

THE DEVELOPMENT OF MATHEMATICAL LEARNING MATERIALS BASED ON PROBLEM-BASED LEARNING TO ENHANCE PROBLEM-SOLVING ABILITY AT SENIOR HIGH SCHOOL

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Abstract

The research aims to produce a mathematics learning tool based on problem-based learning to improve problem-solving abilities in semester II class XI high school material that is valid, practical, and effective. This type of research is development research, while the population in this research is class XI students at SMAN 4 Payakumbuh using a random sampling technique class. This research uses a development model consisting of 3 stages: the initial investigation stage, the development or prototyping stage, and the assessment stage. Data collection techniques in this development model are interviews with teachers and students and questionnaires for teachers and students. The validation test stage consists of self-evaluation and validation sheets for the RPP and LKPD. Practicality test instruments describe the practicality of the learning tools being developed. The research results showed that the lesson plans developed averaged 3.56 in the very valid category. In contrast, the LKPD developed had an average of 3.39 in the very valid category. Overall, the practicality value of the RPP is 87.50% with very practical criteria, and the practicality value of LKPD is 88.67% with very practical criteria. This means that based on the questionnaire on the practicality of the RPP and LKPD filled out by educators for mathematics learning tools using the PBL model, it is stated that they are very practical and can be used well by students in learning.

Keywords

Learning Tools, Mathematics, PBL, SMAN 4 Payakumbuh



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INTRODUCTION

Mathematics is a basic science. It plays an important role in the development of science and technology (Rachmantika & Wardono, 2019). Given the important role of mathematics, mathematics is taught from kindergarten, elementary, junior high, and high school. However, some students still find mathematics difficult. Many of them are reluctant to learn mathematics because it is a very important science for everyday life. Understanding mathematics is one of the main prerequisites to being able to continue on to a higher school (Sumarni et al., 2022). Mathematics is the queen of sciences, which means the mother of other sciences (Haryono, 2014);(Fakhri, 2019). Mathematics plays an important role in various aspects of life because many problems in life can be solved with mathematics (Ekawati et al., 2019);(Heris, 2019). Therefore, mathematics is a subject that students need to learn. Given the importance of the government's role in mathematics in ensuring that the learning process runs well, the government formulated eight mathematics learning goals in the 59th edition of the 2014 Permendikbud. Four of them are cognitive abilities that students must master, namely conceptual, communication, reasoning, and problem-solving skills (BSNP, 2016).

According to Rizza (2017), Problem-solving skills are implemented as educational goals. Problem-solving skills require mastery of knowledge that can be applied and help students to be trained in dealing with real-life problems (Yustianingsih et al., 2017);(Prananda et al., 2021). However, the reasoning and problem-solving abilities of Indonesian students are still low, as can be seen from the achievements of eighth-grade Indonesian students, which are almost entirely below the international average. The low-ability of problem-solving is caused by students not trying to solve problems independently, just waiting for the teacher's explanation, and are not used to solving problems (Novianti, 2020).

The researchers conducted initial observations in two schools, namely SMAN 4 Payakumbuh and MAN 2 Payakumbuh. In the initial observation, interviews were conducted with ten students at SMAN 4 Payakumbuh and 15 students at MAN 2 Payakumbuh. From the results of interviews with 22 students, mathematics is a subject that is difficult to understand. Students assume that there are many formulas that will be memorized. The process of learning mathematics, in general, is still focused on increasing the ability to memorize and use concepts. Students can only work on the problem if it is in the same form as what was explained by the teacher. In other words, imitating the teacher's explanation. Only a small proportion of students consider mathematics easy to understand. This will certainly affect the ability to solve problems.

In addition, interviews were also conducted with 3 SMAN 4 Payakumbuh. From daily questions related to problem-solving skills, only students were able to solve them correctly. The results of these values are, of course, related to the learning tools presented by the teacher, which contain lesson plans and worksheets to facilitate students' assignments. Results of interviews with SMAN 4 Payakumbuh teachers, the lesson plans used by teachers were obtained from other schools and edited. As a result, the RPP is not in accordance with the characteristics of the students in the school. In the RPP, it is not visible what abilities will be achieved or will be developed by students. Activities in RPP are very general and have not sparked students' interest in learning, which results in students' problem-solving abilities in real life not being achieved.

Based on the problems found in the initial observations, of course, we need to follow up, namely by choosing the right learning strategy. In teaching mathematics, the teacher should choose a variety of approaches, strategies, methods, and learning media that are appropriate to the situation so that the planned learning objectives will be achieved (Titik, 2014); (Nurkholis, 2018). Learning tools must be integrated with learning materials that are tailored to the needs of students so that learning is meaningful and can achieve learning goals (Wita, 2022). In accordance with the problems above, the learning model is suitable for use in problem-based learning (PBL).

There are several reasons for choosing PBL as a solution to this problem. The first reason for problem-based learning is to design learning systematically to maximize student learning, especially in problem-solving (Muh, 2017). Second, in PBL, the teacher acts as a motivator, asks practical questions, provides teaching materials, and provides the facilities students need to solve problems (Suci, 2020). From the explanation above, it can be seen that the PBL-based device is able to solve the participants' problems, thereby increasing their problem-solving skills. According to Susilawati (2019), improving students' problem-solving abilities through the PBL learning model is better than students receiving traditional learning. Students who study with the PBL learning model are more creative than students who use the traditional model (Kern, 2017); (Trinianti et al., 2021).

Learning tools based on the PBL model will be able to solve problem-solving skills in order to achieve learning mathematics. Based on the description above, the researcher is interested in conducting development research with the title "Development of Problem-Based Learning Mathematical Learning Materials to improve problem-solving skills in Class XI SMA.

METHOD

The paper applies development research, aiming to produce certain products and to test the validity, practicality, and effectiveness of these products (Sugiyono, 2012). In this study, the product that the researchers developed as learning tools in the form of PBL-based lesson plans and worksheets for the mathematical problem-solving abilities of class XI high school students.

The development research model used is the Plomp development model. This model was developed by Tjeerd Plomp and consists of 3 stages, namely the initial investigation, development or prototyping stage, and the evaluation stage. In accordance with the development model used, product development procedures are arranged in three stages. Each of these steps is briefly presented below:

Table 1. Product Development Stages

No.	Stages	Criteria	Description
1.	Preliminary research	Emphasizing content validity	Problem analysis and literature study. The result of this stage is the initial prototype design form.
2.	Prototyping phase		
3.	Assessment Phase	Focusing on consistency (Construct validity) and practicality. Efficiency/effectiveness.	Prototype development to be piloted and revised based on the formative evaluation. Assessing whether the product effective.

The research's subjects were class XI students at SMAN 4 Payakumbuh. The sample classes were selected using random sampling, with an initial class population of 10 classes. Class XI MIPA 2 was selected with a total of 34 students.

The location of this research is SMAN 4 Payakumbuh JL. Kalimantan, Balai Nan Duo, Kec. West Payakumbuh, Payakumbuh City Prov. West Sumatra. Meanwhile, data collection techniques in this research were carried out using validation data by preparing validation sheets, practicality data by preparing questionnaire instruments, and effectiveness data by using computational thinking test questions. Data analysis techniques obtained through data collection instruments will be analyzed using descriptive statistical analysis and qualitative analysis, such as Data Analysis at the Preliminary Research Stage, Validity Data Analysis, Practicality Data Analysis, and Effectiveness Data Analysis.

FINDINGS AND DISCUSSION

Findings

The research process carried out consisted of three stages, namely preliminary research, development or prototyping phase, and assessment phase. These stages are carried out to obtain valid, practical, and effective tools.

Results of Needs Analysis

Based on the needs analysis activities that have been carried out, it can be seen that the interest and interest in learning mathematics is still lacking. This can happen because students have the notion that mathematics is a subject that is difficult and very important to learn, so students are not serious about learning mathematics. Only a small number of students did and took lessons seriously. The rest did not do the exercises given by the teacher and even talked to their friends next door. The fact was found that during the process, it was very rare for students to submit or argue. They only accepted what was given by the teacher.

Thanks to learning like this, students' math skills can hardly be developed, especially problem-solving abilities. This can be seen from the fact that there are still many students who have not been able to measure non-routine word problems and have not been able to present the formulation of systematic questions because students are too focused on examples of problem-solving. Given. Therefore, the problem cannot be solved. The ability to solve math problems with low student achievement in mathematics is still.

One of the factors causing the low ability of students to solve math problems above is learning resources that are not optimal. This learning resource can be in the form of learning tools. Poor math problem-solving skills at SMAN 4 Payakumbuh occur because the learning skills developed by the math teacher are not able to increase students' motivation and interest in learning mathematics, which has resulted in students' abilities, especially math-solving abilities.

Concept Analysis Results

Concept analysis aims to determine what essential concepts must be present in linear programming material. Based on the results of the concept analysis, the material presented in the book is consistent and supports the achievement of learning objectives. However, it is necessary to add sub-materials/topics in learning the topic of linear programming, namely, making a system of inequalities from graphs. This is because, in the books students use, there are questions that discuss systems of linear inequalities from graphs.

LKPD Based on PBL Characteristics

Presentation Aspects

The cover contains information about the PBL-based LKPD titles for class XI SMA, and there are four logos, namely the Padang State University (UNP) logo, Tutwurihandayani, the Ministry of Research, Technology and Higher Education, and the 2013 curriculum.

Figure 1. LKPD Cover Design



Content Aspect

The first stage of PBL is the orientation of students on problems related to everyday life. Complete with illustrations. This is intended to facilitate students' understanding of contextual issues. All teacher students give encouragement from the pictures of the activities carried out in the pictures. Students observe and observe. Based on the results of several student responses related to the material to be studied.

Figure 2. Problem Orientation in PBL LKPD



Result of Expert Review

At the expert review validation stage, learning tools in the form of PBL-based RPPs and LKPD were validated by three experts by consulting and discussing the learning tools created. The learning tools were validated by three mathematics lecturers, one educational technology lecturer, and one language lecturer, as well as one mathematics subject teacher at SMAN 4 Payakumbuh. This validation activity was carried out from January to May 2023. The following are the results of the validation of PBL-based mathematics learning tools to improve problem-solving abilities in the form of lesson plans and LKPD.

PBL-Based RPP Validation Results

Validation of the RPP was carried out by three mathematics lecturers, one language lecturer, and one educational technology lecturer. The results of the PBL-based RPP validation can be seen in the following table:

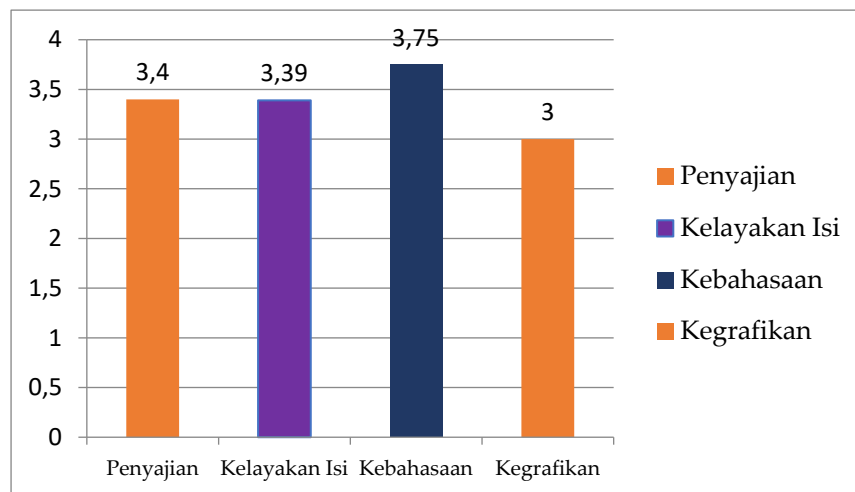
Table 2. Validation Results by Experts

No.	Assessed Aspect	Validity Index	Category
1.	Presentation	3,52	Very Valid
2.	Appropriateness of content	3,53	Very Valid
3.	Language	3,63	Very Valid
	Average Validity of RPP	3,56	Very Valid

Based on Table 2, it can be seen that the results of the RPP validity test for each aspect are very valid. Overall, the RPP developed has an average of 3.56, with a very valid category. Thus, it can be concluded that this PBL-based RPP is valid. Even though it is very valid, based on the validation results by several validators, there are several suggestions for improving PBL-based lesson plans.

PBL-based Student Worksheet Validation Results to improve problem-solving abilities

The aspects assessed in the LKPD are presentation/didactic aspects, content appropriateness aspects, linguistic aspects, and graphic or appearance aspects. The validation results of PBL-based LKPD to improve problem-solving abilities can be seen in the following table:

Figure 3. LKPD Validation Results by Experts

It can be seen that the results of the LKPD validity test for each aspect are valid and very valid. Overall, the LKPD developed has an average of 3.39, with a very valid category. So, it can be concluded that this PBL-based LKPD is valid. Even though it is in the very valid category, there is still little improvement. Improvements made based on validator suggestions.

After the validation process through self-evaluation and expert review was completed, improvements were made to prototype 1 in accordance with the validator's suggestions. The results of the revisions to prototype one are called prototype 2. Furthermore, in prototype 2, a practicality test of PBL-based learning devices was carried out.

Assessment Phase

At the assessment stage, a field test was carried out. After being revised based on input at the one-to-one and small group stages, the learning device was tested in a limited way in class XI SMAN 4 Payakumbuh, with 34 students. The tryout was carried out in 6 meetings.

At this stage, the practicality and efficiency of the developed mathematics learning tools can be seen. The practicality of Learning Tools emerged from the results of interviews with educators and questionnaires filled with students as users of Learning Tools. So far, the effectiveness of the device can be seen from the results of the final test of students' mathematical ability after carrying out the process using the learning device that has been developed. The following are the results of the instrument analysis.

Teacher interview results

The practicality of learning that has been used can be measured by conducting interviews with teachers as users. The aspects that were asked of the teacher were readability and clarity, writing/pictures on learning tools, usability/ease of using learning tools, and sufficient time.

Based on the results of the interviews, it can be said that the learning tools are clear in use and writing, and the words produced do not use ambiguous meanings. Then, at the level of ease of use of the device, the teacher said that the learning device was easy to use, but in the let's practice section, it was hoped that the questions would be a little easier, so what is meant is used as well as possible. Sufficient time to work on LKPD is appropriate, and it's just that in the part of working on the questions, sometimes there is not enough time. Thus, learning tools are said to be practical for use in classroom learning.

Student Practical Questionnaire Results

Practicality questionnaires were given to students after participating in the learning process using the developed LKPD. A total of 18 students were given a questionnaire to fill out in order to measure the practicality of the learning device.

Based on the results of the LKPD practicality questionnaire recapitulation by students, it was found that the average value of the LKPD practicality questionnaire was 77.78% in the practical category. This means that the learning tools developed are practical

Results of the Educator Practicality Questionnaire

The Educator's practicality questionnaire aims to obtain information about the practicality of Learning Tools based on the teacher's opinion. Practicality questionnaires were given to math educators for class XI at SMAN 4 Payakumbuh. The results of the teacher's response questionnaire to the practicality of lesson plans based on genius learning strategy can be seen in Table 3.

Table 3. Recapitulation of Practicality Questionnaire Results Learning Tools with the PBL model (Teachers' Responses)

No.	Assessed Aspect	RPP(%)	Category	LKPD(%)	Category
1.	Instructions for Use	91,67	SP	85	SP
2.	Attractiveness	87,50	SP	83,33	P
3.	Convenience	81,25	P	100	SP
	The use				
4.	Time	75	P	75	P
5.	Equivalence	83,34	P	100	SP
	Averages	87,50	SP	88,67	P

Overall, the practicality value of the RPP with very practical criteria, and the practical LKPD value is 88.67%. That is, practical questionnaires, lesson plans, and worksheets completed by educators for mathematics learning tools with the PBL model are very practical and can be used correctly by studying them.

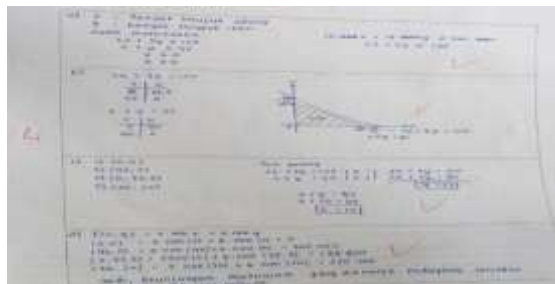
The Effectiveness of PBL-Based Learning Tools

The assessment stage aims to determine the practicality and effectiveness of PBL learning tools in improving students' problem-solving abilities. The assessment stage is carried out when field tests are carried out, namely in classes or large groups. The revised results were obtained in the small group evaluation test, followed by a field test in class XI at SMAN 4 Payakumbuh. At this stage, activities are focused on evaluating the quality of the products produced in the previous stage. The assessment is carried out to determine whether the product meets expectations, is practical, and is effective in improving students' problem-solving abilities. In implementing the field test stage, the students selected are students who have not participated in the one-to-one evaluation and small group evaluation.

In this research, the effectiveness of the learning tools was tested on students in a field test. The learning results obtained in this research were in the form of a description test with five questions. This test was carried out to assess students' problem-solving abilities after learning using PBL-based LKPD. Based on data analysis, there were seven people who did not complete 34 students, with a percentage of 22.22%. Students who do not complete are due to a lack of focus on learning, and students tend to be reluctant to ask the teacher, so students ask their peers, and students do not try to solve the questions given. When compared with the initial solving ability test, which had a completion percentage of 20% compared to the last solving ability test given to students, it was found that the percentage was 77.78%. It can be seen that there is a comparison of the solving ability of students who have not yet compared to those who have learned to use the device. PBL-based learning.

The following are examples of students' answers in completing mathematical communication skills.

Figure 4. Students' responses



Discussion

Validity of Problem-Based Learning Mathematics Learning Tools

Validity in development research is seen in two parts, namely content validity. Putra (2018) reveals a need for the intervention (device to be created) and the design to be in accordance with existing scientific knowledge. Meanwhile, construct validity (consistency) is designing interventions (learning tools) according to logic and appropriate reasons.

The aspects assessed in the RPP validation are aspects of the RPP components. After making several improvements during validation, the RPP developed was valid with a validity value of 3.56 (very valid). The RPP developed based on the 2013 Curriculum on basic fractional competencies meets various aspects, including RPP components learning activities are based on problem-based learning. Based on these results, in terms of content and construct validity, the RPP is valid, so this RPP can be used as a guide for educators in carrying out problem-based learning. With a valid lesson plan, it is hoped that it can be used by educators as a guide for implementing learning in schools so that they can motivate students to learn fractions.

Validity criteria for a product developed in terms of content and construct. At the validation stage of the LKPD, the aspects observed consisted of didactic, content, language, and presentation aspects. In the content aspect, the LKPD validation result was 3.56, which was formulated as very valid. From the validation results of the content aspects of the LKPD, it can be concluded that the LKPD has actively involved students by compiling, processing, and analyzing data and motivating students with various fun activities.

Practicality of Problem-Based Learning Tools

A good learning tool should be practical. The criteria used to assess the practicality of developing this device are the implementation of learning using fractional learning tools based on problem-based learning, convenience which refers to how easy the tool is to use by educators and understood by students, and time, which refers to sufficient time provided for carrying out learning

using the device. This level of practicality was obtained through interviews with educators, giving questionnaires to students as LKPD users, and observation sheets regarding learning implementation. This is in line with the opinion of Wiratama (2019), which states that a learning device is said to be practical if the device can be used easily by educators and students in learning.

In assessing the practicality of this device, data was collected through observations of learning implementation, practicality questionnaires filled out by students, and interviews with educators. The implementation of learning using problem-based learning tools shows that the learning process can create a good classroom situation that encourages students to ask each other questions, answer, and express opinions, and there is interaction between students. Apart from that, learning using problem-based learning tools can stimulate students very well in learning and can develop independence and creativity in understanding LKPD and solving questions.

During the implementation of learning using problem-based learning tools, in general, the time provided is sufficient. However, some students have different opinions because students are used to getting complete information from educators without having to think about finding it themselves. To overcome this problem, during the learning process, educators are tasked with helping students by directing them in thinking so that they can come up with ideas for solving the given mathematical problems.

Effectiveness of Problem-Based Learning Tools

The effectiveness of learning devices is related to the effect or impact of the devices designed on students. According to Nurlaili (2017), effectiveness is divided into two parts, namely expected effectiveness and actual effectiveness, and expected effectiveness, namely the use of problem-based learning intervention tools, which are expected to have an impact in accordance with the expected results. The effectiveness of the research was carried out by giving problem-solving ability test questions to students. According to Nuriyah (2014), Test results can be used to evaluate various aspects of the learning process. Based on data analysis, there are 75.00% of students above the specified KKM score of ≥ 65 .

Furthermore, the average class that uses problem-based learning tools is 77.78%, meaning that classically, they have demonstrated completeness. One thing that causes students' ability to achieve completeness is the use of tools (RPP and LKPD) based on problem-based learning. Wahyuni (2017) also explained that the achievement of the effectiveness of problem-based learning tools is demonstrated by the student's learning outcomes in the form of problem-solving abilities

reaching minimum completeness criteria. This is in line with the opinion of Susanti (2017), who explains that the test scores for students' mathematical problem-solving abilities that have been obtained can be concluded that problem-based learning tools have been declared effective in improving mathematical problem-solving abilities.

CONCLUSION

It can be deemed that the PBL-based learning tools developed for class XI SMA/MA on derivative application material are valid, practical, and effective. The RPP that was developed had an average of 3.56 in the very valid category, while the LKPD that was developed had an average of 3.39 in the very valid category. Overall, the practicality value of the RPP is 87.50% with very practical criteria, and the practicality value of LKPD is 88.67% with very practical criteria. This means that based on the questionnaire on the practicality of the RPP and LKPD filled out by educators for mathematics learning tools using the PBL model, it is stated that they are very practical and can be used well by students in learning. The effectiveness of PBL-based learning tools based on data analysis showed that there were seven students who did not complete it out of 34 students, with a percentage of 22.22%. Students who do not complete are due to a lack of focus on learning, and students tend to be reluctant to ask the teacher, so students ask their peers, and students do not try to solve the questions given. When compared with the initial solving ability test, which had a completion percentage of 20% compared to the last solving ability test given to students, it was found that the percentage was 77.78%. It can be seen that there is a comparison of the solving ability of students who have not yet compared to those who have learned to use the device. PBL-based learning.

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