The Development of Problem-Based Student Worksheets To Improve Mathematical Reasoning Ability In Class XI Students Of SMA Negeri 6 Surakarta

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Abstract. This research aims to develop a valid, practical, and effective problem-based Student Worksheet (LKPD) to improve students' mathematical reasoning ability in class XI IPS 1 SMA Negeri 6 Surakarta. The development research method used is a 4-D model, including Define, Design, Develop, and Dissemination. The subjects in this study were students of class XI IPS 1 SMA Negeri 6 Surakarta. Data collection techniques used interviews, questionnaires, observations, and tests of mathematical reasoning abilities. This research analyses the validity, practicality, and effectiveness of LKPD using criteria scores and test results of mathematical reasoning abilities through a t-test with a significance level of 5%. Based on the analysis results, the developed LKPD meets the criteria of being valid, practical, and effective. Problem-based LKPD declared valid with 79% between the average results of expert assessments and readability tests; practical rated 86% in the intermediate results of observations of the implementation of learning and student responses; effective because there is an increment in students' mathematical reasoning abilities after using LKPD with an adequate level of 0.47 including in the medium category.

Keyword: LKPD, problem-based, mathematical reasoning, linear programming

INTRODUCTION

Mathematics learning continues to develop and demand humans to be more creative and innovative. Mathematics is considered as the key to stimulating thinking and human reasoning ability. As stated before, mathematics develop methods of thinking and reasoning in concluding investigation, exploration, experimentation, and showing similarities, differences, consistency, and inconsistencies [1]. Mathematics has a unique characteristic, emphasising deductive processes that require logical and axiomatic reasoning [2]. Reasoning is important in the learning process [3].

Reasoning is a thinking process that starts from sensory observations (empirical observations) in drawing conclusions that produce several concepts and understandings [4]. The reasoning ability is necessary in making decisions in various scientific social problems [5]. Reasoning was described as a special kind of thinking and drawing conclusions based on premises [6]. It means that reasoning is a thinking process to draw conclusions or construct a new statement by referring to a true statement. Furthermore, the implementation of mathematics learning must be applied based on five mathematical abilities: connection, reasoning, communication, problem-solving, and representation [7]. Also, according to Romberg and Chair, the indicators of mathematical reasoning ability are: (1) drawing logical conclusions; (2) providing an explanation using models, facts, traits, and relationships; (3) estimating answers and solutions; (4) using

patterns and relationships to analyze mathematical situations, drawing analogies and generalizations; (5) constructing and testing conjectures; (6) giving a counterexample; (7) following the rules of inference; (8) checking the validity of arguments, compiling valid arguments; and (9) establishing direct, indirect and indirect use of mathematical induction [8]. Therefore, mathematical reasoning is a necessary aspect of the mathematics learning process to train and develop continuously. The reasoning makes students able to solve problems quickly, precisely and build their minds to master mathematical concepts [2]. Through mathematical reasoning in learning, students practice proposing suspected solutions to problems, finding patterns of completion and using them, providing explanations for patterns, models, images, or properties, checking the truth of an argument, and drawing conclusions correctly and appropriately. In consonant with the statement before, mathematical reasoning skills must be discovered and developed.

Conversely, mathematical reasoning is essential and needs to be recognized, but students' mathematical reasoning is still low. Based on the PAMER UN for the 2016/2017 academic year, the absorption capacity of indicators in solving reasoning problems related to linear programming in SMA Negeri 6 Surakarta students is 36.68% in the national scope. This value belongs to the less category, which indicates that students' reasoning ability is low. In addition, based on the results of the pre-test of mathematical reasoning abilities of students in class XI IPS 1 SMA Negeri 6 Surakarta, as many as 58% of students were unable to provide explanations for models, pictures, traits, or patterns, 77% of children were unable to check the truth of an argument, 79% of students were not able to draw logical conclusions. Based on the five indicators of mathematical reasoning ability, the three indicators obtained from the pre-test results are low. Research results by experts show that students' reasoning skills, especially in mathematics, are significantly weak [9][10][2]. This condition happened because mathematical reasoning abilities are not steady at the secondary school level, a large number of studies show the low mathematical reasoning of students in secondary schools [10]. This result also indicates that the tendency that causes students can't understand the subjects in mathematics. This condition causes by the lack of understanding and usage of decent reasoning in solving the problems given [11]. In proportion to the statement before, the lowest average proportion Indonesian students can achieve is the cognitive domain at the reasoning level of 17% [12].

To train reasoning skills, the teacher can create learning that systematically develops problem-solving, reassures the activation of previous knowledge to build new self-directed understanding, and encourages students to apply various strategies in solving a problem with the correct procedure. During the learning, the teacher should try so that students are skilled in applying concepts or formulas and are more encouraged towards achieving a higher level of reasoning [1]. The learning model that can be used to improve reasoning ability is a problem-based learning (PBL) model. PBL is designed to help students develop thinking, problem-solving, and intellectual skills [13]. PBL can trigger previous understanding to build new knowledge and elaborate on both pieces of knowledge.

Both knowledges can be used to solve a problem so people can absorb them in long-term memory [14]. PBL aims to develop the ability of students to solve a problem or case systematically [15]. Through PBL, students are qualified to solve a real problem by using previous knowledge and constructing new knowledge independently and systematically.

Teaching materials can help students understand concepts that are arranged systematically according to the competencies that students achieved. The teaching materials used in learning mathematics at SMA Negeri 6 Surakarta were guided by the Mathematics Book published by the Ministry of Education and Culture. Based on the observations, the given material and the presentation of the application with the concepts studied are incomplete. Of course, to develop mathematical reasoning abilities, appropriate teaching materials are needed. However, the facts show that the availability of student worksheets that focus on improving mathematical reasoning abilities does not yet exist, the circulating worksheets do not emphasize the process, have not developed students' creative thinking skills [16][17][18]. LKPD can be a solution to improve mathematical reasoning skills because it can be designed in a structure to find conclusions based on the problems.

Based on the explanation above, this article aims to determine how the development of problem-based student worksheets (LKPD) is valid, practical, and effective in improving students' mathematical reasoning abilities.

RESEARCH METHODS

This research uses research and development (R&D) methods. Research and development methods (Research and Development / R & D) are research methods used to produce specific products and test the effectiveness of these products [19]. The development model used is a 4-D model, including defining, design, development, and dissemination. In this study, the development of LKPD only reached the development phase.

The initial stage is the define stage. The define stage is completed by determining and defining the development requirements. The definition is completed through development needs analysis activities. Determination of product development requirements tailored to user needs. The definition stage in this research included needs analysis, student characteristics analysis, material analysis and formulating learning objectives.

The analysis needs to determine the fundamental problems encountered in learning. Interviews conducted the research to assess the needs of teachers and students for teaching materials that can help the learning process. The analysis of student characteristics aims to identify the characteristics of students regarding the level of ability or level of cognitive development of students, and background knowledge. And also the material analysis aims to build concepts on the materials to be delivered to achieve Core Competencies (KI) and Basic Competencies (KD). The material analysis is done by identifying the main material that needs to be taught, collecting and selecting relevant material, and rearranging it systematically to formulate learning objectives.

The development stage consists of the design and development stages. The design stage is done by arranging the LKPD (draft 1) initial draft, research instruments, lesson plans, and mathematical reasoning tests. This LPKD adopts PBL learning steps, namely presenting problems, prerequisite materials, and directive patterns to solve problems. The development stage starts from validating draft 1 LKPD to experts, readability test, and testing for class XI students. LKPD has implemented in class XI IPS 1 at State Senior High School 6 Surakarta in the academic year of 2018/2019.

To assess the validity of the LKPD, the assessment is done based on expert judgment. The instruments use material expert validation questionnaires, media expert validation questionnaires, and readability test sheets. Expert validation in the form of validation of material experts and media experts. The initial draft of the LKPD was validated by material experts on aspects of content feasibility, language feasibility, presentation feasibility, and elements of the PBL approach. After LKPD has been revised and validated by the material expert, LKPD evaluated by a media expert. Media experts validate the LKPD on appearance appropriateness, clarity of writing and images, language assessment, and structure. After that, suggestions and inputs given from experts were using as revision material and draft 2. Draft 2 of the LKPD was tested for legibility on class XII students as users, in which they had studied linear programming material. The readability test was led to determine whether the LKPD could remain in class XI linear programming learning. The readability test assessment instrument is assessed based on material, appearance, language, and benefits. The measurement scale of the validity assess ment instrument is in the form of a Likert scale with five assessment criteria, namely (5) excellent, (4) good, (3) sufficient, (2) less appropriate, (1) significantly less appropriate. The quantitative assessment results are converted back into qualitative data by using the guidelines for converting the assessment results to the Benchmark Reference Assessment (PAP) in Table 1.

TABLE 1. Conversion of Assessment Results with Benchmark Reference Assessment (PAP)

The assessment result (%)	Average result (%)
$0 \leq P < 45$	significantly less appropriate
$45 \leq P < 60$	less appropriate
$60 \leq P < 70$	sufficient
$70 \leq P < 80$	high
$80 \leq P < 100$	excellent

LKPD is declared valid if the results obtained from the analysis of the results of the validity assessment are included in the category of sufficient, high, or excellent ($P \geq 60$)

The practicability of the LKPD was evaluated based on the results of learning observations with the LKPD and student response questionnaires after using the LKPD. The instruments that are used to assess the practicality of LKPD are observation sheets and student response questionnaires. The measurement scale of the practicability assessment instrument used a Likert scale with four assessment criteria. The assessment results in the form of quantitative are then converted back into qualitative data by using guidelines for converting the results of the assessment to the Benchmark Reference Assessment (PAP). LKPD is declared practical if the results obtained from the observer's assessment and response questionnaire have a $P \geq 60$.

The effectiveness of the LKPD was assessed based on the pre-test and post-test results of mathematical reasoning abilities before and after using the LKPD. The effectiveness test was conducted to determine the level of success of the product in improving students' mathematical reasoning abilities. The reasoning ability test instrument consists of 3 items each of the description questions arranged based on reasoning ability indicators. The test instrument is given after students use the LKPD in learning.

Before the test instrument, the content validity is already checked by the validator, item analysis is done to determine the validity and reliability, level of difficulty, and discriminating power. After that the test instrument can be used to collect data. The test results data were analyzed using statistical tests. Before testing the hypothesis, a prerequisite analysis test is carried out, so the result that the data being tested is typically distributed and homogeneous. Prerequisite analysis test in the form of normality test, homogeneity test and independence test. The normality test used the Liliefors test, the homogeneity test used the F test to compare the variance between the pre-test and post-test scores, while the independence test used the Chi-square test, and the significance level was 5%. The analysis in this study used a t-test with a single sample. The t-test was conducted to determine whether there was a difference between the results of the pre-test and post-test, to analyze the growth of student reasoning ability, the test was performed using a normalized gain test.

LKPD is declared effective if 1) on the t-test, there is a significant difference between mathematical reasoning abilities before and after using LKPD. This condition means that the average post-test value is higher than the pre-test value; 2) The normalized gain test value results are included in the high or medium category.

RESULTS AND DISCUSSION

The results of this study are student worksheets based on problems in class XI linear programming material. The development is completed using a 4-D model, which includes define, design, development.

Define

In the define stage, an interview was completed by a mathematics teacher at SMA Negeri 6 Surakarta. From the results of the interview, The teacher used the textbooks published by the ministry of education for teaching material, there were no other teaching materials used. In addition, the teacher said that there were still weaknesses and misconceptions in the textbooks used. Therefore, other teaching materials are needed in addition to textbooks published by the Ministry of Education.

Student of class XI in SMA Negeri 6 Surakarta aged around 15-18 years old. According to cognitive development steps and constructivist theory by Piaget, someone older than 14 years old is included in the operational step and can construct knowledge through assimilation and accommodation process. Giving help is needed within building knowledge is one by teacher in learning process.

LKPD was chosen as the teaching material developed in this study because it can be arranged systematically according to the learning objectives. LKPD can be used by student directly and give them chance by constructing knowledge through homework. In its implementation, LKPD can provide direction through questions in accordance with learning activities so that students can expand and deepen their understanding [20]. Learning activities must be contained mathematical reasoning indicator such as, (1) submit alleged answers and solutions; (2) finding and using patterns to make generalizations; (3) provide an explanation of the model, image, nature, or pattern; (4) draw logical conclusions (5) check the truth of an argument.

Design

The LKPD is organized using the website www.canva.com which contains various student worksheet templates. The initial results of the preparation are a draft which includes cover, introduction, table of contents, learning objectives and concept maps of prerequisite materials, four worksheets of prerequisite material, practice questions, learning objectives, and primary material concept maps, six worksheets of the main material, summaries, practice questions, and bibliography.

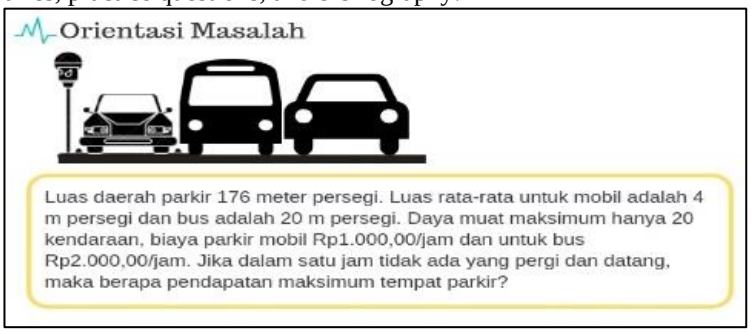

FIGURE 1. The orientation step

LKPD is arranged based on problem-based learning steps. In each stage of learning contains indicators of mathematical reasoning. In Fig. 1, the learning step starts from the problem orientation step; students were asked to submit an alleged solution to the problem of determining the maximum income of a parking lot. This stage stimulates students' mathematical reasoning abilities, namely proposing apparent answers and solutions.

FIGURE 2. Let's learn and investigate step

To start cracking the problem, let's learn and investigate step is conducted to determine the purpose of the problem. In Fig. 2, students were asked to determine the mathematical model of the issues presented in the previous stage. This stage stimulates mathematical reasoning skills, namely the indicators of finding and using patterns to make generalizations.

FIGURE 3. Let's work step

After students investigate the problem's solution, they explain the answer at the let's work step. In Fig. 3, students describe the problem-solving area. This stimulates the mathematical reasoning ability of indicators providing explanations for models, pictures, traits, or patterns.

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Develop LKPD

In developing, draft 1 LKPD was designed to obtain valid, practical, and effective LKPDs. The following are the results of LKPD development in the form of an analysis of the validity, practicality, and effectiveness assessments.

LKPD Validity

The initial draft of the LKPD was validated by experts consisting of material experts and media experts. The validation results are used to revise the initial design. The material experts consist of 1 lecturer in Mathematics Education, Faculty of Teacher Training and Education, Sebelas Maret University and 2 mathematics teachers at SMA Negeri 6 Surakarta. The assessment is calculated based on the average value of each expert. Table 2 shows the assessment of each aspect by material experts.

TABLE 2. Value of Each Aspect of LKPD by Material Expert

Assessment aspect	**Average value (%) by each expert**		
	1	**2**	**3**
Content eligibility	75,71	80	82,86
Performance eligibility	78	80	72
Language assessment	80	80	70
PBL assessment	76	78	78
Average	77	80	76
Category	**High**	**Excellent**	**High**

Based on Table 2, the value of each aspect exceeds 70% with the content feasibility having an average of 79.52%, presentation feasibility 76%, language assessment 76.67%, and PBL assessment 77%. So it can be said that every aspect has high criteria.

The media expert assessment instrument is assessed based on aspects of appearance, clarity of writing and images, language covered in LKPD, and structure. There are two material experts include LKPD editors and layout editors. The average value of each expert determines assessment. Table 3 shows the assessment of each aspect by media experts.

TABLE 3. Value of Each LKPD's Aspect by Media Experts

Assessment Aspect	**Average value (%) by each expert**	
	1	**2**
Display eligibility	78	62,5
Word and picture clarity	76	64
Language assessment	75	80
Structured aspect	73	80
Average	75,3	73,5
Category	**High**	**High**

Based on Table 3, the presentation feasibility has an average value of 70.25%, clarity of writing and pictures 70%, language assessment 77.5%, and 76.5% structured. So it can be said that every aspect has high criteria.

The readability test was carried out to six students of class XII, who were taken at random, 2 people each for each level of high, medium, and low academic ability based on report cards for the even semester of the 2017/2018 school year. Table 4 shows the analysis of the value of each aspect of the readability test.

TABLE 4. Value of Each LKPD's Aspect Readability Test Results

Assessment aspect	Average value (%)
Material	87
Display	82
Language	97
Benefit	85
Average	88
Category	**Excellent**

In Table 4, the average of the total scores for each aspect of the readability test is 88. Based on the benchmark reference assessment (PAP), the readability test results are classified as very high. In addition to providing an assessment of the product, students are asked to provide comments and suggestions.

Based on the three assessments above, the average assessment from material experts, media experts, and readability tests is classified as high criteria so the LKPD is declared valid and can be used in field trials after going through a revision process based on suggestions and input from experts.

LKPD Practicality

The practicality of LKPD was analyzed based on the results of observations and student response questionnaires. Observations were made to assess the implementation of LKPD during class learning. The observation sheet was assessed based on conformity with the lesson plan, the use of the LKPD, and the activities of the students with the LKPD. Observers consist of teachers and students. The assessment is determined from the average rating of the observer.

TABLE 5. Results of Observation of Learning Implementation

Assessment aspect	Average value (%)
RPP suitability	93
The use of LKPD	81
Student activity using LKPD	77
Average	84
Category	**Excellent**

In Table 5, the results of the assessment of each aspect have an average of 84. Based on the rules for converting the evaluation results to the benchmark reference assessment (Penilaian Acuan Patokan/PAP), practical LKPD with very high criteria. Student response questionnaires were assessed based on aspects of the material, appearance, language, and benefits.

TABLE 6. Results of Student's Response Questionnaires to LKPD

Assessment aspect	Average value (%)
Material	85
Display	94
Language assessment	89
Benefit	85
Average	88
Category	**Excellent**

Based on Table 6, the assessment results of each aspect have an average of 88, which includes very high criteria. The students' responses stated that they enjoyed using LKPD and made it easier to understand linear programming material.

Based on the assessment above, the average results of observations and student responses are classified as very high so the LKPD is declared practical and can be used in class XI linear programming learning.

LKPD Effectiveness

The effectiveness test uses the results of the LKPD implementation trial on linear programming learning for students in class XI IPS 1 SMA Negeri 6 Surakarta. Data were collected using a one-group pretest-posttest design, namely pre-test before using LKPD and then post-test after implementation of LKPD in one group of subjects. The statistical test used was divided into three stages: the test of the question instrument, the analysis of prerequisites, and the effectiveness test.

The test instrument test analyzes the mathematical reasoning ability test instrument for validity, reliability, level of difficulty, and discriminating power. Validity is assessed based on internal consistency. Of the 3 pre-test items consisting of 14 sub-items, there is 1 question with $r_{xy} < 0{,}3$ so that item is not used. Of the 3 post-test items composed of 14 sub-items, there are 2 questions with $r_{xy} < 0{,}3$ so that these items are not used. The pre-test questions that are declared valid are then calculated for reliability. Based on the reliability test, the value of $r_{11} = 0{,}79$ was obtained so that the pre-test questions were declared reliable. Post-test questions are declared valid have a value of $r_{11} = 0{,}75$ so that the post-test questions are stated reliable. The difficulty level analysis obtained two sub-items of the pre-test with an elementary level of difficulty, one sub-item with a challenging difficulty level. There are two sub-items with a very easy level of difficulty in the post-test questions so that these sub-items cannot be used.

The analysis prerequisite test was carried out before testing the hypothesis. Prerequisite tests include normality test, homogeneity test, independence test with a significance level of 5%.

The results of the normality test on the pretest data obtained $\bar{x} = 47{,}08$, $s = 19{,}94$, $L = 0{,}15$, $L_{tabel} = 0{,}173$ at the 5% significance level, so DK = $\{L|\mathrm{L} > 0{,}173\}$. Due to $F \notin$ DK, it can be concluded that the pre-test data is normally distributed.

The results of the normality test on the posttest data obtained $\bar{x} = 71{,}88$, $s = 17{,}56$, $L = 0{,}11$, $L_{tabel} = 0{,}173$ at a significance level of 5% so DK = $\{L|\mathrm{L} > 0{,}173\}$. Due to $F \notin$ DK, it can be concluded that the post-test data is normally distributed.

The results of the homogeneity test showed that the variance of the pretest value was ${s_1}^2 = 397{,}65$, the variance of the posttest value was ${s_2}^2 = 308{,}288$, $F = 1{,}2898$, the value of $F_{tabel} = 2{,}41$, DK = $\{F|F > 2{,}41\}$. Due to $F \notin$ DK, it can be concluded that the sample comes from a homogeneous population.

The results of the independence test obtained $\chi^2 = 31{,}19$, and ${\chi^2}_{tabel} = 35{,}2$, DK = $\{\chi^2|\chi^2 > 35{,}2\}$. Because $\chi^2 \notin$ DK, it can be concluded that the pre-test data is independent of the post-test data.

The effectiveness test results were analyzed based on the pre-test and post-test tests of mathematical reasoning abilities. Table 7 shows the data on the results of the mathematical reasoning ability test.

Table 7. Comparison of Pre-Test and Post Test Results

Descriptive parameter	Pre-test value	Post-test value
Average	47,08	71,88
Variances	19,52	17,19
Highest value	90	95
Lowest value	15	35

Based on Table 7, the average mathematical reasoning ability test scores have increased. The post-test variance that is smaller than the pre-test variance indicates that students' mathematical reasoning abilities after using the LKPD are more uniform. The results of the t-test obtained that the t value is -4.67 and the t_{table}value with a significance level of 5% is 2.021. Based on the results of the $t < t_{table}$ is obtained so it can be said that there is a significant difference between the pre-test and post-test results. The result shows that there is a difference between mathematical reasoning abilities before and after using LKPD. LKPD is effective if there is an increase in the mathematical reasoning ability test value after using the LKPD. The level of effectiveness of LKPD in learning is calculated using a normalized gain score. The result of calculating the gain score is 0.47. This score is included in the moderate criteria so that problem-based worksheets effectively improve students' mathematical reasoning abilities.

LKPD is considered suitable to improve students' scientific thinking skills and problem-solving. Problem-solving ability comes from the basis of students' mathematical reasoning abilities. Therefore, various studies have been developed to improve problem-solving abilities [21][22][23].

Each student has different mathematical reasoning abilities, but their reasoning plays a vital role in solving problems. Moreover, this mathematical reasoning ability is an essential skill of mathematics that is needed for several purposes, namely, to understand mathematical concepts, use mathematical ideas and flexible procedures, and reconstruct mathematical understanding [24]. Generally, in class, students' abilities can be grouped into three types: high, medium, and low ability groups [25].

The reasoning is a tool to help understand mathematics, and this mathematical understanding can be used to solve the problems presented in the LKPD. In this study, there were differences in students' reasoning abilities between the pre-test and post-test results, especially before and after using the LKPD. This statement proves that reasoning is a specific part of problem-solving work so it is an essential part of the mathematical process [26][27].

Students should be accustomed to reasoning from the first day at school to increase awareness that every statement requires a justification. In addition, students' curiosity will trigger questions such as why so, how can the answer be correct or how to do it, things like this will help sharpen the reasoning abilities of students [27].

CONCLUSION

Based on theoretical studies and supported by the results of data analysis and referring to the formulation of the problem described in the previous chapter, here are the conclusions. LKPD development uses a 4-D model up to the development stage. In the define stage, it is known that the problem at SMA Negeri 6 Surakarta is that teachers need LKPD as a guide for teaching materials in addition to textbooks published by the Ministry of Education. The design stage is in the form of drafting 1 LKPD based on a linear programming contextual problem. At the development stage, the LKPD that has been designed is then developed through development tests and field trials.

Problem-based worksheets were developed to meet the criteria of being valid, practical, and effective in improving students' mathematical reasoning abilities. Based on the development results obtained valid LKPD with an average rating of 82% with a very high category. LKPD is declared practical with an average assessment of the results of observations and student responses is 86% with a very high category. LKPD is effective in improving students' mathematical reasoning abilities based on the results of increasing post-test results.

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