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Developing Student Worksheets Based on Problem Posing Approach to Improve Students' Reasoning Ability

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ABSTRAK

Penelitian ini bertujuan untuk memperoleh Lembar Kerja Peserta Didik (LKPD) berbasis problem posing yang valid, praktis dan efektif sebagai upaya meningkatkan kemampuan penalaran. Penelitian ini adalah jenis penelitian pengembangan yang dilakukan melalui langkah-langkah Four-D yang terdiri atas define, design, development dan disseminate. Subyek uji coba dalam penelitian ini adalah siswa Kelas VIII SMP Muadz Bin Jabal Kendari. Penelitian ini menggunakan teknik pengumpulan data berupa kuisioner dan tes. Instrumen yang digunakan dalam pengumpulan data terdiri atas lembar validasi, angket respon penggunaan LKPD berbasis problem posing dan tes kemampuan penalaran materi lingkaran. Teknik analisis dalam penelitian ini dilakukan dengan mengacu pada aspek kevalidan, kepraktisan dan keefektifan. Hasil penelitian menunjukkan bahwa (1) hasil validasi dengan rata-rata skor 4,6 yang berarti LKPD berbasis problem posing berada dalam kriteria sangat valid dan layak untuk digunakan (2) Hasil analisis respon peserta didik terhadap penggunaan LKPD berbasis problem posing menunjukkan bahwa rerata respon kelas peserta didik adalah 88,54 yang berarti respos kelas positif dan termasuk dalam kategori praktis. (3) Kemampuan penalaran siswa pada konsep lingkaran mempunyai nilai rata-rata 76,0 dan berdasarkan kriteria yang ditetapkan rata-rata tingkat penalaran siswa dikategorikan tinggi. Hal ini menujukkan bahwa LKPD berbasis problem posing memenuhi kategori efektif. Dengan demikian LKPD berbasis problem posing valid, praktis dan efektif digunakan dalam meningkatkan kemampuan penalaran siswa.

Kata kunci: LKPD, problem posing, lingkaran, penalaran.

ABSTRACT

This research aims to obtain problem-posing-based student worksheets that are valid, practical, and effective worksheets as an effort to improve reasoning abilities. This type of development research carried out through Four-D steps consisting of define, design, development, and disseminate. The test subjects in this research were 8th-grade students at Muadz Bin Jabal Kendari. This research uses data collection techniques in the form of questionnaires and tests. The instruments used in data collection consisted of a validation sheet, a response questionnaire for using problem-posing-based student worksheets, and a reasoning ability test. Analysis techniques in this research were carried out concerning aspects of validity, practicality, and effectiveness. The results of the research show that (1) the validation results with an average score of 4.6, which means that the problem posing-based student worksheets are within the criteria of being very valid and suitable for use, (2) The results of the analysis of student responses to the use of problem posing-based student worksheets show that the average response The student's class is 88.54, which means the class response is positive and is included in the practical category. (3) Students' reasoning abilities on the circle concept have an average score of 76.0, and based on the established criteria, the average level of students' reasoning is categorized as high. This shows that the problem posing-based student worksheets meet the effective category. Thus, problem posing-based student worksheets are valid, practical, and effective for improving students' reasoning abilities.

Keywords: *student worksheets, problem posing, circle, reasoning.*

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Introduction

The five process standards that students need to have in learning mathematics are problem-solving, reasoning and proof, communication, connection, and representation (NCTM, 2000). The National Council of Teachers of Mathematics (NCTM) recognizes reasoning and representation as essential components of mathematics. People who think and think analytically can see patterns, structures, or similarities in real-world situations and symbolic objects; ask whether the patterns are unintentional or occur for a reason; and conjecture, prove, and describe mathematical arguments and statements. Thus, reasoning ability is one of the essential things that students need to master to support their success in learning mathematics (Hasanah et al., 2019).

Reasoning is an essential cognitive aspect of learning mathematics, especially in solving mathematical problems. Reasoning can help students solve the problems they face by encouraging them to think logically when making decisions based on past and present clauses and create new stories that are considered true (Pratiwi et al., 2021). Reasoning can also invite students to communicate thoughts and make connections between ideas and concepts in mathematics (Brodie, 2010). This shows that reasoning and mathematics are inseparable because mathematical material is understood through reasoning.

According to Brodie (2010), mathematical reasoning concerns mathematics-related things. Mathematical reasoning is a process of obtaining a conclusion based on logical-mathematical premises based on relevant facts and sources that are considered correct (Hasanah et al., 2019). Mathematical reasoning is the basis of mathematics in understanding concepts, ideas, and their relationships to solve mathematical problems (Wahyuni et al., 2019). Konita et al. (2019) state that mathematical reasoning is the ability to analyze, generalize, synthesize/integrate, and solve non-routine problems by linking previous concepts.

Mathematical reasoning is a necessary process students use to solve their mathematical problems (Wahyuni et al., 2019). Mathematical reasoning abilities encourage students to think logically, which is an integral part of the mathematics learning process. A person who has mathematical reasoning abilities is shown by indicators which include being able to (1) present verbal, written, mathematical statements, pictures, and diagrams, (2) propose assumptions, (3) carry out mathematical manipulations, (4) draw conclusions, compile evidence, provide reasons or proof of the correctness of the solution, (5) drawing conclusions from the statement, (6) checking the validity of the argument, (7) finding patterns or properties of mathematical phenomena to make generalizations (Pratiwi et al., 2021). Therefore, mathematical reasoning ability is the ability to think logically by connecting known facts, which means the ability to express hypotheses and ideas in the form of mathematical sentences, do mathematics, and make decisions.

Mathematical reasoning is also included in one of the assessment indicators tested in the Trends in International Mathematics and Science Study (TIMSS). This confirms that reasoning ability is a crucial ability for every student to have. However, the situation in the field is not appropriate, indicating that the reasoning abilities of Indonesian students still need to improve. The TIMMS 2015 report ranked Indonesia 44th out of 49 countries. The TIMMS 2015 results in mathematics achievement showed 54% low, 15% medium, and 6% high (Mullis et al., 2016). The low TIMSS results indicate that the average Indonesian student still needs help constructing their mathematical knowledge. The basis for acquiring and developing mathematical knowledge is mathematical reasoning. As Demeter states, mathematical reasoning is the foundation for constructing mathematical knowledge (Marasabessy, 2021).

Several previous study results also show the low mathematical reasoning abilities of students. Students' low mathematical reasoning abilities are caused by poor understanding of the questions, poor identification processes, and inappropriate use of data in formulas (Fisher et al., 2019). The results of other research also show that students have mathematical reasoning abilities in the low category because students are unable to carry out mathematical manipulations, are unable to conclude, compile evidence, provide reasons or evidence for the correctness of solutions, are unable to conclude from statements, and are unable to find patterns or the nature of mathematical phenomena to make generalizations (Wau et al., 2022). Responding to the difficulties students face in learning and developing reasoning abilities, teachers tend to interpret them as a result of students' efforts not being optimal in learning or students' limitations in studying teaching materials. The difficulties students face are the result of an interactive learning process between teachers, students and resources. The difficulties students face in learning may not be the result of the students themselves, but the way their teachers present the materials or the materials used in learning (Marasabessy, 2021). Therefore, appropriate learning is needed to develop students' mathematical reasoning abilities. One lesson that can help students develop their reasoning abilities is problem-posing (Voica & Pelczer, 2010).

According to Herawati et al. (2010), learning problem posing is a learning that encourages students to form/ask questions based on information or situation provided. Herawati further explained that this learning process would make students more active and creative and shape their knowledge. Kojima et al. (2009) researched problem posing. They revealed that problem-posing learning can be presented by imitating an example of problem information, and then students build a new problem from this information. Students who pose problems can connect the problem to a real-life context, are more actively involved, and can provide an understanding of mathematics. In particular, problem-posing practice can bring greater awareness of the relationship between the initial problem and the solution of the mathematical problem and better awareness of the application of problem-solving strategies, knowledge, and processes of mathematical content (Chua & Toh, 2022).

In supporting the objectives and application of problem-posing learning, researchers need to convert the material and competencies students want to achieve into a teaching medium to make it easier for students to carry out learning activities. Media use must be adjusted to students' characteristics, learning styles, and objectives (Farman et al., 2021). The learning media often used in schools is Student Worksheets (LKPD) (Lathifah et al., 2021). LKPD supports learning structured in such a way, consisting of short presentations of material and practice questions to train students to discover and develop their skills (Putra & Agustiana, 2021; Farman et al., 2021). It is hoped that LKPD can make it easier for students to understand concepts and facilitate the development of students' reasoning abilities.

This research aims to obtain a valid, practical, and effective problem-posing-based worksheet on circle material. Such a study is needed because worksheets with problem posing can stimulate interest in learning and help improve students' reasoning skills. Furthermore, in many current studies, student worksheet-based problems posed on circle material have yet to be developed.

Method

This research is a type of development research. Development research is research-oriented towards producing certain products and testing the feasibility of these products. This development research design uses the Four-D model, which consists of 4 steps: define, design, development, and disseminate (Farman, 2023). The define step is defining the provisions in learning that are used as a basis for developing learning media. This step consists of beginning-to-end analysis, concepts, tasks, and formulation of learning objectives (Muna et al., 2017). The design step is designing the LKPD to provide solutions to problems found in learning. The things that are done in this step are making the suitable LKPD and the appropriate format. In this step, an initial LKPD will be obtained, which will be tested first in the development step. The development stage involves carrying out LKPD tests through validation and limited trials. Expert and practitioner testing is carried out by mathematics learning experts and experienced teachers to assess and provide input on the initial product. Test these experts and practitioners to validate the product before being tested in the field. Validation activities are carried out until a learning device with a valid category is obtained. Field trials are carried out in a classroom learning activity. The trial activity aims to determine the practicality and effectiveness of LKPD in learning. Researchers analyzed the data from this trial and then revised it to produce a practical and effective product. The dissemination stage was only for 8th-grade mathematics teachers at Muadz Bin

Jabal Kendari Middle School. Widespread testing activities have yet to be carried out due to limited time.

The test subjects in this research were 8th-grade students at SMP-TQ Muadz Bin Jabal Kendari. This research uses data collection techniques in the form of questionnaires and tests. The questionnaire was used to determine expert and student assessments regarding the LKPD being developed. The test is used to obtain data about the development of mathematical reasoning on circle material while using the LKPD. The instrument used in the research aims to assess the design of the LKPD being developed. The instruments developed include (1) a LKPD validation sheet, (2) a reasoning ability test, and (3) a student response questionnaire. The validation sheet is used to find out data about the quality of the LKPD created by researchers based on the assessments of lecturers/experts. The test contains questions describing circle material with reasoning indicators. The student response questionnaire contains questions designed to determine students' opinions about problem-posing-based student worksheets supporting their ability to reason about circle material. This questionnaire asks students to give the most appropriate "yes" or "no" answer according to them. The indicators used as assessments in the questionnaire are appearance, student motivation, instructions and understanding, readability, language use, and student reasoning.

Analysis techniques in this research were carried out concerning aspects of validity, practicality, and effectiveness. Data analysis of the LKPD validation results was performed by calculating the mean of each criterion and characteristic of the checklist, and then calculating the overall mean of the examiner's assessment. Validity categories are determined using the following criteria: very valid ($4 \leq VR < 5$), valid ($4 \leq VR < 3$), less valid ($3 \leq VR < 2$), and invalid ($1 \leq VR < 2$). LKPD is considered valid if the average assessment score from the validators has a validity value of at least 3 (Farman, et al., 2021).

Student response questionnaires are used to measure students' opinions regarding LKPD. The student response questionnaire data were analyzed as scores by converting each student's mean score to a range from 0 to 100 and calculating the average score of all respondents $\bar{S}$. The following criteria determine the average gain: (a) Positive response when $\bar{S} > 50$ (b) Negative response when $\bar{S} \leq 50$. (Farman & Chairuddin, 2020). Learning design is categorized as practical if the class response is positive.

The effectiveness of LKPD is measured through a test of mathematical reasoning abilities after using LKPD. Data obtained from the results of the reasoning ability test were analyzed as the final score of the learning test, calculating the student's reasoning achievement, calculating the total average of the student's overall reasoning achievement (ASR) and making conclusions with the criteria very high ($85 \leq ASR \leq 100$), high ($70 \leq ASR < 85$), medium ($55 \leq ASR < 70$), low ($40 \leq ASR < 55$), and very low (ASR

<40) (Farman & Yusryanto, 2018). LKPD is effective if the student's score is at least in the high category.

Results and Discussion

1. Define

The define step is carried out through beginning-to-end analysis, concept analysis, task analysis, and learning objective analysis. In the initial final analysis, information was obtained that students needed help developing their reasoning abilities. One learning approach that can develop reasoning abilities is problem-posing. Stoyanova and Ellerton differentiate between problem-posing situations depending on the level of structure, namely free, semi-structured, and structured problem-posing (Harpen & Presmeg, 2013). The choice of problem posing used in this research is a structured form of *problem posing* (*structured problem posing*). Structured *problem posing* is posing questions by creating a new problem based on the problem given by the teacher and solving the problem. So, this form *of problem-posing* is done by reformulating the problem with several changes to make it more straightforward and more understandable in order to solve the problem. Therefore, the material and competencies that students want to achieve need to be converted into a teaching medium so that it makes it easier for students to carry out learning activities. In this case, it is necessary to design mathematics worksheet media that is interactive, varied, and can be accessed anytime and anywhere (Astika et al., 2019).

Concept analysis is done by examining and determining the concepts students will study. The concept designed in this LKPD is a circle. Task analysis aims to identify student tasks that refer to essential competencies and indicators of student learning outcomes. The fundamental competencies and indicators of student learning outcomes that will be identified are circle material, which includes circles and parts of circles, circumference of circles, area of circles, sizes of central angles and circumferential angles of circles, as well as central angles, length of arcs and area of circles. Finally, analyze the goals for achieving learning outcomes. The learning objectives for students in the concept of a circle are that students can determine the parts of a circle, the circumference of a circle, the area of a circle, the size of the central angle, and the circumferential angle of a circle, as well as the central angle, length of the arc and area of the circle.

2. Design

The LKPD referred to in this development is a systematic guide that contains instructions and questions that lead to an activity using students' reasoning abilities. LKPD is designed and arranged based on title, learning objectives, keywords, motivation, instructions, and activities. The LKPD is designed with a combination of blue and orange. Overall, the LKPD divides the concept presentation into five parts: parts of a circle, the circumference of a circle, the area of a circle, the central angle and circumferential angle of a circle, and the central angle, arc length, and circle area. The appearance of the cover design and front page containing the title, learning objectives, keywords, motivation, and instructions is presented in Figure 1.

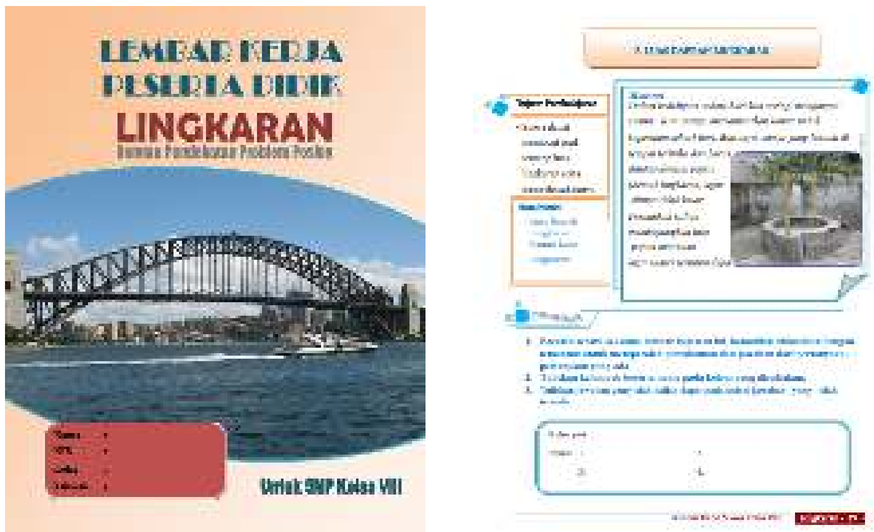


Figure 1. Cover and the front page of worksheet

In the next section, this LKPD presents assignments as problems that are worked on with group friends and independent assignments that students do independently in class. This assignment requires students to complete it step by step according to the instructions given. The instructions given refer to rearranging the questions to complete the task as a whole. In this case, students are facilitated with a structured problem-posing approach. At the end, there are practice questions to do at home.

Figure 2. Problem and individual tasks in worksheet

3. Development

a. Validation

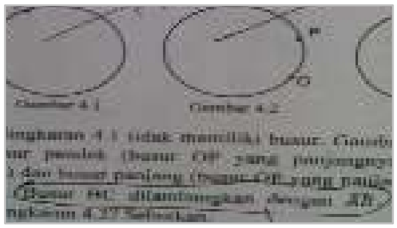
The validation process is done by submitting the LKPD, instruments, and validation sheets to the validator. The validator assesses based on the criteria on the validation sheet. The validation results for each validator are presented as follows.

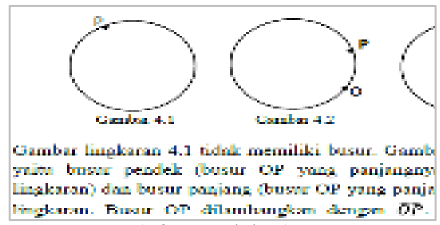
Table 1. Student Worksheet Validation Results

Aspects/Criteria	Validator			CA	AA	TA
	1	2	3			
FORMAT						
1. Clarity of distribution of material	4	5	5	4.7		
2. Has attraction	4	5	5	4.7		
3. Space or location arrangement	4	5	4	4.3	4.7	
4. Appropriate font type and size	5	5	5	5		
5. Suitability of images/illustrations	5	5	5	5		
CONTENTS						
1. Suitability of content/material/questions with indicators and learning objectives	4	4	5	4.3		
2. Suitability for *problem-posing learning*	4	5	5	4.7		4.6
3. Conformity of tasks to the sequence of material	4	5	5	4.7	4.4	
4. Encourage students to develop their reasoning abilities	3	4	5	4		
5. Correct use of terms and symbols	4	5	4	4.3		
LANGUAGE						
1. Use correct Indonesian language rules	4	5	5	4.7		
2. Suitability of sentences to students' level of thinking	5	5	4	4.7		
3. Clear and does not contain double meaning	5	4	5	4.7	4.7	
4. Clarity of instructions and directions	5	5	5	5		
5. The communicative nature of the language used	5	5	4	4.7		

Note: CA= Criteria Average, AA= Aspect Average, TA= Total Average

Based on the table above, the total average (TA) validation obtained is 4.6, and based on the validity criteria set, the LKPD *prototype* meets the valid category with slight revisions. The revised parts of the LKPD include (1) the sentence "elements of a circle" becomes parts of a circle and "area of a circle becomes "area of a circle", (2) the use of appropriate mathematical notation, and (3) adjustment between picture illustrations with the information provided.


(before revision)



(after revision)

Figure 3. Revised Student Worksheet

The LKPD is also validated on student response questionnaires and reasoning ability tests at this stage. Each validator on the student response questionnaire provided validation results. The total average validation of student response questionnaires was 4.6. Based on the validity criteria set, the student response questionnaire prototype meets the valid category with slight revisions. The only revisions made were writing errors.

Meanwhile, the validation results given by each validator on the reasoning ability test sheet were 4.5. This shows that based on the validity criteria set, the prototype of the reasoning ability test meets the valid category with slight revisions. In general, the validation results from the validators of the LKPD and learning instruments are categorized as valid. After revisions have been carried out, the next step is to carry out field trials on the prototype.

b. Implementation

After obtaining a valid LKPD, the LKPD is tested in a class learning activity. This LKPD was tested in class five times. In this lesson, each student is given an LKPD, which is completed by posing problems through group discussions, and the results are presented alternately by several groups at each meeting. Then, at each meeting at the end of the lesson, students are given assignments and quizzes, which are done individually. After learning the topic of circles is complete, a reasoning ability test on the circle material is then carried out to determine the effectiveness of the LKPD, and students fill out a questionnaire to determine the practicality of the LKPD.

Based on the development method proposed, LKPD is practical if it is easy for students to use. Practicality data was obtained through student response questionnaires filled in by students at the end of the trial. The results of the analysis of student response data are briefly presented in the following table:

Table 2. Student Response Questionnaire Results

Question Items	Student Response	
	Yes (%)	**No (%)**
Are you interested in the physical appearance of the LKPD?	93.8	6.2
Are you interested and motivated to use this LKPD?	81.3	18.7
Does the clarity of the LKPD instructions and directions make it easier for you to understand the circle material?	84.4	15.6
Is the size and type of font used in this LKPD easy to read?	100	0
Is the language used in LKPD easy for you to understand?	71.9	28.1
Do the assignments and exercises in the LKPD help you develop your reasoning skills regarding the material?	100	0
Average	88.54	11.36

Analysis results from Table 2. above show that the average student response to the learning process and LKPD is 88.54%. This means that the student's response to the learning process and LKPD is positive. The results of the student's reasoning ability tests' are presented in Table 3.

Table 3. Reasoning Ability Test Results

Score		Category
Highest	95.8	Very high
Lowest	20.8	Very low
Average	76	High

Based on test result data and reasoning level standards, if a student scores 70 or more out of 100, he or she is considered to have high reasoning ability and score only 6 out of 100. Students whose scores do not meet the minimum criteria for consideration, five students in the medium category and one very low category students. Students who score in the low category are because they rarely participate in learning activities due to illness. Apart from that, the level of reasoning for all students averages 76.0. Thus, all students' reasoning levels are in the high category.

Based on data analysis from trial results, the development of student worksheets based on problem posing approach meets the specified criteria: valid, practical, and effective. Thus, problem-posing-based student worksheets have helped students arouse their' interest and mathematical reasoning abilities. Akay & Boz (2010) revealed that learning using problem posing creates a positive attitude toward mathematics learning. Sugandi (2018) stated that problem-posing can improve students' reasoning abilities.

Conclusion

This research develops problem-posing-based student worksheets that meet the criteria of valid, effective, and practical for improving students' reasoning abilities. The validation results of the LKPD show this with an average score of 4.6, which means the LKPD is suitable for use. The analysis of student responses to LKPD showed that the average student class response was 88.54. These results show that the problem posing-based student worksheets are in the positive category, meaning that posing-based student worksheets are practically used in learning. Students' reasoning abilities on the circle concept have an average score of 76.0 and based on the criteria set, the average level of students' reasoning is categorized as high. This shows that the problem posing-based student worksheets meet the effective category.

This LKPD refers more to problem posing in the form of structured problem posing. In the future, consider developing LKPD that focuses on other forms of problem posing (free or semi-structured), taking into account and considering the learning objectives to be achieved. The material can also be expanded to other mathematical domains (e.g., numbers, algebra). Additionally, current technological developments have allowed educators to develop digital-based LKPD. In the future, it is hoped that the development of LKPD will be integrated with technology, including using a live worksheets platform. This can undoubtedly increase students' interest in learning.

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