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Math Learning with Realistic Mathematics Education Approach Based On Open-Ended Problems

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ABSTRACT
This study aims to determine the feasibility and effectiveness of learning mathematics using teaching materials in the form of LKPD with a Realistic Mathematics Education (RME) approach based on open-ended problems. The design used in this research is Research and Development with a development model developed by Dick and Carry. Subjects in this study were students of class X IPA at Al-bairuny Islamic Senior High School in the academic year 2020/2021. Design implementation is using One Group Pretest Posttest Design with instruments in the form of questionnaires and tests. Data on student's understanding of mathematical concepts were collected using instrument tests as many as 5 essay questions. The analysis technique used is descriptive quantitative and qualitative. The results showed that (1) the validation of teaching materials is categorized as valid with an average score of 84,89% based on the expert judgment as well as the percentage of student's responses to learning media of 80,29% categorized as feasible. (2) the effectiveness of teaching materials to reach the achievement of student's competence gets an average score of 80,88 of the student learning outcomes and percentage of classical completeness of 89,47% categorized as very good. Based on the results of research findings and discussion, obtained the conclusion that the mathematics LKPD with the Realistic Mathematics Education (RME) approach based on open-ended problems development is feasible and effective to be used in the teaching and learning process.

***Keywords**: Realistic Mathematics Education; Open-ended problem; LKPD;*

INTRODUCTION
Mathematics is very closely related to everyday life and one of the subjects that play an important role in the world of education because of the great contribution of mathematics that can be used in all fields of human life. According to Khotimah & Nasrulloh (2018), mathematics is the basis of all science and technology in this world. This is what makes mathematics one of the important subjects to be mastered and applied considering the great benefits of mathematics in life so that mathematics learning is required to run optimally to be able to achieve the formulated mathematics learning objectives. Understanding mathematical concepts is a basic ability that must be possessed by students according to the learning objectives of Permendikbud No. 22 of 2016. However, in line with the results of preliminary study through interviews with a mathematics teacher and students class X IPA at Al-bairuny Islamic Senior High School, the problems faced in learning are: most students still have difficulty in understanding mathematical concepts related to the material being taught so that affects to the low learning achievement of students. This is due to facts on the ground which show that the learning process tends to take place conventionally. That is teacher-centered learning which only focuses on theories and accuracy of results so that students cannot find concepts to understand the material during the learning process. This situation ultimately causes students to tend to memorize and assume that mathematics is a big problem filled with symbols and difficult formulas. This proves that students' understanding of the concepts being studied has not been achieved, thus causing learning to be ineffective and leading to a low percentage of completeness learning (Sari & Yuniati, 2018); (Meishanti, et al, 2020). On the other hand, mathematics is also considered the most boring and uninteresting subject because it is an abstract science.

The view that mathematics is a dry science, abstract, theoretical, full of symbols and formulas that are difficult and confusing forms student's negative perception of mathematics (Gazali, 2016).

To improve the quality of current education, the change in the learning paradigm that must be carried out by teachers (conventional) becomes learning activities that further activate student involvement (Khotimah, 2017); (Nasrulloh et al, 2021). There are needs for alternatives and innovations to foster student interest in learning. One of them is by developing effective and interesting learning tools so that students give positive responses to the learning delivered (Rahman, 2017). Teaching materials are one of the learning tools that can help students in understanding material. Good teaching materials, apart from being attractive in terms of appearance and content, must fit with the needs of students towards the material being studied (Rizki & Linuhung, 2016). One of the teaching materials that can activate students and make it easier for students to understand the material is a Student Worksheet (LKPD). According to Prastowo (2014), LKPD is a means to assist and facilitate learning activities so that it is formed effective interactions between students which can make students active. LKPD plays an important role in providing various assignments that are relevant to the material being taught (Kaymakci, 2012). LKPD needs to be designed using an approach that allows students to gain knowledge and meaningful learning experiences and involve students in reconstructing their understanding so that mathematics learning becomes more qualified, efficient and, meaningful.

One approach that can visualize abstract mathematical concepts to become more concrete and easily imagined by students is the realistic mathematics approach or has been known in the world as Realistic Mathematics Education (RME). According to Hadi (2017), a promising approach in learning mathematics is RME. In the RME approach, students are given a wide creative space to develop mathematical representations or models by linking the mathematical concepts of each mathematical problem that they face (Putrawangsa, 2017); (Umardiyah & Nasrulloh, 2021). By making connections between mathematical concepts, mathematics learning becomes meaningful and lasts longer in students' minds. In addition, math problems given to students will be more meaningful if they are presented in the form of non-routine or open-ended. The open-ended offers provision of open problems, which means that the problems faced have various solutions so that it can provide the widest possible experience and opportunity for students to investigate various strategies in interpreting and elaborating problems according to their knowledge and abilities but still true.

This is also supported by research by Fauzi & Waluya (2018) regarding the effectiveness of teaching materials with the RME approach based on open-ended problems. The results showed that the average value of the class that used the application of mathematics learning tools with the RME approach based on open-ended problems was greater than the class that did not use mathematics learning tools with the RME approach based on open-ended problems. Another fact is from the research conducted by Zakaria & Syamaun (2017) regarding the effect of the RME approach on student achievement and attitudes towards mathematics. The results of this study indicated a significant difference between learning mathematics using the RME approach and the traditional approach in terms of achievement in which learning mathematics using the RME approach improves students' mathematics learning achievement.

Based on the problems that have been raised, this becomes the basis for researching the development of this LKPD. LKPD compiled by researchers is LKPD which aims to assist students in finding a material concept as well as applying the concepts that have been found. Students are trained to find concepts independently through activities related to everyday problems that students can imagine and open-ended problems presented in the LKPD. By presenting the developed LKPD, students are expected to be able to see the problem as a whole from various perspectives. So that makes it easier for students to understand mathematical concepts because they have their own understanding in finding mathematical problem-solving. The purpose of this study is to describe the validity and effectiveness of the developed product in the form of a mathematics LKPD with Realistic Mathematics Education (RME) approach based on open-ended problems on linear function material for students of senior high school class X. By this research, it is expected to provide more in-depth information on the development and implementation of LKPD with the RME approach based on open-ended problems as well as being reference material for educators and other researchers who will raise the same theme but with different perspectives and more diverse objects.

METHOD

This research is a research and development (Research & Development) that aims to develop mathematics LKPD with Realistic Mathematics Education (RME) approach based on open-ended problems on the subject of the linear function. Research & Development is a research method used to research, design, produce and test the validity of the products that have been produced (Sugiyono, 2019).

The development model used in this study refers to the ADDIE model developed by Dick and Carry (1996) which consists of five stages, they are Analysis (analysis), Design (design), Development (development), Implementation (implementation), and Evaluation (evaluation). The analysis phase consists of two stages, namely needs analysis and material analysis to determine what product needs to be developed. Needs analysis aims to identify and analyze the feasibility of the product to fit the target. The research instrument used are interviews covering preparation, conditions, and media used in learning and pre-test to measure students' initial abilities. While the material analysis aims to determine the material to be presented in the LKPD which is adjusted to the basic competencies and competency standards that will be achieved by students and the applicable curriculum in schools. In this case, the material is the linear function material for students of senior high school class X in the even semester.

At the design stage, the researcher designs the material according to the data obtained from the analysis stage. The design process is carried out by designing LKPD components and linear function materials which are adjusted to the basic competencies that will be achieved with paying attention to the LKPD structure which includes six components consisting of title, study instructions, competencies to be achieved, supporting information, tasks and work steps and assessments. Next, the researcher determines the appropriate assessment tool, that is the formative assessment which is carried out at the end of the lesson. This assessment is used to see the level of success of learning activities (Nur Azizah, 2017).

The development stage is the product realization stage, namely the stage of producing LKPD which has gone through several revisions based on input and suggestions during the validity test from experts. At this stage, LKPD validation is carried out by a material expert and a media expert. The purpose of the validation is to determine the feasibility of the LKPD theoretically and empirically so then it can be tested further on the respondents.

The implementation stage is the stage of carrying out and implementing the design results. That is the stage of product testing in the field resulting from the development stage that had previously been declared eligible for use. The implementation of the developed product is carried out in schools using LKPD as teaching material in the learning. At this stage, students get feedback on the LKPD by using a feasibility test instrument in the form of a validated student response questionnaire. Students who have used the LKPD during the learning process provide an assessment of the LKPD. This assessment aims to obtain responses related to the validity and effectiveness of the LKPD that has been tested. To test the effectiveness of the LKPD in learning, at this stage students are also given a test in the form of a post-test to measure learning outcomes that have been achieved over a certain period (Sukmadinata, 2017).

The evaluation stage is a stage carried out at each stage of the research. After the analysis data is obtained, an evaluation is carried out which then the results of the evaluation are used as consideration for the next stage. Evaluation is also carried out at the design stage of the product to be developed. After the design, evaluation is carried out as an improvement material if there are things that are not right before proceeding to the product development stage. At the product development stage, product evaluation is carried out based on data obtained from expert validators in the form of input or suggestions for improvement to obtain products that meet expectations. Then the final evaluation is carried out at the implementation stage that is after product trials have been carried out. Evaluation is carried out based on the results of student assessments related to products developed through response questionnaires given after the product is used in learning. This stage is carried out so that the resulting product can be a good product and relevant to the needs of the target.

RESULT AND DISCUSSION

Result

The results of the research at the analysis stage based on the results of interviews with a mathematics teacher and students class X IPA at Al-bairuny Islamic Senior High School, it was found that the characteristics of students had fairly homogeneous mathematics learning abilities. The student's initial ability test in the form of a pre-test showed that all students of class X IPA had not yet achieved the completeness of the KKM score on the linear function material, which meant that all students obtained a

pre-test score below the value of 75. The description of the result of students' initial ability test is presented in Table 1 as follows:

Table 1. Result of Student's Initial Ability Test

Number	Total Student	Interval	Complete Category
1.	0 students	≥ 75	Complete
2.	19 students	< 75	Incomplete
Classical Completeness Percentage		0%	Very Not Good

There are the results of interviews in the preliminary study conducted with teachers and students of Islamic Senior High School class X IPA at the needs analysis stage can be seen in Table 2.

Table 2. Result of Needs Analysis

Number	Analyzed Aspects	Analyzed Result
1.	Learning Process	Conventional learning and teacher-centered
		Students often do not focus during the learning process
		Students are less active when learning takes place
		Students have difficulty in understanding the concept of material being taught
2.	Material/Learning Resource	The teacher does not have a fixed reference book or learning source
3.	Learning Media	The learning media used are only blackboard and chalk

Material analysis was adjusted to the basic competencies and competency standards to be achieved by students as well as the applicable curriculum in the school, namely the 2013 curriculum. The following is a description of the result of material analysis covering the material, competency standards, basic competencies, learning indicators, and learning objectives is presented in Table 3.

Table 3. Result of Material Analysis

Number	Identification	Identification Result
1.	Material	Linear Function – Straight Line Equation
2.	Competency Standards	Using the concept of the linear function, slope (gradient), and linear equation in problem-solving.
3.	Basic Competencies	Determining gradient from equation and graph of the linear function, analyzing linear equation and using them to solve contextual problems.
4.	Learning Indicators	1. Determining slope (gradient) 2. Determining linear equation 3. Determining a linear equation that is parallel or perpendicular to another linear equation 4. Identifying and solving linear function problems
5.	Learning Objectives	1. Be able to explain the concept of the linear function 2. Be able to apply the concept of the linear function 3. Be able to solve linear function problems

The results obtained at the design stage were the design of the LKPD format and tests. This LKPD generally consisted of two parts consisting of an introduction and content. The linear function material presented in the LKPD was prepared using the Realistic Mathematics Education approach. It had five characteristics, that were: "(1) The use of contexts; (2) The use of models; (3) The use of student's own productions and constructions; (4) The interactive character of the teaching process; (5) The intertwinement of various learning strands" (Gravemeijer, 1994). The following is the display of mathematics LKPD with Realistic Mathematics Education (RME) approach based on open-ended problems on linear function material for students of senior high school class X.

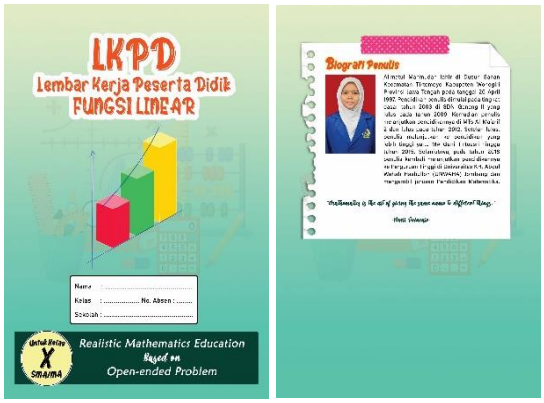

Figure 1. LKPD Cover Section Display

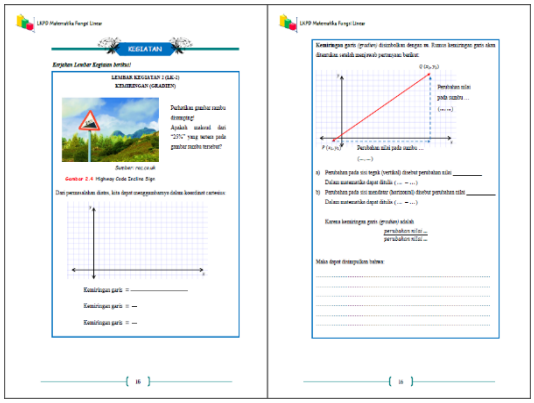

Figure 2. LKPD Content Section Display

The LKPD framework referred to the explanation of Zulkardi (2002). In outline, there were four stages according to the researcher as follows:

- Raising realistic problems. In each sub-subject material, the real problems were given to the "Tahukah Kamu?" point and "Bisakah Kamu?" point. The presentation of realistic problems as shown in Figure 3 was expected to facilitate students in finding a concept.

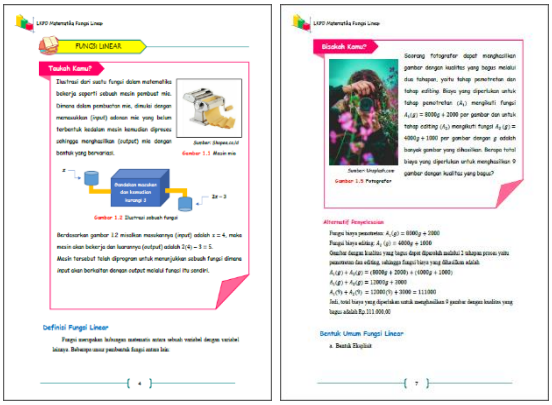

Figure 3. Raising Realistic Problems

- Initial problem-solving activities independently or in groups, given based on realistic situations in the "Kegiatan" point (Figure 4). Students were expected to be able to solve problems according to their respective knowledge and experience.

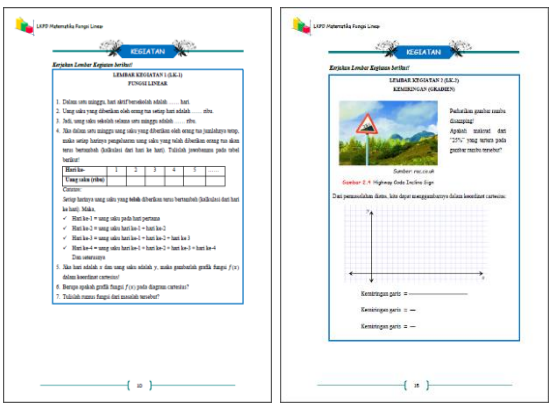

Figure 4. Realistic Problem-solving Activities

- Deepen the material being studied. After solving the given realistic problems, it was necessary to deepen the material in the form of material descriptions for each sub-subject of linear function including the concept of the linear function, slope (gradient), and linear equation.
- Student activities at the end of the material as an evaluation. At the end of the sub-subject material, exercises based on open-ended problems were given as an assessment instrument in each learning activity. This open-ended exercise was expected to enable students to see a problem as a whole from various points of view so that it could improve students' understanding of mathematical concepts towards linear function material because they had their own understanding in finding solutions to mathematical problems. The basis of openness, according to Neny et al. (2016) could be classified into three types: (1) Process is open; (2) End products are open and; (3) ways to develop are open. Thus, the open-ended problem solves and raises new problems (from problem to problem).

After the LKPD design was complete, then at this development stage, the LKPD was tested for validity. The validity tests used are the validity test of experts consisting of a material expert and a media expert. The material expert and media expert were given a questionnaire and the product was developed in the form of LKPD. The filling of the questionnaire was adjusted to the experts' assessment of the product being developed. The following are the results of LKPD validation by the material expert and media expert:

Table 4. Result of Material Expert Validation Data Analysis

Number	Validity Assessment Indicator	$\boldsymbol{P = \frac{\sum x}{\sum xi} \times 100\%}$	Validity Category
1.	Preliminary Aspect	73,33%	Valid
2.	Content Aspect	70,90%	Valid
3.	Evaluation Aspect	71,43%	Valid
4.	Closing Aspect	80,00%	Valid
	Average	73,91%	Valid

Based on table 4, the average percentage of LKPD assessment by the material expert was 73.91% with a valid category, so that the LKPD was valid and could be used but needed to be revised. The improvement suggestion from the validator which was used as repair material was that the LKPD needed to be added to a table of contents to make it easier for students to use.

Table 5. Result of Media Expert Validation Data Analysis

Number	Validity Assessment Indicator	$\boldsymbol{P = \frac{\sum x}{\sum xi} \times 100\%}$	Validity Category
1.	Graphic Feasibility Aspect	98,40%	Very Valid
2.	Language Eligibility Aspect	93,33%	Very Valid
	Average	95,87%	Very Valid

Based on table 5, the average percentage of LKPD assessment by the media expert was 95.87% with a very valid category. The suggestion for improvement from the validator was that separators between sub-chapters of material were not appropriate so the LKPD needed to be revised and refined. The following are the results of overall validations:

Table 6. Result of Overall Validation Data Analysis

Number	Validity Assessment Indicator	Validity Value	Validity Category
1.	Material Expert	73,91%	Valid
2.	Media Expert	95,87%	Very Valid
	Average	84,89%	Very Valid

Based on table 6, the average percentage of LKPD assessment by the experts was 84.89% with a very valid category. Therefore, it could be concluded that the LKPD developed had been valid according to the experts' assessment. After going through the validity test and revision, then the LKPD was tested on 19 students of class X IPA at Al-bairuny Islamic Senior High School on the implementation stage. The

following are the results of the LKPD trial based on the students' assessment of the response questionnaire:

Table 7. Result of Student Response Questionnaire Data Analysis

Number	Practicality Assessment Indicator	$P = \frac{\sum x}{\sum xi} \times 100\%$	Validity Category
1.	Material Aspect	78,77%	Feasible
2.	Language Aspect	83,16%	Very Feasible
3.	Interest Aspect	80,00%	Feasible
	Average	80,64%	Feasible

Based on table 7, the result obtained from respondents was 80.64% with feasible category. Furthermore, to test the effectiveness of LKPD in learning, at this stage students were also given a test in the form of a post-test to measure learning outcomes that had been achieved during learning at the end of the meeting. The level of effectiveness could be known by comparing the post-test results obtained with the KKM value. KKM value of class X IPA was 75, which meant the score 75 was included in the complete category and the score < 75 was in the incomplete category. The following are the results of LKPD effectiveness in terms of the post-test results:

Table 8. Result of LKPD Effectiveness Test

Number	Total Student	Interval	Complete Category
1.	17 students	≥ 75	Complete
2.	2 students	< 75	Incomplete
Classical Completeness Percentage		89,47%	Very Good

Based on table 8, it can be seen that 17 out of 19 students met the completeness category in learning mathematics with a value of up to 75 (KKM value). With a classical completeness percentage of 89.47%, it showed that by using the developed LKPD, student learning achievement increased in the very good category.

The last stage of this research was the evaluation stage. At this stage, revisions were made to the developed LKPD. Improvements were made based on the results of the assessment and suggestions from both validators and students. All suggestions for improvement of the developed LKPD were revised properly.

Discussion

Based on the research results, it can be seen that learning mathematics using the Realistic Mathematics Education (RME) approach based on open-ended problems has high effectiveness in learning. This is indicated by differences in the results of classical learning completeness at the pre-test and post-test which are presented in Figure 5.

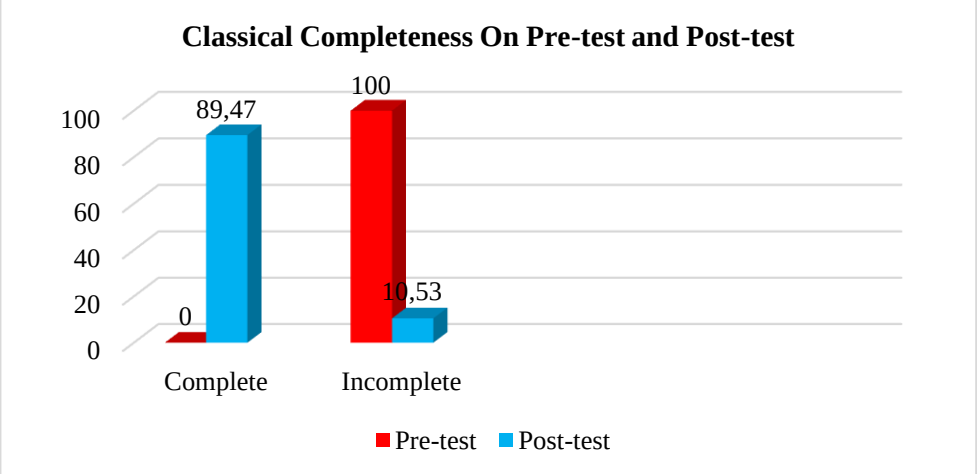

Figure 5. Classical Completeness On Pre-test and Post-test

In figure 5, the post-test results show that the students' classical completeness have met the effective criteria with the percentage of classical learning completeness that was obtained from the post-test results (89.47%) in the very good category, which is greater than the classical learning mastery obtained from the pre-test results (0%) in the very not good category. These differences are caused by the following factors, including:

First, learning that uses the RME approach based on open-ended problems does not only present problem situations related to contextual problems in everyday life but a problem is called "realistic" if the problem can be imagined (imaginable) or real in the mind of students (Rahman, 2017). So that learning will be more meaningful and students become easier to understand the problems faced. This is according to the opinion of Sari & Yuniati (2018) which states that students will feel close to mathematics because students experience it themselves in real life so that learning mathematics will feel more meaningful. In addition, the problem faced is open-ended problems so that it allows students to explore various strategies in solving a problem according to their knowledge and abilities. This is following the opinion of (Bernard & Chotimah (2018) that open-ended stimulates students to create a variety of answers so that mathematics learning becomes more meaningful. When the learning is meaningful, the learning process will be easier for students to understand, and students will better understand the essence of learning (Wulandari et al., 2020).

Second, learning emphasizes the meaningfulness of the student's learning process so that concepts will last longer in students' minds. This is according to the opinion of Liwis et al. (2017) that realistic learning emphasizes the meaningfulness that links activities related to real-life and close to the child's environment in a learning process that can be obtained through various ways. Learning does not begin with definitions, properties, or formal rules with various formulas and examples of their application, but begins with the provision of basic concepts associated with various phenomena/events that can be imagined by students. So that learning will be more active and interesting because the problems given are problems related to the life they face.

Third, learning with the RME approach based on open-ended problems makes students physically and mentally active in solving mathematics problems. Students construct their own understanding to solve problems. This is following the statement of Dwipayana et al. (2018) that a main principle of the RME is that students must actively participate in the learning process. Students are allowed to build their knowledge and understanding. Abstract mathematical concepts need to be transformed into things that are real for students. So that learning no longer adheres to the transfer to knowledge paradigm because it involves the active participation of students in learning. This is according to the opinion of Hidayat & Sariningsih (2018) that by solving open-ended problems, students can express their ideas freely without interference from the teacher so that the active role of students can be seen.

Fourth, the problems presented to increase the involvement of students actively so that effective interaction is formed between students and mathematics. This is the main focus in presenting open-ended problems. That is by building an interactive activity between mathematics and students so that students are encouraged to answer problems through various strategies (Aini, 2016). This is in line with research conducted by Fauzi & Waluya (2018) that learning with the RME approach based on open-ended problems has a positive effect on improving students' mathematical communication skills. Students explore their own knowledge so that students can present the solution results and express their opinions more boldly.

CONCLUSIONS

Based on the results of research and discussion, it can be concluded that (1) the teaching material developed in the form of LKPD with the RME approach based on open-ended problems meet the validity criteria and are suitable for use according to the experts' assessment. According to the results of product trials; (2) teaching material in the form of LKPD with the RME approach based on open-ended problems developed were effectively used in the learning process. This is indicated by the percentage of classical learning completeness obtained from the post-test results after using mathematics LKPD with the RME approach based on open-ended problems in learning (89.47%) which is greater than the percentage of classical learning completeness obtained from the pre-test results before using mathematics LKPD with RME approach based on open-ended problems (0%). Student achievement increases along with the increasing understanding of students' mathematical concepts.

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