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DEVELOPMENT OF PROBLEM-BASED LEARNING STUDENT WORKSHEETS ON STATISTICAL MATERIAL ON THE ABILITY TO UNDERSTAND MATHEMATICS CONCEPTS

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ABSTRACT

This study aims to produce Problem-Based Learning student worksheets (LKPD-PBL) on statistical material on the ability to understand mathematical concepts for class VIII SMPN 17 Bengkulu City, which are valid and practical. The urgency of this study is based on the importance of enhancing students' ability to understand mathematical concepts. Preliminary observations indicate that many students struggle to deeply comprehend statistical concepts due to conventional teaching methods. Therefore, an innovation in teaching materials is needed to help students develop their conceptual understanding through the Problem-Based Learning (PBL) approach. This study was a Design Research (DR) using type development studies, consisting of level preliminary and level prototyping with flow formative evaluation, self-evaluation, one-to-one, expert review, small group, and field test. The study instrument consists of a validity questionnaire, a practicality questionnaire, and interviews. The study results showed that the development of LKPD-PBL was: 1) valid based on the results of revisions through the expert review and one-to-one stages regarding aspects of material, construction, language, and readability; 2) practical based on the results of revisions through the small group stage regarding ease, clarity, and usefulness.
Keywords: Design Research, Problem-Based Learning, Student Worksheets, Understanding Mathematical Concepts.

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PRELIMINARY

For most students, studying mathematics is not enjoyable, as evidenced by their consistently low mathematics scores (Arizon & Irwan, 2021). Students' low mathematical proficiency is due to their limited understanding of mathematical concepts. The low ability to understand mathematical concepts results in students giving poor results in mathematics learning (Klorina & Prabawanto, 2023). Students often need clarification and have difficulties learning mathematics due to a lack of understanding of mathematical concepts (Rahimah, 2009). Meisya and Arnawa (2021) stated that students were still less able to apply mathematics learning concepts when given training due to their lack of ability to understand mathematical concepts. When studying mathematics, students must have the

ability to understand mathematical concepts. This skill is crucial as it trains students to think deductively and recognize relationships between mathematical concepts in real life (Anin & Dirgantoro, 2023).

Understanding mathematical concepts is a basic ability in the mathematics learning series. Understanding mathematical concepts is the ability to understand various mathematical topics, including knowing the concepts being studied, seeing how concepts are used, solving problems presented, and understanding concepts that can be expressed in other forms (Pasaribu et al., 2020). Students must first understand the concept to solve mathematical problems and their real-life applications (Fitriani et al., 2023). In fact, in general, students still need to improve their understanding of mathematical concepts. One of the most challenging topics for students is statistics. This subject has unique characteristics, such as involving the understanding of abstract concepts, data analysis, result interpretation, and the use of various representations, making it difficult to grasp without an appropriate instructional approach.

Based on the observations and interviews with mathematics teachers and students at SMPN 17 Bengkulu City, researchers found several problems in the mathematics learning process, including the lack of teaching materials that could guide participants to discover mathematical concepts independently. Learning is teacher-centered; students only receive the material provided directly, so they are less actively involved in learning. Students need help understanding mathematical concepts, especially in statistics material. This is proven by looking at the statistical daily test score data; 19 out of 32 students' scores still need to be below the Minimum Completeness Criteria (KKM), meaning that 59.375% of students still need to complete their studies. These things certainly have an impact on student achievement and learning outcomes. The success of teaching and learning activities is influenced by teacher factors, students, and how the teaching and learning activities are carried out (Rahimah, 2006).

The lack of teaching materials in schools is the main obstacle to implementing mathematics learning. Teachers' teaching materials have yet to help students learn to understand mathematical concepts (Priyatno et al., 2021). Researchers observed that teachers did not use textbooks in teaching. The school provides textbooks published by the Ministry, uses a scientific approach, and adapts them to the Independent Curriculum. Teachers reported difficulties using the textbook due to the lack of clear guidelines and steps for discovering concepts. For example, in statistical material, textbooks only present definitions, formulas, and example problems without systematically guiding students to

understand fundamental concepts, relate them to real-life situations, or develop critical thinking skills. As a result, students tend to memorize formulas without truly understanding the underlying concepts. The case is the same as the findings made by Rahimah (2022), which states that teachers are reluctant to use textbooks because they have limitations in supporting a scientific approach, and teachers are still hesitant and experience difficulties in using textbooks that cannot be properly accounted for.

Teachers only use teaching modules purchased from publishers in the teaching and learning process. However, the teaching modules still need to be more effective in guiding students to discover mathematical concepts independently. The teaching module only summarizes the material, formulas, and example questions. The comprehension material is difficult to understand and does not contain clear processing steps, so students need clarification about how to solve the questions correctly. It is recommended that the teaching module be accompanied by other teaching materials that can improve students' ability to understand mathematical concepts. One of the teaching materials that can support the learning process is student worksheets (LKPD).

LKPD is a good learning alternative because it helps students increase information about the concepts studied through structured learning activities (Armiati & Purwanti, 2019). LKPD is a type of printed teaching material that includes activities containing instructions and steps that must be carried out to maximize understanding and achieve learning goals (Novelia et al., 2017). LKPD makes it easier for educators because students will learn independently to understand concepts and carry out written assignments (Marshel & Ratnawulan, 2020). LKPD is very important in the learning process because it can help students understand the material taught by the teacher (Aliza et al., 2018). LKPD can also increase understanding and strengthen students' memory of the material being taught (Serevina & Heluth, 2022). LKPD can help students discover and understand concepts independently through the activities they do.

Apart from using LKPD, implementing an appropriate learning model will also determine the success of learning. One of the proper learning models to support LKPD is Problem-Based Learning (PBL) (Fortuna et al., 2021). The PBL model is a learning model that uses real-world problems as a learning context and demands optimal student activity in critical thinking, problem-solving skills, and acquiring problem-based knowledge (Husniah & Azka, 2022). The PBL model also helps students to be mindful of the issues around them, and understudies will be effectively included in communicating mathematics thoughts and displaying their mathematics learning (Putri et al., 2021). Hermansyah (2020)

states that the PBL model has the advantages of 1) challenging abilities and providing satisfaction in finding new information; 2) increasing learning motivation; 3) helping transfer knowledge to understand real-world problems; 4) helping to acquire new knowledge and develop it; 5) develop critical thinking skills and adapt to new knowledge. With the existence of LKPD-PBL, thinking skills in understanding mathematical concepts can be developed with activities that ask students to make assumptions to find concepts (Setiyaningrum & Sari, 2023).

Previous research states that LKPD-PBL has a good influence on students' ability to understand mathematical concepts. The research results of Basri et al. (2020) concluded that the development of LKPD-PBL can increase students' understanding of concepts in the categories of valid, practical, and effective. The same thing is true; research conducted by Istiqomah et al. (2023) stated that LKPD-PBL supported concept understanding, as evidenced by increased students' knowledge of mathematical concepts. The PBL model has been adapted to a scientific approach involving students actively in the learning process to improve students' skills in asking questions, trying/gathering information, reasoning, and communicating, which can help improve understanding of concepts (Melati et al., 2019).

Based on the background description above, LKPD-PBL on statistical material is necessary for understanding valid and practical mathematical concepts. The results of this research can be a reference in developing better teaching materials and an inspiration for educators to get students used to working on problem-based mathematics questions.

METHODS

The product developed in this study is LKPD-PBL for eighth-grade junior high school statistics material. The LKPD-PBL is designed to guide students in understanding mathematical concepts through contextual problem-solving processes. It incorporates the stages of PBL, including problem orientation, organizing students, facilitating investigation, developing solutions, and evaluating the problem-solving process. Through these stages, students are expected to actively construct their conceptual understanding and engage more deeply in the learning process.

The type of research used is design research-type development studies, which refers to the Tessmer development model. This model consists of a preliminary stage and a prototyping stage (formative evaluation), which includes self-evaluation, expert reviews, one-to-one, small group, and field tests (Tessmer, 1993). The research procedure carried

out at the prototyping stage with a formative evaluation flow adapted to Tessmer (1993) can be seen in Figure 1.

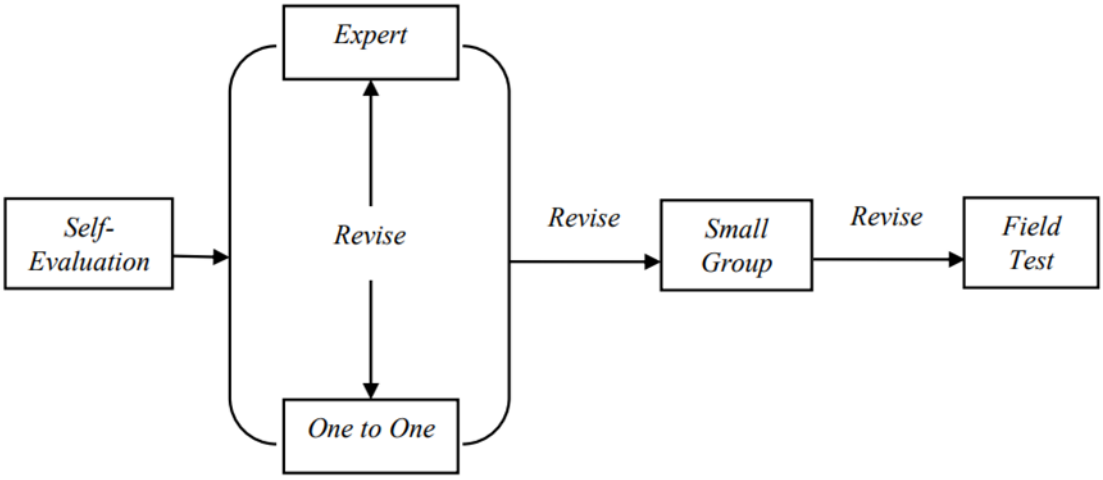


Figure 1. Formative Evaluation Research Procedure

At the self-evaluation stage, the initial prototype LKPD was reviewed and evaluated by the researcher to produce prototype 1 LKPD. At the expert review stage, prototype 1 LKPD was validated by several experts. At the one-to-one stage, prototype 1 LKPD was also tested along with the expert review stage with several students to see the validity of the LKPD in terms of readability. Suggestions and comments from experts and one-to-one were used to revise the LKPD so that prototype 2 LKPD was valid and obtained. At the small group stage, prototype 2 valid LKPD was tested in small groups to determine the practicality of the LKPD in producing prototype 3 LKPD valid and practical. At the field test stage, prototype 3 LKPD, valid and practical, were tested on research subjects.

The research subjects were 31 students in class VIII A of SMPN 17 Bengkulu City who were randomly selected. Meanwhile, the teacher selected the trial samples based on the students' diverse abilities and those of other classes. The one-to-one trial sample consisted of three students from classes VIII D and VIII E. The small group trial sample consisted of six students from class VIII E. This development research focused on developing LKPD with statistical material for class VIII JUNIOR HIGH SCHOOL. The study was carried out in the even semester of the 2023/2024 academic year.

The instruments used in this research were validity questionnaires, practicality questionnaires, and interviews. The validity questionnaire is used to determine the validity of the LKPD-PBL. The practicality questionnaire is used to determine its practicality.

Interviews were conducted to explore students' comments or suggestions regarding the LKPD.

The data analysis technique uses descriptive analysis. The stages for analyzing data from the validity and practicality questionnaire are: 1) assessing each item based on two aspects, namely usability and revision; if it is revised, the validator will write things that need to be revised in the revision notes column provided, 2) make improvements based on the revision of the notes, 3) assessment is carried out repeatedly if there are still revisions, 4) assessment will stop when there are no revision notes in each aspect. Data from interviews in the form of comments and suggestions regarding LKPD were analyzed by describing them.

RESULT AND DISCUSSION

LKPD-PBL development begins with a preliminary stage and a prototyping stage with a formative evaluation flow. The results and discussion of the LKPD's development are described below.

Preliminary Stage

The preliminary stage consists of two stages: the preparation stage and the preparation stage. In the preparation stage, problem and needs analysis, curriculum analysis, and student characteristics analysis are carried out. The preparation stage refers to the results of the preparation stage to produce an initial prototype of the LKPD. The steps for preparing LKPD are carrying out curriculum analysis based on the preparation stage, compiling a map of LKPD needs, determining LKPD titles, and writing LKPD. The results of the preliminary stage as the initial design for LKPD development are presented in Table 1.

Table 1. Results of the Preliminary Design Stage of LKPD Development

Analysis	Results	Solution
Problem and Need Analysis		
Learning Materials	Statistics material is difficult for students to understand. Many need help understanding the basic concepts of statistics.	Develop LKPD with statistical material that can help students understand basic statistical concepts.
Teaching Materials	The teaching materials used are teaching modules, which contain material summaries, formulas, and example questions.	Develop LKPD, which includes activities to discover and understand concepts through clear and systematic activities and work steps.
Learning Process	Learning is still centered on the teacher; students must be more actively involved.	Developing LKPD with a Problem-Based Learning model that is student-centered through a collaborative problem-based learning approach.

Curriculum Analysis		
Curriculum	Schools still need to implement the independent curriculum optimally; students are not actively involved in learning, discovering, and understanding material concepts independently.	Developing LKPD with a problem-based learning model based on the independent curriculum. Students are actively involved in understanding concepts independently through activities on problem-based LKPD.
Analysis of Student Characteristics		
Academic Ability	Students' academic abilities in statistics material are heterogeneous; some have low, medium, and high skills.	Developing LKPD that can help students with diverse abilities understand statistical concepts through problem-based learning.
Concept Understanding	Students' understanding of mathematical concepts still needs to be improved, especially in statistics material.	Developing LKPD can help students with low conceptual understanding abilities through problem-based learning.
Student Character	The character of students is heterogeneous. Some are highly interested in learning and are active, while others are less active.	Developing LKPD that can help students with diverse characters and interests through problem-based learning.

Prototyping Stage (Formative Evaluation)

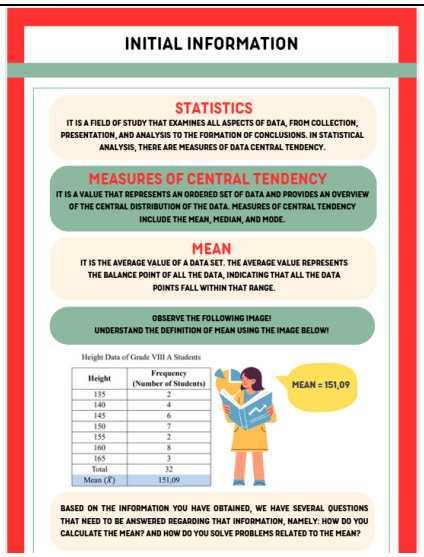
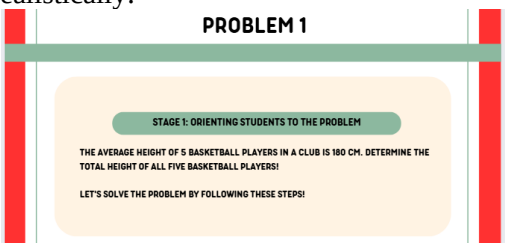
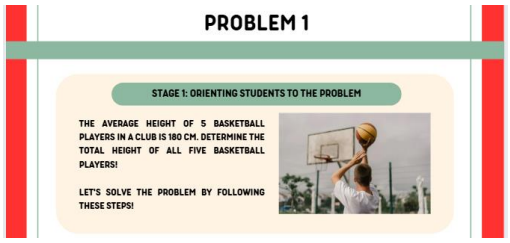
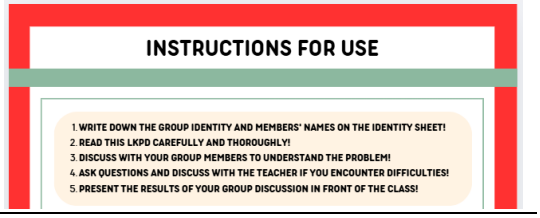
The results of the initial draft of the LKPD, which has passed the preliminary stage, will be subjected to formative evaluation through the self-evaluation, expert review, one-to-one, small group, and field test stages. The results of the formative evaluation stage are described as follows.

Self-Evaluation Stage

At this stage, the researcher reviewed and evaluated the initial prototype of the LKPD-PBL, which had been prepared at the preparation stage. Evaluations are carried out repeatedly at different times and at different time intervals. The assessment is based on three aspects: material, construction, and language. In this evaluation process, various improvements were made according to these three aspects. The revised evaluation results produced prototype 1 LKPD. The evaluation results of each aspect can be seen in Table 2.

Table 2. Evaluation Results of the Self-Evaluation Stage

Number	Before Revision	After Revision
1.	From the material aspect, no introductory information in the form of pictures, tables, or graphs can help the thinking process.	Added introductory information in the form of tables and figures.

Number	Before Revision	After Revision
		
2.	From the construction aspect, no drawings for each problem can represent the problem realistically.	Add images to each problem.
		
3.	From a language aspect, the instructions for using the LKPD still use full stops, even though the sentences are command sentences.	The full stop is changed to an exclamation mark.
		

Expert Review Stage

At this stage, prototype 1 of the LKPD-PBL was then validated by several experts. Prototype 1 was given to three experts: expert validators (lecturers) and practitioner validators (teachers), namely two mathematics education study program lecturers and one mathematics teacher. Prototype 1 was assessed, evaluated, and given input from material, construction, and language aspects. Each validator assesses one aspect according to their respective areas of expertise. In this validation process, various improvements were made according to these three aspects. The validation results for each element can be seen in Table 3.

Table 3. Expert Review Stage Validation Results

Aspect	Rated Aspect	Revision Notes
Material	The LKPD has met the learning objectives of determining the size of data concentration (mean, median, and mode).	The initial information in LKPD 1 regarding the mean needs to be clarified. For medians in LKPD 2, initial information should be provided for even and odd data.
Construction	The title of the LKPD is visible.	The LKPD's subtitle, "Model Problem-Based Learning," is not clear enough to read, so you should change the font.
Language	The language used in the LKPD is appropriate for students.	In problem 3 on page 11 of LKPD 1, it is best to replace the phrase "satu pekan" with "satu minggu" to make it easier for children to understand.
	The punctuation used in the LKPD is correct and appropriate.	On page 2, instructions for using each PBL stage, the explanation section is equipped with punctuation marks.

One-to-One Stage

At this stage, prototype 1 LKPD-PBL, which had been prepared and evaluated by the researcher, was also tested one-on-one (along with the expert review stage) on three students one-to-one (individually) who were selected based on their abilities, namely each of them high, medium, and low determined by the mathematics teacher in the class. This trial was carried out to see the validity of the LKPD in terms of readability and problems in the questions on the LKPD-PBL. After conducting the trial, students were asked to fill out a questionnaire and provide comments regarding questions that were difficult to understand, and interviews were conducted. At this stage, suggestions and one-to-one comments from experts are used to revise the LKPD. From the revision results, a valid prototype 2 LKPD-PBL was obtained. The results of the one-to-one trial for improving the LKPD are presented in Table 4.

Table 4. Results of One-to-One Phase Trial

Rated Aspect	Revision Notes
I can understand the steps in the LKPD easily.	The steps in LKPD 1 regarding settlement procedures could be more understandable.
This LKPD helped me conclude.	LKPD 1 helped me gather information but did not help me conclude.
The problems given in the LKPD are easy for me to understand.	Problem 2 on LKPD 2 is difficult for me to understand.
The writing on the LKPD is clear and easy to read.	Activity 2, page 8 of the LKPD 3 section, with the subtitle "determining the middle value of the sequence," should be clarified so that it does not merge with the question.

Based on the results of the revised LKPD developed at the expert review and one-to-one stage, it was found that the LKPD-PBL on statistical material had been declared

valid with the validity assessment stopping at the second trial meeting because there were no revision notes on any aspect of the validity sheet. This is by the statement of Fajri et al. (2022) that in development study type design research, the validity of LKPD is determined at the formative evaluation stage, namely the expert review and one-to-one stage. Comments and suggestions at the expert review stage and students' knowledge at the one-to-one stage regarding the problem and readability of questions, initial design, or prototype 1 is certified as qualitatively valid (Zulkardi et al., 2020).

The LKPD developed in terms of the material aspect has met the learning outcomes and objectives to be achieved. The steps used in the LKPD are based on the PBL model syntax and are designed to guide students in attaining indicators of understanding mathematical concepts. The problems given on the LKPD are by the statistical material and learning objectives. Assignments on LKPD can guide students in understanding mathematical concepts in statistics material. Activities in LKPD have been designed to guide students in restating an idea, presenting concepts in mathematical representations, using certain procedures or operations to solve problems, and applying concepts or algorithms in problem-solving. This is in accordance with the statement by Gustin et al. (2020) which states that a valid LKPD is one that aligns with the implemented material and corresponds to the intended learning outcomes and objectives.

The LKPD is considered valid from a construction aspect if the LKPD design is based on the development components that have been determined. The LKPD has fulfilled the required structures and formats, namely containing the identity or title of the LKPD, user identity, learning achievements and objectives, work instructions, supporting information, work time, and tasks and work steps. LKPD has also fulfilled the design aspect with an attractive appearance due to the suitability of the colors, writing, and images presented. The layout of the LKPD is also appropriate, such as the pages on the LKPD not being too dense with writing, using a numbering and writing system, and having clear images. The LKPD also contains clear PBL syntax or steps and work orders. This is in line with the statement by Sari et al. (2020) that the construct requirements in developing LKPD relate to its structure, format, design, and stages. According to Prastowo (2015), the necessary structure and format of LKPD should include a title, user identity, learning objectives and outcomes, LKPD work instructions, supporting information, work duration, assignments, and work steps.

The LKPD meets several linguistic aspects, including using the correct type of letters to make the writing on the LKPD easy to read. The language used in the LKPD is

also appropriate to the level of students' abilities. LKPD also meets the accuracy and appropriateness of punctuation, question sentences, command sentences, and language by good and correct Indonesian language rules. The LKPD also meets the aspects of the language used, namely simple, clear, and easy to understand. LKPD must be easily understood by its users, and comprehension should be preceded by effective communication. Therefore, the language used must be appropriate for the students (Kosasih, 2021).

Small Group Stage

At this stage, the practicality of the LKPD-PBL will be seen by conducting trials in small groups of six students selected by the teacher directly with the provisions of high, medium, and low-ability students. The six students will be divided into three groups consisting of two students each. At this stage, students discuss how to solve problems on the LKPD. During the work process, observations were made to see the practicality of using the LKPD. After completing the work, students are asked to fill out a questionnaire and provide comments regarding difficult questions; then, an interview is conducted. From the students' comments, the LKPD was revised, and the results of the revision produced prototype 3 LKPD-PBL, which was valid and practical. The results of small-group trials for improving LKPD are presented in Table 5.

Table 5. Results of the Small Group Phase Trial

Rated Aspect	Revision Notes
This LKPD helps me gather information.	There was little information that I could get and collect on LKPD 1 and 2.
The writing on the LKPD is clear and easy to read.	LKPD 2, page 11, has an incorrect word writing (kosep).
The problems given in the LKPD are easy for me to understand.	On LKPD 3 page 12, on the first question, I need help understanding the problem in question.
Overall, the LKPD is easy for me to use.	It's easy for me to use the LKPD, but I have difficulty allocating time to work on it because I don't have time to work on activities and problems.

Based on the results of the revised LKPD developed at the small group stage, it was found that the LKPD-PBL on statistical material had been declared practical, with the practicality assessment stopping at the second trial meeting because there were no revision notes on any aspect of the practicality sheet. In the design research and development study type, the practicality of LKPD is determined at the small group stage. The small group testing stage was carried out to see the practical aspects of the LKPD being developed because the results of this stage will be input for making improvements so that a practical LKPD is obtained (Fajri et al., 2022).

LKPD is practical if the LKPD developed can be used by students in the learning process without many problems. LKPD is considered practical if users or students do not encounter difficulties in terms of material presentation or the use of learning media (Tuzzahra et al., 2020). The practicality components used as an assessment include ease, clarity, and usefulness in using LKPD (Rahayu et al., 2019). The practicality of the LKPD is obtained from the fulfillment of these components, namely the existence of instructions and steps on the LKPD that students can understand and follow easily. The sentences and writing on the LKPD are easy for students to read and understand. The images used in the LKPD are also appropriate to the material so that it is clear for students to understand the images. The practicality of LKPD can also be seen from the LKPD aspect, which can help students work together in groups, collect and process information, understand the concepts being studied, and draw conclusions.

Field Test Stage

After obtaining a valid and practical prototype 3 LKPD-PBL, a field test was carried out. The LKPD was tested on research subjects, namely 31 students in class VIII A of SMP Negeri 17 Bengkulu City. The learning process is carried out at the field test stage using LKPD. The field test results are used to see students' ability to understand mathematical concepts after using the LKPD. During the field test, the researcher observed the learning process by making observations.

Discussion

The results of this study align with the research conducted by Istiqomah et al. (2023), which found that LKPD-PBL supports concept comprehension, as evidenced by students' improved mathematical knowledge and engagement in the learning process. The similarity between this study and previous research lies in the effectiveness of PBL in enhancing students' understanding of mathematical concepts. However, this study highlights differences in the readability and structure of LKPD, where validation results suggest the need for improvements in language use and problem presentation to better suit the characteristics of junior high school students. Additionally, this study includes a field trial phase to assess the effectiveness of LKPD-PBL in actual classroom settings.

The implementation of PBL in this study significantly improved students' understanding of mathematical concepts. Students became more actively engaged in exploring concepts through problem-solving in LKPD-PBL, such as identifying data patterns and interpreting results independently before receiving explanations from the teacher. This approach fostered critical thinking and student autonomy compared to

conventional teacher-centered methods. Furthermore, student interaction increased, as evidenced by discussions in finding solutions, indicating that LKPD-PBL also enhanced collaborative skills in mathematics learning.

Although LKPD-PBL effectively enhances students' understanding of mathematical concepts, its implementation presents several challenges. This method requires more time than conventional learning, as students must explore and discuss before fully grasping the concepts. Additionally, teachers' readiness to facilitate discussions remains a challenge, as does students' adaptation, with some initially being passive in problem-based learning. Therefore, effective guidance strategies are necessary to help students adapt and actively engage in the LKPD-PBL approach.

CONCLUSION

Based on the description of the research results, it can be concluded that the development of LKPD-PBL on statistical material on the ability to understand mathematical concepts was declared valid based on the results of revisions through the expert review and one-to-one stages regarding aspects of material, construction, language, and readability. The LKPD was declared practical based on the results of revisions through the small group stage regarding ease, clarity, and usefulness.

The research results into developing LKPD-PBL on statistics material can be used as teaching material for mathematics subjects. Teachers or other researchers should be able to create LKPD-PBL using different materials. Researchers also hope that teachers or other researchers can implement problem-based learning, especially those that use real problems.

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