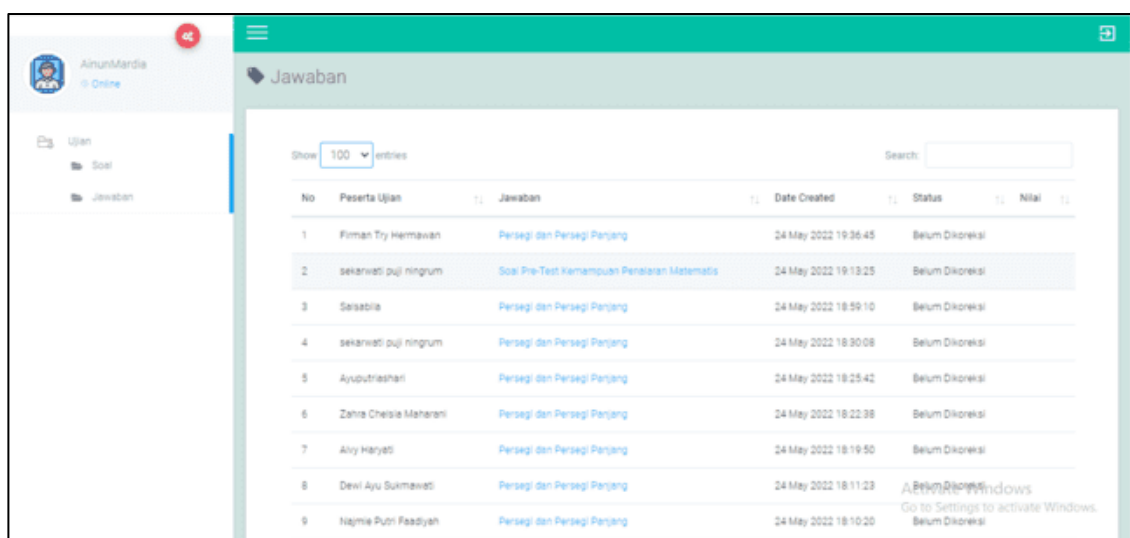


Figure 5. Answer page view

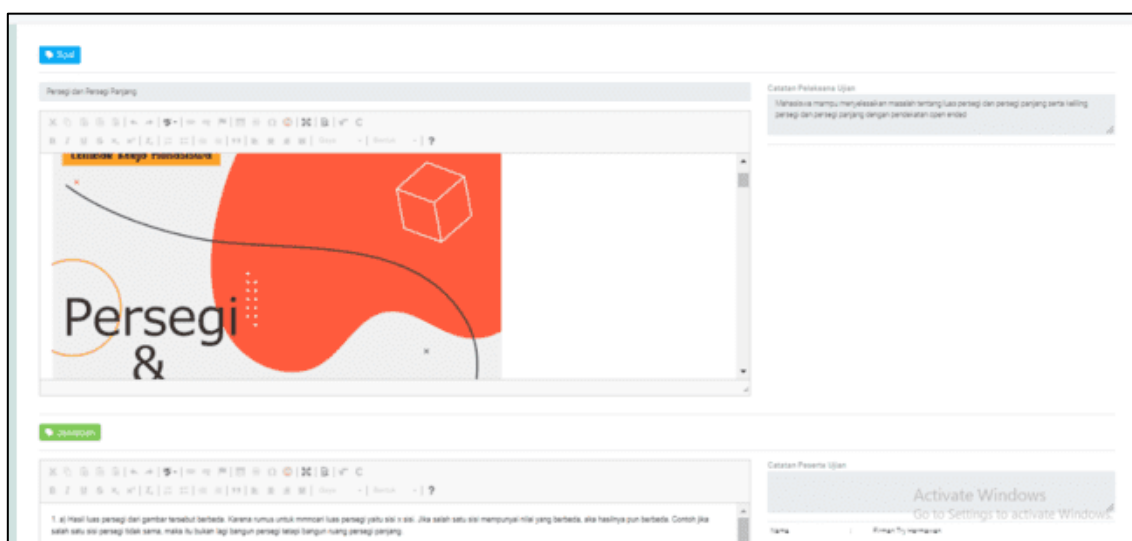


Figure 6. e-LKM and answer view



Figure 7. e-LKM with open-ended based MiKIR Approach

3.4 Develop

The stages of e-LKM development are validated and evaluated by three experts to observe the quality of the designed e-LKM and whether it is suitable for use. e-LKM validation and test instruments consist of 3 components that are assessed by the validator, namely the material aspect consisting of several criteria, namely the e-LKM component (identity, topic, and purpose); the suitability of the topic and purpose of the e-LKM; the suitability of the contents of the e-LKM with the topics and needs of students as well as mathematical concepts; the e-LKM work stage provides space to go through the MiKIR phase; presentation of e-LKM and depth of e-LKM content and benefits of e-LKM. The language validation aspect consists of several criteria, namely information, commands, questions, and symbols in e-LKM; the language used in the e-LKM follows the correct Indonesian language rules; the language used in e-LKM is effective and efficient; mathematical symbols in e-LKM using equation math; the language in the e-LKM is easy to understand and does not cause ambiguity and is following the characteristics of students; systematic question construction in e-LKM. The media validation aspect consists of several criteria, namely the appearance of the e-LKM cover; use of e-LKM letters (types and fonts); e-LKM layout arrangement; e-LKM background; illustrations, pictures, and photos in e-LKM; e-

LKM color composition; e-LKM display design; e-LKM usability and e-LKM flexibility; availability of space to write opinions.

Table 1. The Results of The Validation by Expert in Material Aspect, Language Aspect, and Media Aspect

Validator	Total Poin	Persentase	Criteria
Material aspect	58	77,33%	Valid
Language aspect	32	80,00%	Valid
Media aspect	50	76,92%	Valid

From Table 1, it can be concluded that the results of the validation by the experts obtained an average value that was included in the correct category. Therefore, the higher the validity of the teaching materials developed, the better the conclusions, the level of meaning, and the usefulness of the teaching materials, therefore they are suitable for the teaching and learning process (S. Hartini, 2018). The next stage is to test the level of practicality of the e-LKM with the open-ended problem-based MiKIR approach. At this stage, the e-LKM is tested on prospective teacher students of the PGMI UIN Sulthan Thaha Saifuddin Jambi study program. Questionnaires were given to 10 students in the trial class to see the practicality of the developed e-LKM. This questionnaire was filled out by students who had worked on the developed e-LKM. This questionnaire assesses appearance, grammar, writing and pictures, learning steps, materials, questions, and the MiKIR phase.

After the questionnaire was distributed to students, the results of the practicality questionnaire were 83.76% according to the practicality indicators, and the practicality of the open-ended problem-based e-LKM MiKIR approach was declared practical. The practical elements in question are:

- the attractive appearance of the e-LKM,
- the writing and pictures on the e-LKM are clear and attractive, and
- the suitability of the e-LKM at the MiKIR stage.

Practicality leads to student perceptions. Students' perceptions of worksheets are influenced by various things, for example writing, pictures, and colors can affect students' motivation in studying worksheets. In addition, the practice questions in it allow students to gain knowledge and train them to study independently (Sulistiyowati, Nur Inayah Syar, 2021).

3.5 Discussion/Trial Plan

To see the practicality of e-LKM, a trial was carried out on 14 UHAMKA PGSD students in semester 5 of the 2021/2022 academic year. The product trial was carried out in July 2022. Furthermore, students were given a questionnaire to find out the practicality of the e-LKM. The results of calculating practicality questionnaire scores are presented in table 2 below.

Table 2. Practicality Test Results for Each Aspect

No	Statement	Obtained Score
1	Display of e-LKM Open ended Integrated MiKIR Assisted LIMIT this mathematics learning subject is interesting to study	51
2	Grammar and sentence construction in e-LKM Open ended Integrated MiKIR Assisted LIMIT in mathematics learning courses easily understood by students	52
3	The writing and pictures on the e-LKM Open ended Integrated MiKIR Assisted LIMIT in mathematics learning courses look clear and interesting	54

4	Learning steps in e-LKM Open ended Integrated MiKIR Assisted LIMIT mathematics learning courses can make students become active	52
5	The material presented in the LIMIT-Assisted Open ended Integrated MiKIR e-LKM for mathematics learning courses is in accordance with the learning objectives to be achieved	52
6	Questions on e-LKM Open ended Integrated MiKIR Assisted LIMIT mathematics learning subjects provide space to improve students' mathematical reasoning abilities	54
7	Questions on e-LKM Open ended Integrated MiKIR Assisted LIMIT mathematics learning subject contains open ended questions	55
8	The questions on the LIMIT-Assisted Open-ended Integrated e-LKM for mathematics learning courses are applied using LIMIT	52
9	e-LKM Open ended Integrated MiKIR Assisted LIMIT mathematics learning courses provide space for students to go through the "Experience" phase	54
10	e-LKM Open ended Integrated MiKIR Assisted LIMIT mathematics learning courses provide space for students to go through the "Interaction" phase	51
11	e-LKM Open ended Integrated MiKIR Assisted LIMIT mathematics learning courses provide space for students to go through the "Communication" phase	53
12	e-LKM Open ended Integrated MiKIR Assisted LIMIT mathematics learning courses provide space for students to go through the "Reflection" phase	50
13	Questions on e-LKM Open ended Integrated MiKIR Assisted LIMIT this mathematics learning subject can be understood and worked on by students	52
14	Questions on e-LKM Open ended Integrated MiKIR Assisted LIMIT this mathematics learning subject can make it easier for students to understand learning concepts	49
15	e-LKM Open ended Integrated MiKIR Assisted LIMIT this mathematics learning subject has differences compared to the commonly used	53
Average		52,26
Practicality calculation score		87,1

Based on the data in the table, it can be seen that for the lowest weighted score of 49 obtained at point number 14 with the question statement on the LIMIT-Assisted Open-ended Integrated MiKIR e-LKM this mathematics learning course can make it easier for students to understand learning concepts, this shows an indication that students have difficulty understanding open ended questions because they are still not familiar with open ended questions while the types of open ended questions should continue to be familiar with math problems. This is in line with what was explained by Ruslan, AS and Santoso, B (2013) questions Open ended is rarely found in mathematics package books and requires deep thought in its completion. For the acquisition of the highest weight score of 55 at point number 7 with the question statement on the LIMIT-Assisted Open ended Integrated MiKIR e-LKM the mathematics learning course contains open ended questions indicating that all the questions presented in the e-LKM are in the form of questions This open ended is in accordance with the researcher's target. then the average practicality questionnaire was 52.26, if the percentage calculated for practicality calculations was obtained 87.1 with a very practical category. This means that on average all respondents gave a good response to the use of e-LKM and e-LKM is very practical to use in lectures.

In addition, the practicality questionnaire also provides space for submitting comments/criticisms/suggestions. This is intended so that students are more flexible if they want to express their opinions. Some students gave positive comments, which were very interesting and greatly helped by the existence of this e-LKM. And there are suggestions from students that it still needs improvement regarding the mathematical symbols in the e-LKM to make it easier to use the thinking approach is very well used in designing teaching materials because the elements contained in the thinking approach encourage students to carry out more practical and meaningful learning activities according to research conducted by Mardita Meza, et al., (2022). The learning process by utilizing a thinking approach strengthens lecturers as facilitators because lecturers only need to direct students in the learning process takes place and students will show their respective creativity (Maryanti Indra, et al, 2021). This approach also provides opportunities for students to discuss and better understand

mathematical content (Kartika Sari, 2020). The MIKIR approach also supports 21st century skills (Siregera Syahputra, 2020). Furthermore, the open ended approach, if used in making questions/assessments, also shows results. very practical user response and positive user comments. Research by Kurniawan H, et al, 2018 obtained student responses that open ended questions were very interesting and they could create their own. Likewise the assessment instrument developed using open ended by Arsyad Nurdin, et al (2017) shows the level of practicality by its users. The results of this research became a reference for researchers to integrate an open ended thinking approach, as evidenced by the results of research by researchers who produced Open ended e-LKM teaching materials integrated with MIKIR which were very practical to use by students.

4. CONCLUSION

The open-ended E-LKM was developed using the MiKIR approach with a 4D development model design (four-D models) consisting of defining, designing, developing, and disseminating. The development of this e-LKM resulted in an e-LKM with an open-ended problem-based MiKIR approach as valid and practical teaching material. In line with the resulting e-LKM, this study recommends that lecturers or teachers make e-LKM and apply it in the learning process using the LIMIT application. Researchers also hope there will be dissemination related to the spread of good practices by utilizing open-ended e-LKM. In addition, because the scope of material in the e-LKM produced in this study is still limited, further research it can be done to develop an e-LKM with an open-ended problem-based MiKIR approach for other materials.

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