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Design and development of mathematics student worksheets based on problem based learning to improve understanding of spatial geometry in elementary schools

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ABSTRACT

This study aims to develop teaching materials in the form of Student Worksheets (LKPD) based on Problem-Based Learning for spatial geometry material in fifth grade elementary schools. The background of this study is the low mathematics learning outcomes and the limited teaching materials that can encourage active student involvement. The development process uses the ADDIE model with validation from material experts, media experts, and design experts which shows that the developed LKPD meets the criteria of very valid. The results of the effectiveness test show that this LKPD is able to improve conceptual understanding, active involvement, and student learning outcomes in mathematics learning. This study concludes that LKPD based on Problem-Based Learning is suitable for use as an alternative teaching material in elementary schools. The recommendation from this study is the need for teachers to integrate problem-based teaching materials into mathematics learning on an ongoing basis and to develop other materials and levels so that the results are broader and deeper.

INTRODUCTION

Elementary education is a crucial foundation for developing students' thinking skills and skills for the next level of education. Mathematics, as a core subject, plays a significant role in developing logical, analytical, and systematic thinking skills. However, many elementary school students still struggle to grasp mathematical concepts, particularly spatial geometry (Wijaya et al., 2024). This material requires visualization skills, spatial imagination, and an understanding of the relationships between three-dimensional shapes, which are often abstract for elementary school-aged students. Limited availability of concrete media and less interactive teaching materials contribute to students' poor understanding of these spatial concepts.

Spatial geometry plays a crucial role in everyday life and in the development of higher-order thinking skills Zetriuslita et al., (2025). Understanding the shape, size, and position of objects in space helps students develop spatial reasoning, the ability to visualize, manipulate, and understand the relationships between objects. This ability not only forms the foundation for learning advanced mathematics such as algebra and trigonometry but also contributes to other fields such as science, technology, and the arts. Therefore, mastery of spatial geometry from an early age needs to be facilitated through contextualized learning and encouraging active student involvement.

International survey results, such as those from the Program for International Student Assessment (PISA), show that Indonesian students' mathematics skills remain below the average of participating countries, with mathematics literacy scores in the range of 375, placing Indonesia 73rd out of 80 PISA participating countries (PISA, 2019). This low achievement indicates the need for more innovative learning strategies, particularly in developing conceptual understanding and critical thinking skills. Several studies Nur et al., (2022), Hickendorff et al., (2019) and Haliza & Sari (2025) confirm that difficulties in learning mathematics in elementary schools are largely due to a lack of motivation,

monotonous learning methods, and teaching materials that do not encourage active and reflective thinking.

One approach considered effective in addressing these issues is Problem-Based Learning (PBL). The PBL model places students at the center of learning by emphasizing contextual problem-solving, encouraging them to think critically, analyze, and find solutions independently. In the context of learning spatial geometry, PBL is particularly relevant because it can help students connect abstract concepts to real-world situations, such as determining how much water a particular aquarium or toy box can hold, or figuring out how to arrange several lunch boxes so that they fit in a bag without leaving too much empty space. Thus, PBL not only enhances conceptual understanding but also develops higher-order thinking skills.

Previous research Koerunnisa et al., (2025) and Mulyasari (2022) has shown that Problem-Based Mathematics Worksheets (LKPD) are effective in improving critical thinking and mathematical problem-solving skills. However, most of this research focuses on numbers or basic operations, while PBL-based teaching materials for spatial geometry are still limited, particularly for fifth-grade elementary school students. In fact, according to Piaget's theory, students' cognitive development at this age is in the concrete operational phase, where learning becomes more meaningful when accompanied by concrete and visual problem-solving activities.

Based on this background, this study aims to develop valid, practical, and effective Problem-Based Mathematics Worksheets (LKPD) for fifth-grade elementary school spatial geometry. This development is expected to improve students' understanding of spatial concepts and critical thinking skills, and serve as an alternative, innovative teaching material for teachers in implementing active, creative, and enjoyable mathematics learning.

RESEARCH METHODS

This research is a research and development (R&D) project aimed at producing teaching materials in the form of Student Worksheets (LKPD) based on Problem-Based Learning (PBL) for fifth-grade elementary school Mathematics, specifically on the topic of Understanding Cubes and Rectangular Cubes. The goal of this development is to produce teaching materials that meet the criteria of validity, practicality, and effectiveness, thereby improving the quality of student learning processes and outcomes. The development model used is the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Diniyah et al., 2025).

The analysis stage was conducted to identify learning needs, obstacles experienced by students, and actual conditions in the field. Based on observations in fifth-grade students at SD Negeri 064990, it was found that mathematics learning still relies on textbooks, with a minimal variety of teaching materials that encourage critical thinking. Students also demonstrated difficulty in understanding spatial geometry concepts, particularly regarding cubes and recessive cubes. These findings align with research by Netson & Ain (2022) revealed that elementary school students often experience difficulties in understanding abstract mathematical concepts. Therefore, innovative teaching materials are needed that are suited to the characteristics of fifth-grade students and can also increase their engagement in learning.

Based on the analysis, the design phase focused on planning the development of PBL-based student worksheets (LKPD). The LKPD design took into account the applicable curriculum, core competencies, learning indicators, and PBL syntax, which encompasses problem orientation, organization, investigation, development, and analysis of results. At this stage, research instruments were also developed, including expert validation sheets, student response questionnaires, and learning outcome tests.

In the development phase, the LKPD design was then realized as a preliminary product. The preliminary product was validated by material experts, media experts, and instructional design experts to ensure its content, presentation, and integration with the PBL model. This validation is crucial to ensure the resulting teaching materials meet the expected quality criteria (Ramezani & Mostafavi, 2025).

The implementation phase was conducted through a limited trial on fifth-grade students at SD Negeri 064990. The study population consisted of all 77 fifth-grade students, divided into three classes. The sample was determined using purposive sampling, considering equivalence in academic ability, willingness to participate in the trial, and comparable teacher backgrounds. Based on these considerations, two classes with 52 students were selected and then divided into two groups (experimental class 1 and experimental class 2).

The evaluation phase was conducted to assess the effectiveness of the developed PBL-based Student Worksheets (LKPD). The evaluation instruments included learning outcome tests, student response questionnaires, and observation sheets for learning implementation. The research design used a pretest-posttest to assess improvements in student understanding before and after the use of the LKPD. The data obtained were analyzed quantitatively to assess improvements in learning outcomes and descriptively to assess student responses. This evaluation was used not only to assess the success of the product but also to provide a basis for making improvements to optimize the LKPD and ensure it meets the needs of elementary school students.

RESULTS AND DISCUSSION

In the initial stage of developing mathematics student worksheets (LKPD) based on Problem-Based Learning (PBL), a needs analysis was conducted as part of the ADDIE development model. This analysis stage was divided into two sub-stages: an initial needs analysis and a student needs analysis.

The initial needs analysis aimed to determine the extent to which currently available teaching materials could support the achievement of learning objectives. Through classroom observations and discussions with teachers, it was discovered that students experienced difficulties in understanding the material on geometric shapes, particularly in connecting mathematical concepts to everyday contextual problems. This aligns with previous research findings that indicate that limited contextual teaching materials can hinder the understanding of mathematical concepts (Azizah, 2025). Furthermore, researchers distributed questionnaires to two homeroom teachers at SDN 064990 Kwala Bekala to obtain further information regarding the initial needs for developing teaching materials. The questionnaire results indicated the need for more interactive and problem-based teaching materials to increase student engagement.

The student needs analysis was conducted to identify students' readiness and abilities to participate in PBL-based learning. Based on interviews with teachers and previous evaluations of student learning outcomes, it was found that the teaching methods used did not encourage active student engagement in critical thinking. This resulted in poor conceptual understanding and decreased student motivation, which aligns with research by Nurbavliyev et al., (2022) which emphasized the importance of active learning in improving student motivation and understanding. Furthermore, questionnaires distributed to 26 fifth-grade students corroborated these findings, with the majority expressing a need for more engaging and intellectually challenging teaching materials.

The results of the initial needs analysis and student needs analysis indicated a significant need to develop PBL-based mathematics worksheet (LKPD) teaching materials that could address challenges in understanding spatial concepts and increase student active engagement. These findings provide an important basis for proceeding to the teaching materials design stage. Therefore, developing teaching materials that respond to these needs is expected to improve the effectiveness of mathematics learning in the classroom.

Description of the Design Phase Result

The design phase aims to develop learning materials that are in accordance with the results of the needs analysis, student characteristics, and curriculum that have been analyzed previously. In this phase, the content structure, delivery strategy, supporting media, and design for learning evaluation will be formulated. Some of the main activities in the design stage of Problem Based Learning-based LKPD teaching materials are as follows:

a. The formulation of Learning Outcomes (CP) and Learning Objectives (TP)

Based on the indicators that have been analyzed previously, the Learning Outcomes (CP) and Learning Objectives (TP) are designed to improve students' problem solving skills and critical thinking skills in accordance with the Problem Based Learning approach. The complete formulation is presented in the following table.

Table 1. Learning Outcomes and Objectives

Learning Outcomes (CP)	At the end of phase C, the learning outcomes are: 1. Learners can recognize various spatial figures, can arrange and decompose spatial figures. 2. Learners can determine the position of objects against other objects. 3. Learners can classify, compare, and present data.
Learning Objective (TP)	1. Through group discussion activities, students classify various kinds of objects according to their shape (cubes and rectangular prisms) correctly. 2. Through group discussion activities, learners can identify the simple elements of building spaces (cubes and rectangular prism) correctly.

b. Concept Maps and Materials Concept Maps

To support a structured understanding of the learning content, concept maps were developed to outline the main ideas and relationships within the material on cubes and rectangular prisms, including their properties, nets, and real-life applications. The material is then organized so that it can be presented in the form of problem-based activities. The concept map of the material can be seen in the figure 1.

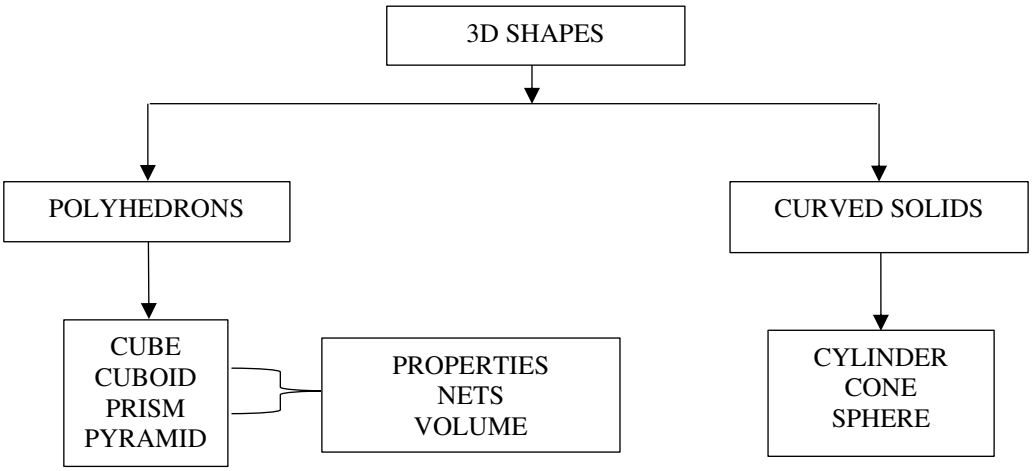

Figure 1. Concept Map of the Building Space Material

c. Design of Problem Based Learning (PBL) Based Mathematics Learner Worksheet (LKPD)

At this stage in the activity, researchers are faced with steps to compile teaching materials on one particular product to be tested and revised to be implemented in the field. The structure of the Problem Based Learning (PBL)-based Mathematics Learner Worksheets (LKPD) developed in this study includes: cover, preface, table of contents, PBL syntax, learning outcomes and objectives, material, collection of PBL-based questions, reading list, and author profile. The cover of the book with the title "Learner Worksheets (LKPD) Build Spaces" is equipped with images related to the topic of discussion. It can be seen in the figure 2.

Figure 2. LKPD Cover

Description of Development Stage Results

At the development stage, the aim of developing teaching materials for problem-based learning (PBL)-based mathematics student worksheets (LKPD) is carried out in accordance with the design that has been designed. To create a prototype of teaching materials that are ready to be tested and applied, while ensuring the product meets the needs, design, and learning objectives. Then validation from learning experts is needed. Validation of learning experts in the Development of Teaching Materials for Mathematics Learner Worksheets (LKPD) Based on Problem Based Learning (PBL) for grade V Elementary School consists of 2 (two) learning material experts, 2 (two) learning media experts, and 2 (two) learning design experts. Based on the assessment questionnaire instrument that has been given to learning material experts, learning media experts, and learning design experts, the validation results of each expert can be seen as follows:

a. Assessment by Learning Material Experts

The assessment was carried out by validators covering aspects: content feasibility, material presentation, and language covering 17 (seventeen) assessment indicators. In making revisions, researchers refer to the results of the discussion by following the suggestions and instructions of the validator. Validators there are 2 (people) material experts to conduct the assessment, the results of expert validation of assessments and responses by material experts show that the average score of each aspect in the assessment indicators and responses of the two learning material validators is 82, when classified in percentage form then the result is 82% "Very Valid" criteria category. So it can be concluded that the assessment and responses by material experts can be well received as expected by researchers.

b. Assessment by Learning Media Experts

The assessment was conducted by validators covering aspects: appearance, presentation and graphics with 13 (thirteen) assessment indicators. In making revisions, researchers refer to the results of the discussion by following the suggestions and instructions of the validator. Validators there are 2 (people) media experts to conduct the assessment, the results of expert validation of assessments and responses by media experts show that the average score of each aspect in the assessment indicators and responses of the two learning media validators is 88, when classified in percentage form then the result is 88% "Very Valid" criteria category. So it can be concluded that the assessment and responses by media experts are well received as expected by researchers.

c. Assessment by Learning Design Experts

The assessment was conducted by validators covering aspects: appearance, presentation, and graphics covering 17 (seventeen) assessment indicators. In making revisions, researchers refer to the results of the discussion by following the suggestions and instructions of the validator. The results of expert validation of the assessment and responses by design experts show that the average score of each

aspect in the assessment indicators and responses of the two learning design validators is 83, when classified in percentage form then the result is 83% "Very Valid" criteria category. So it can be concluded that the assessment and responses by design experts can be well received as expected by researchers.

Description of Results Implementation Stage

In this implementation stage, researchers carried out a series of activities as follows:

a. Preparing instruments and devices that have been validated and revised based on expert advice.
b. Carry out learning using the developed products, usually in the form of limited trials.
c. Observing learner involvement and participation, as well as teacher response.
d. Collecting data on learning outcomes, either through tests (pre-test and post-test), activity observations, or questionnaires.
e. Analyzing the data to measure the effectiveness of the implemented product.

At the Implementation stage to find out the development of teaching materials for problem-based learning (PBL)-based mathematics student worksheets (LKPD) is effectively used in the learning process.

Description of Results Evaluation stage

The Evaluation Stage is the final stage in the ADDIE development model, which aims to assess the quality, effectiveness, and achievement of the objectives of the Problem-Based Learning (PBL)-based Mathematics Student Worksheets (LKPD). At this stage, researchers carry out classroom learning activities through the application of treatments in two experimental classes, namely experimental class 1 and experimental class 2, to measure the extent to which the LKPD is able to support student learning processes and outcomes. Evaluation is carried out not only to assess the suitability of the LKPD with learning objectives, but also to ensure that the LKPD is suitable for use in real learning contexts and has a positive impact on students' conceptual understanding and critical thinking skills. Learning activities at this stage are implemented through two meetings in each experimental class, following a systematically designed learning flow as shown in the following table.

Table 2. Flow of Learning Activities

Day	Experimental class activity 1	Experimental class activity 2
1	Pre-test, learning begins with the initial product LKPD	Pre-test, learning begins with the final product LKPD
2	Continuation of Learning material, Post-test	Continuation of learning material, post-test

With learning activities in the classroom, it is necessary to pay attention to being the focal point of the researcher so as not to get out of control of the research objectives. So it takes a directed evaluation focus on each treatment for experimental class 1 to be better at the treatment of experimental class 2. The results of the evaluation focus comparison can be seen in the following table:

Table 3. Comparison of Evaluation Focus

Evaluation Component	Experiment Class 1	Experiment Class 2
Learning Media	Initial version of LKPD (before revision)	Final version of LKPD (after revision)
Models/Methods	Lecture, Q&A	PBL, Group Discussion
Evaluation Objectives	Compare Learning Outcomes	Effectiveness Test
Instruments	Observation, Test	Observation, Test, Questionnaire

In the learning process activities at the day 1 meeting, a pre-test was carried out on experimental class 1 and experimental class 2 to find out students' understanding of building space material. From the results of the pre-test analysis that has been obtained, it is known that the level of understanding of

students in mastering the learning material. Then the researcher conducts an appropriate analysis so that the learning to be applied is in line with the analysis of learning objectives. The research analysis process on the development of teaching materials is known through the assessment results.

From the Pre-test given to experimental group 1 students using teaching materials for the initial product (before revision). From the analysis, the average pretest score was 30.96 with the highest score reaching 50 and the lowest score was 15 out of a maximum total of 100. These results show that overall, students' initial understanding is still in the low category, especially when understanding the basic concepts of building spaces such as cubes and rectangular prism. Many students have not been able to solve problems related to the properties of spatial shapes, volume. This finding shows that teaching mathematics about the material of building spaces requires a more contextual learning method and involves students actively.

From the Pre-test given to experimental group 2 students before the start of learning by using teaching materials for Problem Based Learning (PBL) based learner worksheets (LKPD), the average pretest score was 29.42 with the highest score reaching 50 and the lowest score was 10 out of a maximum total of 100. These results show that overall, students' initial understanding is still in the low category, especially when understanding the basic concepts of building spaces such as cubes and rectangular prism. Many students have not been able to solve problems related to the properties of spatial shapes, volume. This finding shows that teaching mathematics about the material of building spaces requires a more contextual learning method and involves students actively.

At the end of the learning process, a post-test was conducted on experimental class 1 to identify product deficiencies. And in experimental class 2 focus on the effectiveness and improvement of learning outcomes about building space material. From the results of the post-test analysis that has been obtained, it is known that the level of understanding of students mastering the learning material.

From the results of the Post-test analysis given to experimental class 1 students after the end of the learning process using the initial version of the LKPD teaching material. then the results of the post-test analysis obtained an average value of 62.12 with the highest score reaching 75 and the lowest score is 50 out of a maximum total of 100. These results show that overall, students' final understanding of learning is still in the low category, especially when understanding the basic concepts of building spaces such as cubes and rectangular prism. Many students have not been able to solve problems related to the properties of space, volume even though there is an improvement from the pre-test assessment results.

From the analysis of the Post-test given to experimental class 2 students after the end of the learning process using teaching materials based on Problem Based Learning (PBL), the average score was 89.03 with the lowest score of 80 and the highest score was 95 out of a maximum total of 100. These results indicate that students' understanding of building space material has been achieved.

Problem Analysis

To determine the improvement of learning outcomes in the experimental class, the data that has been obtained is analyzed by statistical calculations. From the results of the analysis obtained N-gain results, N-gain values and the percentage of improvement in student learning outcomes, can be seen in the following table:

Table 4. N-gain Results, N-gain Values, and Percentages of Experimental Class 1

Student Name	Pre-test	Post-test	N-gain	N-gain value	Percentage (%)	Interpretation
Al Ikwan	40	65	0,42	Medium	42	Fairly Effective
Alfathin	35	55	0,31	Medium	31	Ineffective
Alvin	50	70	0,40	Medium	40	Fairly Effective
Aurel	15	55	0,47	Medium	47	Fairly Effective
Cristian	20	60	0,47	Medium	47	Fairly Effective
Daniel	30	50	0,29	Low	29	Ineffective
Dante	50	75	0,50	Medium	50	Fairly Effective
Elsa	30	60	0,43	Medium	43	Fairly Effective
Frans	25	70	0,60	Medium	60	Effective
Ganda	30	65	0,50	Medium	50	Fairly Effective
Gio	45	70	0,45	Medium	45	Fairly Effective

Student Name	Pre-test	Post-test	N-gain	N-gain value	Percentage (%)	Interpretation
Indri	30	55	0,36	Medium	36	Ineffective
Jherico	15	70	0,64	High	64	Effective
Julioner	20	65	0,56	Medium	56	Effective
Julius	15	60	0,53	Medium	53	Fairly Effective
Maichel	30	65	0,50	Medium	50	Fairly Effective
Mario	30	50	0,29	Low	29	Ineffective
Mikhael	35	60	0,38	Medium	38	Ineffective
Novan	30	55	0,36	Medium	36	Ineffective
Putra	40	65	0,42	Medium	42	Fairly Effective
Rayhan	20	65	0,56	Medium	56	Effective
Renius	40	70	0,50	Medium	50	Fairly Effective
Samudra	45	70	0,45	Medium	45	Fairly Effective
Shaqila	40	65	0,42	Medium	42	Fairly Effective
Tania	15	50	0,41	Medium	41	Fairly Effective
Yohana	30	55	0,36	Medium	36	Ineffective
Total	**805**	**1615**	**11,58**	**Medium**	**1158**	**Ineffective**
Average	**30,96**	**62,12**	**0,45**		**44,54**	

From the learning outcomes of students can be categorized as moderate. This shows that the use of teaching materials for student worksheets (LKPD) in the initial version (before revision) in the material of building space has not all students in experimental class 1 passed according to the Minimum Completion Criteria value limit of 75. The learning outcomes of students are less efficient with the use of teaching materials for student worksheets (LKPD) in the initial version (before revision) is not fully optimal even though the learning method with an approach based on lectures and questions and answers to students. From the average n-gain obtained in experimental class 1 is 0.40 and the percentage of N-gain is 45%.

In the analysis of n-gain results, the n-gain value and percentage in experimental class 2 with the treatment of using teaching materials for problem-based learning (PBL) based student worksheets (LKPD) can be seen in the following table:

Table 5. N-gain Results, N-gain Values, and Percentages of Experiment Class 2

Student Name	Pre-test	Post-tes	N-gain	N-gain Value	Percentage	Interpretation
Adzkia	35	85	0,77	High	77	Highly Effective
Ahmad	40	90	0,83	High	83	Highly Effective
Al Ridho	15	80	0,76	High	76	Highly Effective
Andika	40	90	0,83	High	83	Highly Effective
Chyntia	45	95	0,90	High	90	Highly Effective
David	30	85	0,79	High	79	Highly Effective
Franssion	30	95	0,92	High	92	Highly Effective
Glerinov	15	90	0,88	High	88	Highly Effective
Ina	25	85	0,80	High	80	Highly Effective
Jogi	20	85	0,81	High	81	Highly Effective
Kayla	40	90	0,83	High	83	Highly Effective
Lestari	35	85	0,77	High	77	Highly Effective
Maickel	40	95	0,92	High	92	Highly Effective
Martkes	15	90	0,88	High	88	Highly Effective
Nola	15	95	0,94	High	94	Highly Effective
Nur	20	90	0,87	High	87	Highly Effective
Raffly	15	80	0,77	High	77	Highly Effective
Raymon	20	85	0,75	High	75	Effective
Reza	20	90	0,88	High	88	Highly Effective
Rina	50	95	0,90	High	90	Highly Effective
Risky	15	90	0,88	High	88	Highly Effective
Septiana	30	90	0,86	High	86	Highly Effective
Sri	40	95	0,92	High	92	Highly Effective
Tasya	30	90	0,86	High	86	Highly Effective
Visca	35	85	0,77	High	77	Highly Effective
Zio	50	90	0,80	High	80	Highly Effective
Total	**765**	**2315**	**20,11**	**High**	**2189**	**Highly Effective**
Average	**29,4**	**89,03**	**0,77**		**84,19**	

From the learning outcomes of students can be categorized as moderate. This shows that the use of teaching materials for problem-based learning (PBL) based learner worksheets (LKPD) in the final version (after revision) in the material of building space not all students in experimental class 2 passed according to the limit of the Minimum Completeness Criteria (KKM) value of 75. Effective student learning outcomes with the use of teaching materials for problem-based learning (PBL) based learner worksheets (LKPD) in the final version (after revision) are fully optimized with learning methods with a problem-based learning approach and group discussions in students.

Discussion

The development of Problem-Based Learning (PBL) Student Worksheets (LKPD) for spatial geometry using the ADDIE development model involved five stages: Analysis, Design, Development, Implementation, and Evaluation. Each stage contributed to achieving valid, practical, and effective learning outcomes.

In the Analysis stage, researchers identified student and teacher needs for teaching materials that could enhance engagement and conceptual understanding. The analysis revealed that conventional learning was not optimal in fostering students' critical thinking and problem-solving skills. This finding aligns with research by Safitri et al. (2023) and Wijnia et al. (2024), which found that the implementation of PBL significantly increased student motivation and understanding through learning activities that required active participation. Theoretically, this aligns with Piaget's constructivism theory, which emphasizes that knowledge is built through direct experience and the process of assimilating and accommodating new concepts.

Next, in the Design and Development stage, the LKPD was prepared with attention to content validity, design, and practicality. Validation by material experts and design experts yielded scores of 90% and 87%, respectively, categorized as "Very Adequate" (Lia et al., 2022). Practicality assessments by teachers and students also yielded scores of 91.24%, indicating that the worksheet is easy to use and engaging for students. Theoretically, these findings align with Vygotsky's learning theory, which emphasizes the importance of scaffolding and social interaction in supporting students' cognitive development. PBL-based worksheets provide a collaborative context in which teachers act as facilitators, helping students reach their Zone of Proximal Development (ZPD).

In the implementation phase, the worksheets were applied to geometry learning (cubes and cuboids) using a PBL approach. Paired t-test analysis revealed a significant increase between students' pre-test and post-test scores, indicating improved conceptual understanding after using the worksheets. These results demonstrate that PBL-based worksheets are effective in helping students connect geometric concepts to real-world situations and fostering critical thinking skills. Consistent with Ausubel's view, learning will be more meaningful if students are able to connect new information to their existing knowledge structures. This is reinforced by research by Wardani & Fiorintina (2023) and Nasution & Setyaningrum (2024), which found that PBL can deepen conceptual understanding while improving students' higher-order thinking skills.

In the evaluation phase, the results of validity, practicality, and effectiveness tests indicated that the developed student worksheets met all eligibility criteria. Based on student questionnaires, an effectiveness score of 84.76% was obtained, categorizing them as "Very Effective" (Omojemite, 2025). This finding supports the opinions of Sefriani et al., (2020) and Wantoro et al., (2025), who emphasized that every learning product must undergo validity and effectiveness testing to ensure its feasibility and positive impact on learning outcomes.

Overall, the results of this study indicate that the development of PBL-based mathematics student worksheets using the ADDIE model successfully produced valid, practical, and effective teaching materials for improving elementary school students' conceptual understanding and critical thinking skills. This demonstrates that the application of PBL, rooted in constructivism and meaningful learning theory, can create an active, collaborative, and contextual learning environment. Thus, it is hoped that this LKPD can be an alternative innovative teaching material that can significantly increase students' interest, understanding, and mathematical problem-solving abilities.

CONCLUSION

This research produced a Student Worksheet (LKPD) based on Problem-Based Learning (PBL) on spatial geometry for fifth-grade elementary school students using the ADDIE model. Validation results from material, media, and language experts indicated that the developed product was highly feasible for use. A learning trial also demonstrated that this PBL-based LKPD improved students' conceptual understanding, active engagement, and critical thinking skills in mathematics learning.

However, this research has limitations. The product trial was conducted in only one school with a limited sample size, so the generalizability of the results requires further testing. Furthermore, this study focused solely on cognitive aspects, while non-cognitive aspects such as student motivation, attitudes, and social skills were not thoroughly examined.

Based on these findings, it is recommended that teachers use PBL-based LKPD as an alternative interactive and contextual teaching material in mathematics learning. Schools are expected to provide support in the form of training and facilities to develop similar teaching materials. For future research, it is recommended to develop PBL-based LKPD at different levels or in other subjects, and to expand the focus to non-cognitive aspects to provide a more comprehensive picture of the impact of teaching material use.

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