AL IBTIDA: JURNAL PENDIDIKAN GURU MI (2025) VOL 12 (2): 496- 510
DOI: http://dx.doi.org/10.24235/al.ibtida.snj.v12i2.19922

Al Ibtida: Jurnal Pendidikan Guru MI
ISSN: 2442-5133, e-ISSN: 2527-7227
Journal homepage: http://syekhnurjati.ac.id/jurnal/index.php/ibtida
Journal email: alibtida@syekhnurjati.ac.id

Developing a Worksheet Based on Problem-Based Learning for Mathematics Subjects in Grade V Elementary Schools

Yeni Dwi Kurino*
*Elementary School Teacher Education Study Program, Faculty of Education and Teacher Training, Universitas Majalengka, Indonesia
E-mail: yenidwikurino@unma.ac.id

Yuyun Dwi Haryanti**
**Basic Education Study Program, Postgraduate Program, Universitas Majalengka, Indonesia
E-mail: yuyundwiharyanti18@gmail.com

Devi Afriyuni Yonanda***
***Basic Education Study Program, Postgraduate Program, Universitas Majalengka, Indonesia
E-mail: deviafriyuniyonanda@unma.ac.id

Nia Kania****
******Mathematics Education Study Program, Faculty of Education and Teacher Training, Universitas Majalengka, Indonesia
E-mail: nikania@unma.ac.id

Silvyra Rismawati*****
*******Basic Education Study Program, Postgraduate Program, Universitas Majalengka, Indonesia
E-mail: silvyraganiar@gmail.com

Received: January 24th, 2025. Accepted: October 14th, 2025. Published: October 31st, 2025.

Abstract

Mathematics learning in elementary schools still faces challenges related to the limited availability of instructional materials that support active learning and students' problem-solving skills. Student worksheets commonly used in classrooms tend to be conventional and have not fully integrated problem-based learning approaches, which limits students' engagement and ability to apply mathematical concepts in real-world situations. Therefore, this study aimed to develop a problem-based learning student worksheet for mathematics learning on three-dimensional shapes in third-grade elementary school and to examine its quality. This study employed a research and development approach using the ADDIE model, which consists of the Analysis, Design, Development, Implementation, and Evaluation stages. The research subjects were students from one third-grade elementary school class. Data were collected through expert validation sheets, teacher and student response questionnaires, and learning outcome tests. The data were analyzed using descriptive quantitative and qualitative techniques. The results indicated that the developed Worksheet were valid based on expert judgments, practical according to positive responses from teachers and students, and effective, as indicated by the improvement in students' learning outcomes after using the worksheets. The results

of the study indicate that the developed worksheet has a very high level of validity (4.39), very practical usability (89.83%), and is effective in improving students' learning outcomes, as indicated by the increase in the average score from 63.20 to 81.35. Thus, the problem-based learning Worksheet is suitable for use as instructional material to support meaningful mathematics learning in elementary schools.

Keywords: *student's worksheet, problem based learning, ADDIE, three-dimensional shapes, elementary mathematics.*

Abstrak

Pembelajaran matematika di sekolah dasar masih menghadapi tantangan terkait dengan keterbatasan ketersediaan bahan ajar yang mendukung pembelajaran aktif dan kemampuan pemecahan masalah siswa. Lembar kerja siswa yang umum digunakan di kelas cenderung konvensional dan belum sepenuhnya mengintegrasikan pendekatan pembelajaran berbasis masalah, yang membatasi keterlibatan siswa dan kemampuan untuk menerapkan konsep matematika dalam situasi dunia nyata. Oleh karena itu, penelitian ini bertujuan untuk mengembangkan lembar kerja siswa berbasis masalah untuk pembelajaran matematika tentang bangun tiga dimensi di kelas tiga sekolah dasar dan untuk menguji kualitasnya. Penelitian ini menggunakan pendekatan penelitian dan pengembangan dengan model ADDIE, yang terdiri dari tahapan Analisis, Desain, Pengembangan, Implementasi, dan Evaluasi. Subjek penelitian adalah siswa dari satu kelas tiga sekolah dasar. Data dikumpulkan melalui lembar validasi ahli, kuesioner tanggapan guru dan siswa, dan tes hasil belajar. Data dianalisis menggunakan teknik kuantitatif dan kualitatif deskriptif. Hasil menunjukkan bahwa lembar kerja yang dikembangkan valid berdasarkan penilaian ahli, praktis menurut tanggapan positif dari guru dan siswa, dan efektif, sebagaimana ditunjukkan oleh peningkatan hasil belajar siswa setelah menggunakan lembar kerja tersebut. Hasil penelitian menunjukkan bahwa lembar kerja yang dikembangkan memiliki tingkat validitas yang sangat tinggi (4,39), kegunaan praktis yang sangat tinggi (89,83%), dan efektif dalam meningkatkan hasil belajar siswa, sebagaimana ditunjukkan oleh peningkatan nilai rata-rata dari 63,20 menjadi 81,35. Dengan demikian, Lembar Kerja Pembelajaran Berbasis Masalah cocok digunakan sebagai bahan pembelajaran untuk mendukung pembelajaran matematika yang bermakna di sekolah dasar.

Kata kunci: *LKPD, pembelajaran berbasis masalah, model ADDIE, bangun ruang, matematika sekolah dasar.*

INTRODUCTION

Mathematics learning in elementary schools plays a strategic role in developing students' logical thinking skills, problem-solving skills, and understanding of basic concepts from an early age. In practice, however, learning math in lower grades, especially fifth grade, often focuses on following steps and using textbooks as the only way to learn (Asmar & Delyana, 2023; Syelfia & Armiati, 2020). This situation leads to students being passive, less engaged in the learning process, and experiencing difficulties in meaningfully understanding mathematical concepts (Amrina et al., 2020; Asmar & Delyana, 2023; Syelfia & Armiati, 2020). Initial observations and findings from various studies indicate that low student engagement and weak mathematical problem-solving skills are closely related to the limited

teaching materials used by teachers in their lessons. One teaching material that has the potential to support active and meaningful learning is worksheets (Kampe et al., 2005; Kim & Gerrits, 2025; Munir & Nur, 2018). Worksheets serve as learning guides that can guide students' activities in discovering concepts, practicing thinking skills, and connecting material to real-life situations (Calamlam & Calamlam, 2025; Putri et al., 2024; Wongsila & Yuenyong, 2019).

However, in reality, worksheets used in elementary schools are generally conventional, containing material summaries and routine practice questions, and are not designed to stimulate higher-order thinking and problem-solving skills (Melati et al., 2019; Nenggala et al., 2024; Putra & Suparman, 2020). These types of worksheets are not fully aligned with the demands of 21st-century learning and the implementation of the Independent Curriculum, which emphasizes student-centered learning (Patappa et al., 2024; Rosbiono et al., 2020; Yani et al., 2020). The Problem-Based Learning (PBL) approach is considered a relevant learning approach to address these issues (Fitriani et al., 2023; Hord et al., 2016; Mohamad Noor et al., 2022; Putra et al., 2025). Problem-based learning places contextual problems as the starting point of learning so that students are encouraged to think critically, discuss, and identify solutions independently and collaboratively (Martaida et al., 2017).

Various studies have shown that problem-based learning is effective in improving students' problem-solving abilities and understanding of mathematical concepts (Pratiwi & Simangunsong, 2021; Witzel et al., 2022; Yang & Oh, 2023). However, most of this research focuses on the application of the problem-based learning model in the learning process or at the upper grade level, while studies specifically developing problem-based learning worksheets for fifth-grade elementary school students are still relatively limited (Hayyu et al., 2020; Rosita et al., 2014; Samsudin et al., 2019).

The research gap lies in the limited development of teaching materials in the form of worksheets systematically designed based on problem-based learning and tailored to the characteristics of fifth-grade elementary school students' cognitive development. Furthermore, existing worksheets rarely integrate simple contextual problems relevant to students' lives and do not optimally facilitate the stages of problem-based learning, from problem orientation to investigation to presentation of learning outcomes. This situation indicates a need for innovative teaching materials that are not only materially appropriate but also effective in supporting meaningful learning processes. Based on this gap, the novelty of this research lies in the development of problem-based learning (PBL) mathematics worksheets specifically designed for fifth-grade elementary school students. These worksheets take into account the characteristics of early elementary school-aged students, the context of problems relevant to everyday life, and the integration of problem-based learning steps into each learning activity. The developed worksheets not only contain practice questions but also guide students through a systematic process of thinking, discussion, reflection, and drawing conclusions.

As a solution, this research developed valid, practical, and appropriate PBL-based worksheets for fifth-grade elementary school mathematics. These worksheets are expected to serve as an alternative teaching material that supports active learning, increases student engagement, and assists teachers in implementing mathematics instruction oriented toward conceptual understanding and problem-solving. Thus, the development of PBL-based

worksheets is expected to contribute to improving the quality of mathematics learning in elementary schools.

METHODS

This research is a research and development (R&D) project aimed at producing worksheets based on problem-based learning for fifth-grade mathematics in elementary schools. The development model used is the ADDIE model, which includes stages of Analysis, Design, Development, Implementation, and Evaluation (Damayanti et al., 2024; H. Pujiastuti et al., 2024; Waithira et al., 2024). The ADDIE model was chosen because it is systematic and appropriate for developing user-oriented learning tools and is easy to implement in elementary school contexts (Mandala et al., 2025; E. Pujiastuti et al., 2025; Susanto et al., 2025).

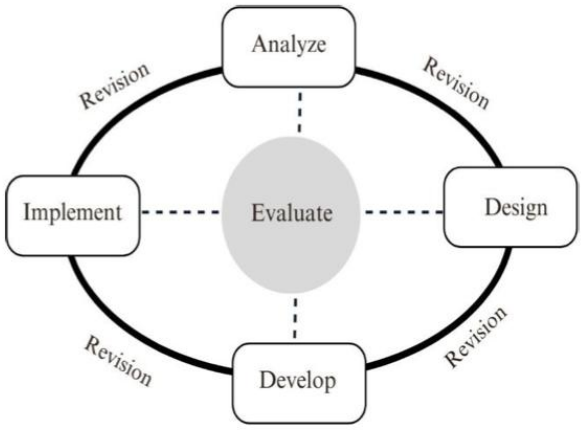

Figure 1. ADDIE Model

Analysis: a learning needs analysis was conducted through a preliminary study in elementary schools, including curriculum analysis, fifth-grade student characteristics, and analysis of teaching materials used by teachers. The curriculum analysis focused on relevant fifth-grade mathematics competencies and materials, while the student characteristics analysis included students' initial abilities, learning styles, and levels of cognitive development. Furthermore, an analysis of mathematics learning issues was conducted, particularly the limitations of worksheets that do not facilitate problem-solving and active learning.

The design phase aimed to create a prototype worksheet based on problem-based learning. At this stage, a worksheet framework was developed, encompassing learning objectives, material mapping, indicator development, contextual problem-based learning activity design, and assessment instrument planning. The worksheet structure was designed following the steps of problem-based learning: problem orientation, student organization, investigation, presentation of results, and reflection. Furthermore, the worksheet display design was also adapted to the characteristics of fifth-grade students to ensure it was engaging and easy to understand.

Development: the worksheet product development was carried out based on a systematically developed learning design, taking into account the characteristics of third-grade elementary school students and the mathematics learning outcomes in the subject of geometric shapes. The geometric shapes material developed in the Worksheet includes the

introduction and understanding of simple geometric shapes, such as cubes, cuboids, cylinders, and spheres, along with their characteristics, including the number of sides, edges, and vertices. The material is presented contextually by linking geometric shapes to objects frequently encountered by students in everyday life, such as pencil cases, cardboard boxes, cans, and balls. The developed worksheets contain a series of learning activities that encourage students to observe, identify, group, and solve simple problems related to geometric shapes. Each activity is complemented by engaging visual illustrations, clear instructions, and practice questions structured in stages, from basic understanding to application of the concept. Thus, the worksheets serve not only as practice sheets but also to develop students' thinking skills and conceptual understanding of geometric shapes.

Next, the developed worksheets were validated by material experts, media experts, and learning experts. The validation by the material experts focused on the suitability of the worksheet content for the curriculum, the validity of the geometric shape concepts, and the accuracy of the examples and problems presented. Validation by the media experts assessed graphic aspects, including layout, color use, clarity of geometric shape illustrations, and text readability, ensuring the worksheets were easy to use for third-grade students. Meanwhile, validation by learning experts assessed the suitability of the worksheets to the characteristics of elementary school students' cognitive development, the clarity of instructions, and the integration of learning activities in achieving learning objectives. Input and suggestions from the experts were used as the basis for product revisions, including aspects of content, language, presentation, and visual appearance. Revisions were made to clarify the concept of geometric shapes, simplify the language to make it more communicative for third-grade students, and improve the illustrations to make them more representative and engaging. The revision process was carried out in stages until worksheets were valid, easy to use, and suitable for use in mathematics learning on geometric shapes in fifth-grade elementary schools.

Through these development and validation stages, the resulting worksheets are expected to help students understand the concept of geometric shapes in a more concrete and meaningful way, as well as support teachers in implementing effective mathematics learning that is appropriate to the characteristics of elementary school students.

Implementation was carried out by piloting the revised worksheets with research subjects. The pilot test was conducted in a limited area in one fifth-grade elementary school. Teachers and students used the problem-based learning worksheets in their mathematics learning process, according to a pre-designed scenario. This stage aimed to determine the practicality of using the worksheets and the responses of students and teachers to the developed product.

Evaluation was conducted continuously at each ADDIE stage and comprehensively after product implementation. Formative evaluation was conducted during the analysis, design, and development stages to improve the product, while summative evaluation was conducted after the pilot test to assess the feasibility and effectiveness of the problem-based learning worksheets in supporting mathematics learning.

The research design for the product pilot test phase employed quantitative and qualitative descriptive methods, aiming to assess the validity, practicality, and feasibility of the worksheets. The study population was all fifth-grade elementary school students at the

school where the study was conducted. The sample was determined using purposive sampling, with one fifth-grade class consisting of 30 students serving as the trial subjects at Majalengka. The fifth-grade teacher was also involved as a respondent to assess the practicality of the worksheets. The research procedure included planning, developing expert-validated worksheets, product revisions, limited trials, and evaluating the trial results. All stages were carried out systematically according to the ADDIE steps to ensure that the resulting product met the feasibility criteria and learning needs.

Data collection techniques included expert validation sheets, teacher and student response questionnaires, and learning outcome tests. The validation sheets were used to obtain data on the feasibility of the worksheets from material, media, and learning experts. The questionnaires were used to collect data on the practicality and user responses to the worksheets, while the learning outcome tests were used to obtain initial data on the achievement of learning objectives after using the worksheets.

Data analysis techniques used were descriptive, quantitative, and qualitative. Quantitative data from the validation sheets and questionnaires were analyzed by calculating feasibility and practicality percentages, then categorized based on specific criteria. The data obtained from the mathematical problem-solving test were analyzed using descriptive and inferential statistical techniques. Descriptive statistics were used to determine the mean, minimum score, maximum score, and standard deviation of the students' pretest and posttest results. Before conducting further analysis, the data were tested for normality and homogeneity to ensure that they met the assumptions for parametric testing. After the data were confirmed to be normally distributed and homogeneous, a paired sample t-test was conducted to determine whether there was a significant difference between students' mathematical problem-solving abilities before and after the implementation of the Problem-Based Learning (PBL)-based worksheets. Qualitative data, in the form of suggestions and input from experts, teachers, and students, were analyzed descriptively to improve the product. The results of the analysis were used to determine the quality of the developed problem-based learning worksheets.

RESULTS AND DISCUSSION

Discussion study This focused on quality problem-based learning worksheets developed and reviewed from the aspects of validity, practicality, and effectiveness**.** The third aspect is the main indicator. To determine eligibility, something like product development in learning mathematics at school-based.

Validity

Validity worksheets were assessed by 3 (three) expert validators, namely expert material, expert learning, and media experts. Evaluation covers aspect eligibility content, language, presentation, and graphics using a Likert scale of 1–5.

Table 1. Validation results of worksheet

Rated aspect	Average Score	Category
Eligibility content	4.45	Very valid
Linguistics	4.32	Very valid

Rated aspect	Average Score	Category
Presentation	4.40	Very valid
Graphics	4.38	Very valid
Overall average	4.39	Very valid

Based on the results of the expert assessment, the worksheets in the context of Majalengka got an average score of 4.39, which is in the very valid category. This shows that worksheets are in accordance with the demands of the curriculum, the characteristics of basic student schools, and the capability to integrate the local context of Majalengka in a way appropriate for learning mathematics. Results from the validation expert show that worksheets based on problem-based learning, which was developed, are in the category "valid." Validity This reflects the suitability of content worksheets with competence-based purpose learning and the characteristics of material for mathematics class V, as well as the principles of problem-based learning. Aspects of linguistics assessed have used simple, communicative, and appropriate language with the level of cognitive development of basic school students. In addition, the presentation materials and activities learned in worksheets have been arranged in a systematic and logical way so that it is easier for students to follow stages of learning based on the problem. Eligibility graphics worksheets also support readability and power visual appeal, which is important for increasing motivation for study students. Thus, validity worksheets show that developed products have fulfilled eligibility criteria in a way that is both theoretical and substantial.

Practicality of Problem Based Learning Worksheet

The practicality worksheet was reviewed based on teacher and student responses during stage implementation. Questionnaire results show that worksheets are in the category "practical," which means easy to use in the learning process. The teacher assesses that worksheets help in managing learning mathematics in a more structured way, especially in applying problem-based learning steps. Worksheets give clear guidance for teachers and students in carrying out activity-learning-based problems so that the learning process can walk in accordance with planning. From the students' side, worksheets are assessed as easy to understand, interesting, and encouraging active involvement in learning. Students feel helped in understanding mathematical material through problems contextually presented in worksheets. Findings This shows that worksheets are not only worthy in terms of content but also practical for use in real in-class context learning.

Practicality worksheets were measured through questionnaire teacher and student responses after using the worksheets in learning mathematics.

Table 2. Practicality results of worksheet

Respondents	Average Score (%)	Category
Teacher	91.25%	Very practical
Student	88.40%	Very practical
Average	89.83%	Very practical

Questionnaire results show that worksheets based on the contextual Majalengka have an average practicality score of 89.83%, placing them in the "very practical" category. Teachers rate the worksheets as easy to use and systematic and say they help the learning process. While that is true, students find worksheets interesting, easy to understand, and helpful; they finish problem mathematics.

The Effectiveness of Problem Based Learning Worksheet

The effectiveness of worksheets is reviewed based on results. Study student after using worksheets in learning mathematics. Analysis results show existence improvement results. Study students after using worksheets based on problem-based learning. Improvement This indicates that worksheets are effective in helping students understand draft mathematics and develop problem-solving abilities. Learning that begins with a presentation problem contextual push for students to think actively, discuss, and discover solutions in an independent and group way. This process helps students build a deeper understanding of more concepts compared to conventional learning. Thus, the effectiveness of worksheets shows that developed products Not only is it feasible and easy to use, but it also provides a positive impact towards the process and results of the study of mathematics students in Class V of the school base

Table 3. The Descriptive Statistics

Variable	Minimum	Maximum	Mean	Standard Deviation
Pretest	50	75	63.20	7.45
Posttest	70	92	81.35	6.80

Based on the analysis of descriptive statistics, the results provide a description of mathematics students' problem-solving abilities before and after the implementation of context-based worksheets in Majalengka. The number of respondents involved in this study is as high as 30 students. At this stage of the pretest, the minimum score obtained by a student is 50 and the maximum value is 75, with an average (mean) of 63.20 as well as a standard deviation of 7.45. This result shows that ability of beginning students to finish problem mathematics. Still is in the category currently with sufficient variation and diverse ability.

After being given treatment in the form of learning using worksheets based on the context of Majalengka, the results of the posttest show a significant increase. The minimum value increases become 70 and value maximum reaches 92, with an average of 81.35 as well as a standard deviation of 6.80. An increase in this average value indicates that the ability of students to settle problems in mathematics experiences improvement after the use of Worksheet. In addition, the decrease in the mark deviation standard shows that the ability of students has become more even. With this, in a way, descriptively, it can be concluded that the implementation of worksheets based on the contextual Majalengka has a positive impact on improving the ability to settle the problem of mathematics students in school.

Table 4. Tests of Normality

Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Statistics	f	ig.	Statistics	f	ig.
Pretest			.200*		

Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Posttest	121	0	.180	958	0
	134	0		952	0

Lilliefors Significance Correction* This is a lower bound of the true significance.

Based on the results of the data normality tests using the Kolmogorov–Smirnov and Shapiro–Wilk tests, the distribution of pretest and posttest ability values for settlement problem mathematics students has been described. Remembering that the sample study was not enough of 50 students, the Shapiro–Wilk test was used as the main reference in making the decision.

The results of the Shapiro–Wilk test show that the mark significance (Sig.) for pretest data is 0.200 and for posttest data is 0.180. Both mark significance at the level of significance of 0.05, so it can be concluded that the pretest and posttest value data are normally distributed. In addition, the results of the Kolmogorov–Smirnov test also show a mark significance above 0.05, which increasingly strengthens the conclusion that the research data fulfill the assumptions of normality.

With fulfillment assumptions of normality, research data, this worthy For analysis, use the statistical test parametric, in particular *the paired sample t-test*, to frame the test of the effectiveness of the implementation of worksheets based on the context of Majalengka to assess the ability of students to solve problems in school-based mathematics.

Table 5. Test of Homogeneity of Variances

Levene Statistics	df1	df2	Sig.
1,598	1	58	.214

Based on the results of the homogeneity test variance using Levene's Test, we obtained a Levene statistic of 1.598 with degrees of freedom df1 = 1 and df2 = 58 and a significance (Sig.) of 0.214. The significance value is bigger than the level of significance of 0.05, so it can be concluded that the inter-data variance group nature is homogeneous. With fulfillment assumptions of homogeneity variance, this research data fulfills one of the prerequisites. For done analysis, statistics are parametric so that testing the effectiveness of learning using the *t-test* can be continued in an accurate and valid way.

Table 6. Output of the paired sample t-test

Pair	Mean	Standard Deviation	Std. Error Mean
Pretest	63.20	7.45	1.36
Posttest	81.35	6.80	1.24

Based on the results of the paired samples statistics, obtained description of the comparison of the ability to settle the problem of mathematics students before and after the implementation of worksheets based on the context of Majalengka. The average pretest score was 63.20 with a sample size of 30 students, a standard deviation of 7.45, and a standard error of 1.36. This result show that ability beginning student in finish problem mathematics Still is in the category currently .

After being given treatment in the form of learning using Worksheet based on the context of Majalengka, the value of the posttest average increased to 81.35, with a sample size of 30 students, a standard deviation of 6.80, and a standard error of 1.24. Increasing this average value shows the existence of improved ability to settle the problem of mathematics students after the use of Worksheet. In addition, the value error relative to the small standard shows that the average obtained is representative enough of the ability of the population sample. With this, in a way, it can be descriptively concluded that the implementation of worksheets based on the context of Majalengka has a positive impact on improving the ability to solve mathematics problems for students in school.

Table 7. The Paired Samples Correlations

Pair	Correlation	Sig.
Pretest & Posttest	.712	.000

Paired Samples Test

Paired Differences	Mean	Standard Deviation	Std. Error Mean	95% Confidence Interval of the Difference	t	f	Sig. (2-tailed)
Pretest – Posttest	-18.15	7.12	1.30	Lower: -20.82 Upper: -15.48	-13.95	9	.000

Based on the results of the paired samples correlations, the obtained mark correlation between pretest and posttest scores was as big as 0.712 with a mark significance of 0.000. Correlation value shows the existence of a strong and significant relationship between the ability to settle mathematics problems of students before and after the implementation of worksheets based on contextual Majalengka. This indicates that the changeability of the student after treatment is closely related to the ability at the beginning that the student possessed.

Next, the results of the paired samples test show that the average difference between pretest and posttest scores is as big as −18.15, with a standard deviation of 7.12 and a standard error of 1.30. The 95% confidence interval is in the range −20.82 to −15.48, which does not cover zero value. T-value of −13.95 with degrees of freedom of 29, and mark significance Sig. (2-tailed) = 0.000, which is smaller than the level of significance of 0.05.

Based on the results, it can be concluded that there is a significant difference between the ability to solve mathematics problems of students before and after the use of worksheets based on the context of Majalengka. Thus, the application of Worksheet based on the context of Majalengka has proven effective in a significantly increasing way.

Figure 2. Worksheet with PBL video barcode

Overall, the results of the study indicate that the problem-based learning worksheet developed meets valid, practical, and effective criteria, making it a suitable supporting teaching material for mathematics in Class V of basic school. These Worksheet can be one of the alternative solutions for increasing the quality of learning more meaningful mathematics and student-centered and development-oriented thinking ability as well as problem-solving.

The findings of this study demonstrate that the implementation of Problem-Based Learning (PBL)-based worksheets significantly improved students' mathematical problem-solving abilities. The paired sample t-test revealed a statistically significant difference between pretest and posttest scores (Sig. 2-tailed = 0.000 < 0.05), indicating that the observed improvement was a result of the instructional intervention rather than chance. This result confirms that integrating PBL principles into structured instructional materials effectively enhances learning outcomes in elementary mathematics.

From a theoretical perspective, these findings are strongly supported by constructivist learning theory, which posits that knowledge is actively constructed by learners through meaningful experiences. In PBL environments, students engage with contextual problems, collaboratively explore possible solutions, and reflect on their reasoning processes. Such active engagement fosters deeper conceptual understanding. Hord et al. (2016) emphasize that constructivist-based pedagogy combined with appropriate scaffolding significantly supports students' cognitive development in solving complex mathematical tasks. The structured stages embedded in the developed worksheets—problem orientation, investigation, discussion, and reflection—align closely with this theoretical foundation.

Furthermore, the findings align with Bruner's discovery learning principles, which suggest that students achieve stronger conceptual retention when they actively discover knowledge rather than passively receive information. The worksheets developed in this study encouraged exploration of three-dimensional shapes through contextual representations, enabling students to connect mathematical concepts to real-life situations.

Empirically, the results are consistent with prior research demonstrating the effectiveness of problem-based learning in mathematics education. Pratiwi and Simangunsong (2021) reported that the PBL model significantly improved students' mathematical problem-solving skills, particularly in conceptual reasoning tasks. Similarly, Witzel et al. (2022) found that intensive problem-solving instruction enhances mathematical understanding, especially among elementary students. Additionally, Putra and Suparman

(2020) concluded that student worksheets designed according to PBL principles effectively promote higher-order thinking and problem-solving competencies.

Other studies also reinforce the effectiveness of problem-oriented instructional materials. Melati et al. (2019) confirmed that PBL-based worksheets demonstrate high validity and positively influence students' conceptual understanding. Moreover, Nenggala et al. (2024) found that problem-based electronic worksheets significantly improved students' engagement and learning performance. These findings support the argument that structured, problem-oriented instructional materials are essential for maximizing the impact of the PBL approach.

Another important finding in this study is the decrease in standard deviation from pretest to posttest scores, indicating a more homogeneous distribution of students' abilities after the intervention. This supports Vygotsky's social constructivist perspective, particularly the concept of the Zone of Proximal Development (ZPD), where collaborative interaction enables students to achieve higher levels of understanding with peer and teacher support. The group investigation and discussion components embedded in the worksheets likely contributed to reducing achievement gaps among students.

What distinguishes this study from previous research is its focus on systematically developing instructional materials that explicitly integrate PBL stages into worksheets tailored to fifth-grade elementary students. While many studies examine the implementation of the PBL model, this research contributes to instructional design innovation by embedding the model into structured learning materials that guide students step-by-step through the problem-solving process.

Overall, the findings strengthen both theoretical and empirical evidence that problem-based learning, when integrated into well-designed worksheets, effectively improves mathematical problem-solving skills, promotes meaningful learning, and supports the development of higher-order thinking skills in elementary education.

CONCLUSION

Based on results, research, and discussion, it can be concluded that the worksheet for students based on problem-based learning on the subject lesson of mathematics material in Class V of the school is developed on a basis that fulfills the criteria of being valid, practical, and effective. The validity of the worksheet is demonstrated by its suitability of content, language, presentation, and graphics with a competence base as well as the characteristics of the development of basic student school skills. The practicality of the worksheet is reflected in the positive responses from teachers and students who stated that the worksheets are easy to use and interesting and help the learning process of mathematics become more directed and meaningful. The effectiveness of Worksheet is visible from the improvement results of the study of students as well as the active involvement of students in solving real mathematics-based problems. Therefore, the problem-based learning worksheet is suitable to be used as an instructional material in elementary mathematics learning, as it supports active, meaningful, and student-centered learning while improving students' problem-solving abilities.

REFERENCES

Amrina, Z., Zuzano, F., & Wahyuni, Y. (2020). Development of Problem-Based Mathematical Learning Model to Improve Creative Thinking Ability of Elementary Teacher Education Students, Bung Hatta University. *Journal of Physics: Conference Series, 1554*(1). https://doi.org/10.1088/1742-6596/1554/1/012068

Asmar, A., & Delyana, H. (2023). Effect of independent student learning on problem solving using the worksheet geometry based on PjBL. In Yerizon, F. Tasman, R. Rifandi, & NA Rusyda (Eds.), *AIP Conference Proceedings* (Vol. 2698). American Institute of Physics Inc. https://doi.org/10.1063/5.0122570

Calamlam, J. M. M., & Calamlam, J. M. (2025). The Pre-Service Teacher Classroom-Based Action Research (PST-CBAR) Workbook. *International Journal of Learning in Higher Education, 33* (1), 1–33. https://doi.org/10.18848/2327-7955/CGP/v33i01/1-33

Damayanti, II, Ayu, A., Sariah, UI, Mustaqfiroh, M., Oktaviani, IA, & Nursyahidah, F. (2024). Development of ethnomathematics-based curved three-dimensional shape learning media using augmented reality. *AIP Conference Proceedings, 3106* (1). https://doi.org/10.1063/5.0215290

Fitriani, Y., Yerizon, Y., Arnawa, IM, Asmar, A., & Rusyda, NA (2023). Development of mathematical learning tools based on discovery learning to improve problem-solving skills in class XI. In Yerizon, F. Tasman, R. Rifandi, & NA Rusyda (Eds.), *AIP Conference Proceedings* (Vol. 2698). American Institute of Physics Inc. https://doi.org/10.1063/5.0122396

Hayyu, AN, Dafik, D., Tirta, IM, Wangguway, Y., & Kurniawati, S. (2020). The analysis of the implementation of inquiry based learning to improve mathematical student proving skills in solving dominating metric dimension number. In Dafik (Ed.), *Journal of Physics: Conference Series* (Vol. 1538, Issue 1). Institute of Physics Publishing helen.craven@iop.org. https://doi.org/10.1088/1742-6596/1538/1/012093

Hord, C., Tzur, R., Xin, Y.P., Si, L., Kenney, R.H., & Woodward, J. (2016). Overcoming a 4th grader's challenges with working-memory via constructivist-based pedagogy and strategic scaffolds: Tia's solutions to challenging multiplicative tasks. *Journal of Mathematical Behavior, 44*, 13–33. https://doi.org/10.1016/j.jmathb.2016.09.002

Kampe, J. C. M., Goff, R. M., & Connor, J. B. (2005). First-year hands-on design on a dime - almost! *ASEE Annual Conference and Exposition, Conference Proceedings*, 6431–6451.

Kim, C., & Gerrits, R. (2025). Developing active learning activities for didactic perfusion courses. *Perfusion (United Kingdom), 40*(7), 1559–1566. https://doi.org/10.1177/02676591251314930

Mandala, AS, Anwar, L., Sa'dijah, C., & Zulnaidi, H. (2025). Development of mobile augmented reality-based geometry learning games to facilitate spatial reasoning. *Infinity Journal, 14*(2), 323–348. https://doi.org/10.22460/infinity.v14i2.p323-348

Martaida, T., Bukit, N., & Ginting, EM (2017). The Effect of Discovery Learning Model on Student's Critical Thinking and Cognitive Ability in Junior High School. *7*(6), 1–8. https://doi.org/10.9790/7388-0706010108

Melati, P., Yulkifli, Y., & Fauzi, A. (2019). Validity of student worksheet based on problem based learning model assisted by practical tools with digital display. In S. Abu Bakar,

C. Wurster, Ramli, R. Jaafar, Yohandri, & Festiyed (Eds.), *Journal of Physics: Conference Series* (Vol. 1185, Issue 1). Institute of Physics Publishing helen.craven@iop.org. https://doi.org/10.1088/1742-6596/1185/1/012057

Mohamad Noor, N.M., Mohemad, R., & Alop, F. (2022). Formative Assessment of Cognitive Level in Database Subject Using Problem-Based Learning Approach (pp. 105–115). Springer Nature. https://doi.org/10.1007/978-981-16-7228-6_11

Munir, M., & Nur, RH (2018). The development of English learning model based on contextual teaching and learning (Ctl) in junior high schools. *International Journal of Language Education, 2*(1), 31–39. https://doi.org/10.26858/ijole.v2i1.4326

Nenggala, MP, Razi, P., Hidayati, H., & Sari, SY (2024). Electronic Student Worksheet for Solving Problems in Physics Material Based on Problem-Based Learning. *International Journal of Information and Educational Technology, 14*(7), 945–954. https://doi.org/10.18178/ijiet.2024.14.7.2121

Patappa, AR, Prasetyo, ZK, & Rahmanto, T. (2024). Development of physics worksheet with discovery learning-stem to improve student problem solving skills. In E. Retnowati, A. Wiyarsi, P. White, NK Thoe, S. Hamdi, F. Fauzi, & WSB Dwandaru (Eds.), *AIP Conference Proceedings* (Vol. 2622, Issue 1). American Institute of Physics. https://doi.org/10.1063/5.0133572

Pratiwi, CD, & Simangunsong, L. (2021). The impact of problem based learning models on problem-solving ability to prove the limits of algebraic functions. In H. Suwono, H. Habiddin, & D. Rodic (Eds.), *AIP Conference Proceedings* (Vol. 2330). American Institute of Physics Inc. https://doi.org/10.1063/5.0043387

Pujiastuti, E., Sugiman, S., & Pambudi, M. (2025). Promoting Mathematics Problem-Solving Ability in Gamification Integration Using Augmented Reality. *European Journal of Educational Research, 14*(2), 645–660. https://doi.org/10.12973/eu-jer.14.2.645

Pujiastuti, H., Hidayat, S., Hendrayana, A., & Haryadi, R. (2024). Creation of Mathematics Learning Media Based on Augmented Reality to Enhance Geometry Teaching and Learning. *E3S Web of Conferences, 482* . https://doi.org/10.1051/e3sconf/202448205012

Putra, LIA, & Suparman, S. (2020). Design of student worksheet according to PBL learning model to improve problem-solving skills. *International Journal of Scientific and Technological Research, 9*(3), 4967–4973.

Putra, ZAZ, Susilo, H., Suwono, H., & Ibrohim, I. (2025). Revealing the effect of problem-based learning combined with the use of digital mind maps on students' creative thinking. *Journal of Pedagogical Research, 9*(3), 43–61.

Putri, RII, Hartono, Bos, R., Trundle, K., Shahrill, M., Meilinda, & Kurniawan, D. (Eds.). (2024). 5th Sriwijaya University Learning and Education (SULE) International Conference 2022: Reimagining Learning Toward Equitable Education. In *AIP Conference* Proceedings (Vol. 3052, Issue 1). American Institute of Physics.

Rosbiono, MR, Sopandi, W., & Anggraeni, D. (2020). Implementation of problem-based learning (PBL) approach in instructional chemistry with the context of tofu liquid waste treatment. *International Journal of Learning, Teaching and Educational Research, 19*(5), 47–77. https://doi.org/10.26803/ijlter.19.5.4

Rosita, A., Sudarmin, S., & Marwoto, P. (2014). A problem-based learning tool oriented towards green chemistry on salt hydrolysis to develop students' conservation soft

skills. *Indonesian Journal of Science Education, 3*(2), 134–139. https://doi.org/10.15294/jpii.v3i2.3112

Samsudin, A., Suhandi, A., Rusdiana, D., Kaniawati, I., Fratiwi, NJ, Zulfikar, A., Muhaemin, MH, Hermita, N., Mansur, u., Wibowo, FC, Supriyatman, S., Malik, A., & Coştu, B. (2019). Optimizing Students' Conceptual Understanding on Electricity and Magnetism through Cognitive Conflict-Based Multimode Teaching (CC-BMT). In S. Pramuditya, S. Permana, S. Sahin, M. Kinoshita, A. Waris, O. Muraza, & D. Irwanto (Eds.), *Journal of Physics: Conference Series* (Vol. 1204, Issue 1). Institute of Physics Publishing helen.craven@iop.org. https://doi.org/10.1088/1742-6596/1204/1/012027

Susanto, n., Dafik, D., Indah Kristiana, AI, Fatahillah, A., & Alfarisi, R. (2025). Enhancing Mathematical Creative Thinking in Ethno-Geometry Learning Using Augmented Reality Technology. *Mathematics Teaching-Research Journal, 17*(3), 70–87. https://www.scopus.com/inward/record.uri?eid=2-s2.0-105012042537&partnerID=40&md5=b0702f857d7509c668c718a2f99fcd3b

Syelfia, S., & Armiati, A. (2020). The Development of learning devices with realistic mathematics education based in the pharmaceutical program to improve mathematical problem-solving. *Journal of Physics: Conference Series, 1554*(1). https://doi.org/10.1088/1742-6596/1554/1/012061

Waithira, N., Mutinda, B., Shah, K., Kestelyn, E., Bull, S., Boggs, L., Lang, T., & Cheah, P.Y. (2024). Addressing the gap in health data management skills: an online self-guided course for researchers and health professionals. *BMC Medical Education, 24* (1). https://doi.org/10.1186/s12909-024-06405-y

Witzel, B., Myers, J. A., & Xin, Y. P. (2022). Intensive Word Problem Solving for Students With Learning Disabilities in Mathematics. *Intervention in School and Clinic, 58*(1), 9–14. https://doi.org/10.1177/10534512211047580

Wongsila, S., & Yuenyong, C. (2019). Enhancing grade 12 students' critical thinking and problem-solving abilities in learning of the STS genetics and DNA technology unit. *Journal for the Education of Gifted Young Scientists, 7*(2), 215–235. https://doi.org/10.17478/jegys.549005

Yang, S.-Y., & Oh, Y.-H. (2023). Video-Assisted Versus Traditional Problem-Based Learning: A Quasi-Experimental Study Among Pediatric Nursing Students. *Journal of Nursing Research, 31*(3), E277. https://doi.org/10.1097/jnr.0000000000000557

Yani, CF, Murni, A., & Roza, Y. (2020). Mathematics Teaching Videos with the Context of Riau Culture to Enhance the Mathematical Problem Solving Ability of Class VIII Students on the Material of Polyhedron. In Saktioto, TT Nugroho, S. Taib, Evelyn, R. Linda, NN Wahibah, N. Hermita, Novitri, & Dahnilsyah (Eds.), *Journal of Physics: Conference Series* (Vol. 1655, Issue 1). IOP Publishing Ltd. https://doi.org/10.1088/1742-6596/1655/1/012070