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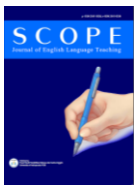

Research Article

Problem-Based Learning Worksheets to Improve Concept Understanding Skills of Sixth-Grade Elementary School Students

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A B S T R A C T

This research is motivated by the lack of skills in understanding mathematical concepts among sixth-grade elementary school students. This study aims to develop Problem-Based Learning worksheets to improve the concept understanding skills of sixth-grade elementary school students. The research subjects are 30 sixth-grade students at SDN 2 Sido Binangun. The development stages of the method used in this research are Research and Development (R&D) with the ADDIE model. The instruments used in this research are validation sheets, student response questionnaires, and teacher response questionnaires. The research data consists of questionnaire results, the feasibility of the worksheets, and the responses of students and teachers, which are analyzed qualitatively and descriptively based on score criteria. The results show that Problem-Based Learning worksheets can improve students' concept understanding with an N-Gain of 0.63. Therefore, it can be concluded that Problem-Based Learning worksheets can enhance the concept-understanding skills of sixth-grade elementary school students.

INTRODUCTION

The development of science and technology (IPTEK) in the 21st century makes education very important in producing the human resources (HR) needed by the world (Rohman, Fauzan, and Yohandri 2020; Afrijal et al. 2023; Rohman et al. 2023). Education is a conscious effort to improve an individual's knowledge, attitudes, and skills. However, based on research conducted by the International Educational Achievement (IEA), International in Mathematics and Science Study (TIMSS), and Programme for International Student Assessment (PISA) all show that the literacy levels in reading, science, and mathematics of students in Indonesia consistently rank lower compared to other countries. In 2018, Indonesia ranked 72nd out of 77 countries in reading literacy and 70th out of 78 in science literacy (OECD, 2018).

Mathematics consists of abstract ideas symbolized in a hierarchical and deductive manner, making it a high-level mental activity (Hasratuddin, 2021). Mathematical knowledge is essential for students to develop logical and systematic thinking, communicate ideas, solve everyday problems, and foster reasoning abilities (Umar, Hasratuddin, and Surya 2022; Alzanatul Umam and Zulkarnaen 2022). One of the objectives of mathematics education, according to the Ministry of National Education (Depdiknas), is to ensure that students can understand mathematical concepts deeply, explain the relationships

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between concepts clearly, and apply mathematical concepts or logic fluently, accurately, efficiently, and appropriately in problem-solving (Budiarti, Purwanto, and Hendriana 2019). In line with these objectives, learning mathematics requires students to understand concepts well. At the elementary school level, mathematical concepts must be well instilled in students because elementary school students tend to think concretely (Apriliyana, Masfu'ah, and Riswari 2023).

Concept understanding is when a student has comprehension and can explain the material learned based on their understanding, making learning meaningful (Cahyaningsih and Nahdi 2021). Indicators of concept understanding include students' ability to explain concepts in their own words, distinguish examples and non-examples of an idea, and conclude a concept without specific imagery or symbols (Umar, Hasratuddin, and Surya 2022; Siems-Muntoni et al. 2024). Concept understanding is a student's ability to master the knowledge the teacher gives comprehensively, not just by knowing but also by understanding it. Thus, students know and can also understand and apply the concepts in daily life. Agreeing with this(Harianja, Tampubolon, and Manalu 2023; Sujana 2023; Bosica, Pyper, and MacGregor 2021).

Based on an interview with the teacher of Grade VI at SD Negeri 2 Sido Binangun, several reasons indicate that students' performance on solid shapes remains low and below the minimum competency criteria (KKM) of 70. One of the main reasons is that many students struggle to understand the fundamental concepts of solid shapes, such as identifying the properties of solids and calculating their volume and surface area. This issue is reflected in the test results, which show that most students could not answer questions that assessed their understanding of solid shapes correctly. The teacher also noted that fewer than ten students achieved scores above the KKM, and most students needed clarification when asked to apply the theory to practical problems. Further efforts are required to improve their understanding, including more interactive and applied teaching approaches.

Further findings in this study reveal that teaching materials in Student Worksheets have yet to be utilized in the learning process. The material presented by the teacher is sourced from government-published books available at the school. Many teachers still need help developing student worksheets even though they effectively improve students' learning outcomes. To address these challenges, it is necessary to create accessible and engaging mathematics lessons and various learning resources.

The low understanding of concepts is demonstrated by most students being unable to reformulate the solutions to the given problems (Umam & Zulkarnaen, 2022). Additionally, teaching materials in the form of student worksheets have not yet been used in the learning process; the material educators deliver is from government-published books available at the school. Many teachers still struggle to develop worksheets, even though worksheets is very effective in improving student learning outcomes. To address students' difficulties, it is necessary to develop accessible and enjoyable mathematics learning and varied learning resources.

Educators can enhance concept understanding by using teaching materials and applying learning models. The Ministry of Education and Culture (Kemdikbud, 2010) states that teaching materials are designed to support educators in learning. Teaching materials used in elementary school teaching and learning process include Student Worksheets. Worksheets is an instructional tool consisting of questions from information designed to guide students in understanding complex ideas as they work systematically (Choo et al. 2011). When creating worksheets, it is necessary to pay attention to the requirements for its preparation. Didactic requirements relate to the universal use of worksheets, meaning advanced and slower students can effectively use it. Construction requirements are shown through simple Language, clear sentence structure, good vocabulary, etc. A creative and attractive worksheets appearance, appropriate use and placement of images, limited font selection, etc, demonstrate technical requirements. Meeting these three requirements makes the developed worksheets fall into the practical category (Rohman et al. 2023).

A learning model can guide educators in achieving learning objectives, thereby improving student learning outcomes. Among the various learning models that can be used, the Problem-Based Learning (PBL) model can be applied in the learning process. PBL is a problem-based learning model where instruction is delivered by presenting a problem, asking questions, facilitating investigation, and opening dialogue ()(Pramudiyanti et al. 2023; Sani, 2015; Yinka, Tunde, and Hakeem 2021; Bosica, Pyper, and MacGregor 2021; Harianja, Tampubolon, and Manalu 2023; Reed, Mullen, and Boyles 2021). Furthermore, (Kosasih 2014; Van Hooijdonk et al. 2024; Desnita et al. 2021; Sujana 2023) states that problem-based learning is carried out by providing stimuli in the form of problems, which are then solved by students, aiming to enhance their skills in mastering learning materials.

Based on the above explanation, this research introduces an innovation by developing Problem-Based Learning-based mathematics worksheets to improve concept understanding among sixth-grade elementary school students. The novelty in developing these worksheets lies

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in its application to elementary school students to improve learning outcomes in three-dimensional shape material. Based on the background presented, the researcher conducted a study to develop Problem-Based Learning-based mathematics worksheets to improve the concept understanding of sixth-grade elementary school students.

METHOD

The type of research used in this study is Research and Development (R&D) with the ADDIE method. Research and development methodology is utilized to produce a specific product and test its effectiveness. This study aims to develop teaching materials in the form of Problem-Based Learning-based mathematics worksheets to enhance the concept understanding abilities of sixth-grade students at SDN 2 Sido Binangun. The research procedure adapts the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The stages of the ADDIE model are as follows:

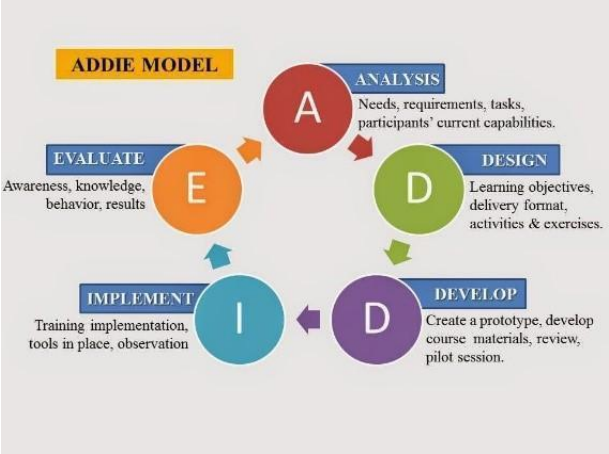

Figure 1 ADDIE Phases According to Branch (2009:2)

1. Analysis

The initial stage or analysis in the development process of the worksheets conducted by the researcher involved analyzing the problems and needs of both educators and students. This included activities such as observing the learning process, utilizing learning resources, understanding student characteristics, and identifying the issues that necessitate the development of Problem-Based Learning (PBL) worksheets. Additionally, the researcher analyzed the Learning Outcomes (Capaian Pembelajaran or CP) and Learning Objective Flow (Alur et al. or ATP) to be achieved to enhance concept understanding in mathematics, precisely the material on cubes and rectangular prisms for sixth-grade students at SDN 2 Sido Binangun.

2. Design (Initial Product Design)

In this stage, the framework for the Problem-Based Learning worksheets is drafted, and assessment instruments are designed. The worksheets are designed using Canva Pro and printed on A4 paper with visually appealing images to attract students' attention. Based on the previously analyzed worksheet specifications, this stage aims to design the initial product, including the validator and practicality assessment instruments.

3. Development (Product Development)

The product development stage involves validating the Problem-Based Learning worksheets by six expert validators: two material validators, two media validators, and two language validators. The product development stage aims to determine the validity of the Problem-Based Learning worksheets.

4. Implementation

Once the worksheets are validated and deemed valid, the next stage is testing them with students and educators. Two sixth-grade teachers at SDN 2 Sido Binangun conducted the educator trial, while the student trial involved 30 students. The purpose of the implementation stage is to determine the practicality of the worksheets based on the responses of students and educators during the development of the Problem-Based Learning worksheets.

5. Evaluation

The evaluation stage follows the implementation phase. The evaluation stage aims to determine the effectiveness of the Problem-Based Learning worksheets in improving learning outcomes by administering pre-test and post-test activities. The results will be used as a reference to observe the improvement in learning outcomes by comparing the results before and after using the Problem-Based Learning worksheets.

Research Procedure

1. Validity Analysis

This analysis aims to measure the validity level of the developed Problem-Based Learning worksheets by referring to the assessment scores from the material, media, and language validators. After calculating the Aiken index, the results can be interpreted according to Table 1.

Table 1 Interpretation of Product Validation Index

Score Range	Criteria
V > 0,8 – 1	Very valid
V > 0,6 – 0,799	Valid
V > 0,4 – 0,599	Sufficiently valid
V > 0,2 – 0,399	Less valid
V ≤ 0,2	Not valid

2. Practicality Analysis

Practicality analysis is necessary to assess the responses of students and educators regarding the feasibility of the developed Problem-Based Learning worksheets. The level of product feasibility can be calculated using the mean formula, with the feasibility categories based on the Likert scale calculation, as shown in
Table 2.

Table 2 Categories of Educator and Student Feasibility

Score Range	Category	Criteria
81% x ≤ 100%	Very good	Eligible
61% x ≤ 80%	Good	
41% x ≤ 60%	Sufficient	Not Eligible
21% x ≤ 40%	Less	
≤ 21%	Very less	

3. Effectiveness Analysis

The effectiveness analysis of the problem-based learning worksheets can be determined from the students' pre-test and post-test results. The assessment results serve as a reference for improving students' concept understanding. The effectiveness test can be calculated using the N-Gain Score. The criteria for evaluating the N-Gain score are explained in Table 3.

Table 3 N-Gain Criteria

Score Range	Normalized Score
g-Hight	g ≥ 0,7
g-Moderate	0,7 > g ≥ 0,3
glow	g < 0,3

Meanwhile, pre-test and post-test results can be categorized as shown in Table 4.

Table 4 Categorization Based on Pre-test and Post-test Results

Category	Normalized Score
Very Hight	X ≥ M + 1.5 SD
Hight	M + 0.5SD ≤ X < M+1.5SD
Moderate	M-0.5SD ≤ X < M+0.5SD
Low	M-1.5SD ≤ X < M-0.5SD
Very Low.	X < M-1.5 SD

RESULTS AND DISCUSSION

This research was conducted through the analysis phase (preliminary study) to understand and analyze the initial conditions, including field needs analysis, learning achievement mapping analysis, learning objectives analysis, and analysis of student needs in the sixth grade of SD Negeri 2 Sido Binangun. The analysis phase involved interviewing sixth-grade educators at SD Negeri 2 Sido Binangun. From the interviews, it was found that student learning outcomes were not optimal, especially in Mathematics. It was noted that the teaching process did not use instructional materials such as worksheets. The educators relied on government-published textbooks available at the school. Many teachers faced difficulties in developing worksheets, although worksheets are known to be highly effective in improving student learning outcomes (Choo et al. 2011; Reed, Mullen, and Boyles 2021; Sujana 2023; Rohman et al. 2023; Rohman F et al. 2023).

The second stage is the design phase. During this stage, a framework for Problem-Based Learning-based worksheets was developed and accompanied by assessment instruments. These worksheets were designed using the Canva application and printed on A4 paper. The objective of this stage was to design the initial product and assessment instruments for validity and practicality based on the worksheet specifications analyzed in the previous stage. The design result of the Problem-Based Learning-based worksheets can be seen in Figure 2 below.

Figure 2 Display of Mathematics Worksheets based on Problem-Based Learning

The revised Problem-Based Learning worksheet is designed as a teaching material developed to enhance student learning outcomes.

In the third stage, development, the worksheet has been tailored to meet the educational needs of students regarding the topics of cubes and rectangular prisms based on Problem-Based Learning. This phase involved validating the Problem-Based Learning-based worksheet product, which was assessed by six validators comprising two language experts, two media specialists, and two subject matter experts. Testing was conducted to assess the validity of the Problem Based Learning-based worksheet, and revisions were made based on feedback and suggestions from the validators. The results of the Language, media, and subject matter experts' validation can be seen in the following table.

Table 5 Results of Language Expert Validation

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Aspects Assessed	Score Range	Category
Fluent	0,8333	Very Valid
Communicative	0,8750	Very Valid
Dialogical and interactive	0,8750	Very Valid
Suitability with student development	0,8750	Very Valid
Suitability with language rules	0,8438	Very Valid
Average	0,8604	Very Valid

The results of linguist validation of Problem-Based Learning (PBL)-based worksheets showed an Aiken's V value of 0.8604, which is included in the Very Valid category. This result indicates that the worksheet is in accordance with the language criteria needed for learning. The Feasibility Test on the Language aspect includes several important assessments, such as fluency, communicativeness, and language suitability for student development. Clear and understandable language is very important in supporting the learning process because it can reduce student confusion in following instructions and understanding the material (Rohman F et al. 2024). In addition, communicative and interactive language increases student engagement in discussion and problem solving, an indispensable aspect of PBL-based learning (Rohman F et al. 2023).

Furthermore, the language used in the worksheets is adapted to the students' cognitive development level. This ensures that the material presented can be well understood without confusing students (Afrijal et al. 2023; Apriyani, District, and Rosidin 2022). Adherence to language rules, such as correct spelling and grammar, is also very important to establish good literacy in students (Choo et al. 2011; Arcavi 2020). Thus, these worksheets not only teach the subject matter, but also support the development of correct language skills (Reed, Mullen, and Boyles 2021; Rohman F et al. 2023).

Based on the data in Table 5, it can be observed that the language validation achieved an Aiken's V index of 0.8604, categorizing it as highly valid. This validation was based on clarity, communicativeness, dialogical and interactive features, suitability for student development, and adherence to language norms. Therefore, it can be concluded that the language validation of the Problem-Based Learning worksheet is highly valid and suitable for field testing.

Table 6 Results of Media Expert Validation

Aspects Assessed	Score Range	Category
Worksheet Size	0,8125	Very Valid
Cover Content Design)	0,8036	Very Valid
Content Layout Design	0,8250	Very Valid
Average	0,8137	Very Valid

The results of the media expert validation showed that the Problem-Based Learning (PBL)-based worksheet obtained an Aiken's V of 0.8137, which is classified as Very Valid. This indicates that the worksheet media design, including the worksheet size, cover design, and content layout, is very suitable for use in learning. Good media design plays an important role in making materials more engaging and making it easier for students to access the necessary information. With appropriate design, students can more easily understand the tasks given and are more interested in engaging in the learning process.

In general, effective media design helps create a learning environment that supports successful learning. Valid design aspects, such as size and neat layout, can minimize confusion and speed up students' understanding of the material. An attractive design can also increase students' motivation, encouraging them to participate more actively in learning activities. This is very influential in PBL-based learning, where student interaction and involvement are needed to solve the given problem. Therefore, the validity of this media aspect indicates that the worksheets can be used effectively in field trials and in daily learning contexts.

Based on the data in Table 6, the overall media validation results obtained an Aiken's V index of 0.8137, categorizing it as highly valid. This validation was based on aspects such as the size of the worksheet, cover design, and content layout. Therefore, it can be concluded that the media validation of the Problem-Based Learning worksheet is highly valid and suitable for field testing.

Table 7 Results of Content Expert Validation

Aspects Assessed	Score Range	Category
Content Validity Aspect	0,8104	Very Valid
Presentation Validity Aspect	0,8073	Very Valid
Language Validity Aspect	0,8063	Very Valid
Average	0,8080	Very Valid

The results of the material expert validation of the Problem-Based Learning (PBL) based worksheet showed that the worksheet obtained an Aiken's V of 0.8080, which is included in the Very Valid category. This shows that the

content and presentation of the material in the worksheet are very much in accordance with the expected criteria in learning. This validation assesses the suitability of the material to the applicable curriculum as well as its relevance to student development, which is important to ensure the material can be well received and understood by students. Materials that are tailored to the curriculum and students' cognitive development level will make it easier for them to absorb information and apply it in a broader context.

The generalization of these results shows that material validity has a significant impact in improving the quality of learning. Materials that are relevant to the curriculum and appropriate to students' developmental needs will support better understanding and increase students' engagement in the learning process. In PBL-based learning, where students are faced with real problems to solve, the relevance of the material to everyday life and the ability of students to relate the concepts learned are very important. With high material validity, this worksheet can be used effectively in field trials and can have a positive impact on students' ability to think critically and solve problems.

Based on the data in Table 7, the overall content validation results obtained an Aiken's V index of 0.8080, categorizing it as highly valid. This validation was based on aspects such as curriculum alignment and content appropriateness. Therefore, it can be concluded that the content validation of the Problem Based Learning-based worksheet is valid and suitable for field testing.

The researcher retested the developed product in the implementation phase to assess its validity. Practicality testing was conducted with 30 sixth-grade students and educators at SD Negeri 2 Sido Binangun. Before receiving the product, students underwent a pre-test to gauge their initial knowledge. Subsequently, the product was implemented. The next step involved administering a post-test to assess any differences in learning outcomes before and after using the Problem-Based Learning worksheet. Likert scales were used for assessment. The results from the implementation, as evaluated by student and educator validators, can be seen in the following table 8.

Table 8 Practicality Results from Students

Aspects Assessed	Score Range	Category
Interest	86	Very Good
Material	89	Very Good
Language	88	Very Good
Average	88	Very Good

The results of the practical feasibility test on students using the Problem-Based Learning (PBL) based worksheet showed an average score of 88%, which is classified as Very Good. This assessment covers three main aspects: engagement, content and language. The 86% score on the interest aspect shows that the worksheet successfully attracts students' attention and engages them in learning. This high engagement is important in PBL, as it can increase students' motivation and involvement in solving problems (Sanjaya, 2016). The material aspect scored 89%, indicating that the content is highly relevant and easy to understand, supporting students to think critically and solve problems systematically (Bransford et al., 2000). The language aspect scored 88%, indicating that the language used is clear and appropriate for students' cognitive abilities, facilitating effective communication in learning.

Overall, the success in these three aspects indicates that the PBL-based worksheets are highly effective in improving student engagement and understanding of the material. The PBL approach that encourages collaboration and problem solving is further supported by well-designed worksheets. This result confirms that the use of appropriate language, relevant materials, and increasing student interest are instrumental in developing critical thinking, collaboration, and communication skills.

Based on the data in Table 8, the overall practicality assessment of students using the Problem-Based Learning-based worksheet yielded an overall score of 88%, categorized as excellent. The practicality assessment was based on Engagement, Content, and Language. Specifically, for Engagement, it achieved 86% with a rating of excellent; for Content, it achieved 89%, also rated as excellent; and for Language, it achieved 88%, again rated as excellent.

Table 9 Practicality Results of Educators

Aspects Assessed	Score Ranger	Category
Material Suitability	88	Very Good
Suitability of Language Rules	86	Very Good
Suitability of Language Rules	87	Very Good
Display Attractiveness	85	Very Good
Average	86	Very Good

The results of the feasibility test of the Problem-Based Learning (PBL)-based worksheets showed an average score of 88%, which falls into the Very Good category. The feasibility test assessed three main aspects: engagement, content, and language. The 86% score on the interest aspect shows that the worksheet successfully attracts students' attention and increases their engagement, which is very important in PBL learning based on collaboration to solve

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problems. This student engagement increases motivation and accelerates their understanding (Sanjaya, 2016). The 89% score on material indicates that the content is very relevant and easy to understand, supporting students' critical thinking skills in solving problems (Bransford et al., 2000). While the 88% score on language indicates that the use of language in the worksheet is very suitable for students' abilities, facilitating effective communication in the learning process.

Overall, the results of this feasibility test prove that PBL-based worksheets are very effective in increasing student engagement and understanding of the material. The success in the aspects of interest, material, and language prove that the worksheets support the development of critical thinking, collaboration, and communication skills, which are essential in PBL-based learning. Thus, these worksheets can be used as an effective tool to create a more interactive and immersive learning experience for students.

Based on the findings presented in Table 9, the overall practicality assessment of educators using the Problem-Based Learning (PBL)-based worksheet showed an excellent score of 86%. This assessment was grounded on various criteria: content suitability achieved a high rating of 88%, indicating its strong alignment with educational objectives. The PBL syntax appropriateness received an equally commendable score of 86%, affirming its effectiveness in fostering problem-solving skills. Language norms adherence attained a solid 87%, highlighting its compliance with linguistic standards. Additionally, the layout feasibility garnered a respectable 85%, underscoring its practical design for instructional use.

The evaluation stage was tested in an experimental class with 30 students to assess the effectiveness of problem-based learning worksheets. The following are the average pre-test and post-test scores of students in the test class.

Table 10 Results of Pre-test and Post-test

Effectiveness Test	Result	*N-Gain* Skor	*N-Gain* Skor %	Criteria	Category
Pre-test	49	0,63	63,00	Medium	Moderately effective
Post-test	80				

Based on Table 10, it illustrates that there is a significant difference between the pre-test and post-test results as evidenced by the N-Gain value recorded of 0.63 indicating that the PBL approach has a positive influence on improving student understanding (Hake 1998), but it is still in the medium category. Nonetheless, the improvement recorded indicates that PBL is effective in helping students develop a better understanding of the material taught in accordance with the findings in research (Nugraheni and Sutama 2023; Umar, Hasratuddin, and Surya 2022; Rohman et al. 2024).

Furthermore, Table 10 provides an explanation that there is a significant difference between the pre-test and post-test results using the LKS. This is evidenced by the pre-test value of 49 and the post-test value of 80. If the data is grouped into five categories, namely Very High, High Medium, Low, Very Low groups to measure high-level understanding, it can be presented in Table 11.

Table 11 Categories of Conceptual Understanding Abilities Based on Pre-test and Post-test Results

Category	Score	Mean	SD	*Pre-test*	*Post test*
Very High	$X \geq M + 1.5$ SD			0	3
High	$M + 0.5SD \leq X < M+1.5SD$			0	19
Medium	$M-0.5SD \leq X < M+0.5SD$	64,58	18,60	12	8
Low	$M-1.5SD \leq X < M-0.5SD$			13	0
Very Low	$X < M-1.5$ SD			5	0

Table 11 shows the grouping of students' conceptual understanding based on the pre-test and post-test results. In the pre-test, most students were in the medium (12 students), low (13 students), and very low (5 students) categories. However, after participating in learning using PBL-based worksheets, the post-test results showed significant improvement. Three students were in the very high category, 19 students in the high category, and 8 students in the medium category. This indicates that the application of PBL-based worksheets has a positive impact on increasing students' conceptual understanding (Choo et al. 2011; Reed, Mullen, and Boyles 2021; Sutika et al. 2023).

This result is reinforced by statistical tests using paired sample t-test, which shows a Sig value = 0.000, smaller than 0.05. Thus, Ho was rejected and H1 was accepted, indicating a significant difference between the pre-test and post-test scores, where the post-test results were higher. The findings in the study are relevant and confirm that the use of PBL-based worksheets significantly improves students' concept understanding (Rohman et al. 2024; Nugraheni and Sutama 2023).

CONCLUSION

Based on the research results and discussion, it can be concluded that the mathematics worksheets based on Problem-Based Learning (PBL) development effectively

improve students' understanding of concepts in the sixth grade of elementary school.

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