AKSIOMA: Jurnal Program Studi Pendidikan Matematika
Volume 14, No. 4, 2025, 1097–1111

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.13743

DEVELOPING PROBLEM-BASED LEARNING WORKSHEETS TO ENHANCE PROBLEM-SOLVING SKILLS IN NUMBER PATTERNS FOR JUNIOR HIGH SCHOOL STUDENTS

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Received 21 July 2025; Received in revised form 30 November 2025; Accepted 09 December 2025

Abstract

Mathematical problem-solving in number patterns remains a challenge for many junior high school students, partly because classroom instruction is still dominated by conventional teaching and limited learning resources. This study therefore aimed to develop a Problem-Based Learning (PBL)oriented student worksheet on number patterns that is valid, practical, and effective for improving students' mathematical problem-solving skills. Using the Plomp development model, the research followed three phases preliminary investigation, design, and assessment with 35 eighth-grade students at SMPN Lembah Gumanti. Data were collected through expert validation sheets, teacher and student response questionnaires, and a problem-solving test based on Polya's stages, and were analyzed descriptively. The validation results yielded an average score of 3.71, indicating very high validity. Practicality reached 83.8%, showing that the worksheet was easy to use and well received by teachers and students, while effectiveness testing showed that 91.4% of students achieved the minimum mastery criterion in problem solving. These findings lead to the conclusion that the PBL-based student worksheet developed in this study meets the criteria of validity, practicality, and effectiveness, and can serve as a feasible instructional tool to support students' problem-solving skills on number pattern topics.

Keywords: Number patterns; problem-based learning; problem-solving skills; student worksheet.

Abstrak

Kemampuan pemecahan masalah matematika pada materi pola bilangan di tingkat SMP masih menjadi tantangan, antara lain karena pembelajaran didominasi metode konvensional dan sumber belajar yang terbatas. Penelitian ini bertujuan mengembangkan Lembar Kerja Peserta Didik (LKPD) berbasis Problem Based Learning (PBL) pada materi pola bilangan yang memenuhi kriteria valid, praktis, dan efektif untuk meningkatkan kemampuan pemecahan masalah matematika siswa. Penelitian pengembangan ini menggunakan model Plomp yang meliputi tiga tahap, yaitu penyelidikan pendahuluan, perancangan, dan penilaian, dengan subjek 35 siswa kelas VIII SMPN Lembah Gumanti. Data dikumpulkan melalui lembar validasi ahli, angket respons guru dan siswa, serta tes pemecahan masalah berdasarkan tahapan Polya, kemudian dianalisis secara deskriptif. Hasil validasi ahli menunjukkan skor rata-rata 3,71 dengan kategori sangat valid. Uji kepraktisan memperoleh nilai 83,8% yang mengindikasikan LKPD mudah digunakan dan mendapat respons positif dari guru dan siswa, sedangkan uji efektivitas menunjukkan 91,4% siswa mencapai KKM dalam pemecahan masalah. Dengan demikian, LKPD berbasis PBL yang dikembangkan dinyatakan valid, praktis, dan efektif, serta berpotensi menjadi perangkat pembelajaran yang layak untuk mendukung kemampuan pemecahan masalah matematika siswa pada materi pola bilangan

***Kata kunci**: Kemampuan pemecahan masalah; lembar kerja peserta didik; pembelajaran berbasis masalah; pola bilangan*

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.13743

INTRODUCTION

Mathematical problem-solving is a key 21st-century skill that enables secondary students to develop numeracy, higher-order thinking, and the ability to reason through real-world mathematical challenges (Nilimaa, 2023). Developing these competencies is not only a curricular expectation but also a global priority, especially in light of sustainable development goal 4 (quality education), which promotes inclusive and effective learning opportunities worldwide (Edwards et al., 2024).

Despite its global significance, Indonesian students continue to face serious challenges in this area. Barana et al. (2022) and Agusman et al. (2025) reported that learners often rely on procedural memorization and struggle with strategy formation, particularly in solving contextual and open-ended problems. PISA 2022 reflects this issue: Indonesia's average mathematics score was only 366, well below the OECD average. Similar challenges occur in Jordania and Vietnam, where weak curricula and limited resources hinder students' mathematical reasoning ((Ali & Wardat, 2024); (My et al., 2025)).

Beyond mastering content, research highlights the role of cognitive dispositions such as persistence, metacognition, and risk-taking in successful problem-solving. These "habits of mind" influence how students engage with problems and handle uncertainty ((Nurmeidina et al., 2025); (Putra et al., 2024)). Internationally, Alashwal and Barham (2025) emphasized that productive mathematical mindsets support long-term learning, particularly in problem-based learning (PBL) that develop students' problem-solving skills. However, many Indonesian class-rooms still lack tools and practices to nurture these aspects (Novikasari et al., 2024).

Teachers also face difficulties designing authentic, cognitively rich tasks. Ng and Toh (2023) and also Yue et al. (2025) observed that most educators lack structured frameworks for creating meaningful problem-solving activities. This issue is evident in how number patterns key to early algebraic reasoning are taught procedurally, with few opportunities for students to generalize or apply logic (Muslim et al., 2024).

PBL connects learning with real-life contexts, encouraging students to construct, evaluate, and refine their solutions (Alsmadi et al., 2024). Its success, however, depends heavily on supportive instructional tools especially Student Worksheets which scaffold students throughout the problem-solving process. Research by Abdillah and Astuti (2021) and also Andeswari et al. (2021) confirms that well-designed worksheets enhance engagement and reasoning. Similarly, a study by Wardani and Sugandi (2024) found that PBL worksheets improved students' ability to connect mathematical models with real-world problems.

Despite positive findings, there remains a notable gap in Student Worksheet design specifically for number pattern topics. Gradini et al. (2024) highlighted the lack of context-rich, cognitively demanding materials in this area. Ubaidillah and Khotimah (2024) stressed the potential of integrating cultural elements and exploratory activities to increase student motivation. Meanwhile, Diniyah et al. (2021) emphasized the need for worksheets that support metacognitive development through reflective prompts and strategic scaffolding.

Unlike previous worksheet designs, which focused mainly on surface-level validity and task mecha-

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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nics, this study proposes a novel worksheet model that integrates real-life contexts, open-ended strategies, and metacognitive scaffolding specifically designed for number patterns. This multidimensional design addresses both the cognitive and cultural dimensions of student learning. Theoretically, it contributes to the development of culturally responsive, cognitively engaging PBL resources. Practically, it provides a viable instructional tool to help teachers bridge the gap between curriculum demands and classroom implementation, especially within developing education systems.

METHODS

This study employed a development research approach aimed at producing a Problem-Based Learning (PBL)-based student worksheets that is valid, practical, and effective in enhancing junior high school students' mathematical problem-solving skills, specifically on the topic of number patterns. The research was conducted at SMPN Lembah Gumanti, Solok Regency, West Sumatra Province, from April to May 2025. The participants consisted of 35 students from class VIII-B, selected using purposive sampling, considering the class's academic diversity and the relevance of the topic to the current curriculum.

The development model used refers to Plomp's framework, which consists of three main phases: (1) preliminary research, (2) design and prototyping, and (3) evaluation. During the preliminary investigation, a needs analysis was conducted through interviews with mathematics teachers, distribution of student questionnaires, curriculum review, conceptual analysis, and identification of student characteristics. The findings from this phase served as the foundation for designing the content and structure of the student worksheets based on the PBL approach.

In the design phase, the student worksheets was developed by integrating five key components of PBL: presentation of contextual problems, planning for problem solving, individual and collaborative investigation, development and communication of solutions, and reflection on the process. The initial prototype (Prototype 1) underwent four formative evaluation stages: self-evaluation by the researchers, expert validation by five independent validators, individual trials involving students with high, medium, and low academic abilities, and a small group trial involving six students. Revisions from each evaluation stage led to the development of Prototype 4, which was then subjected to field testing with all students of class VIII-B.

The research instruments consisted of: (1) a validation sheet used by experts to assess content quality, construction, and language; (2) a student response questionnaire and teacher observation sheet to evaluate the practicality of the Student Worksheets; and (3) a mathematical problem-solving test based on Polya's four-stage framework. The questionnaire indicators covered clarity of instructions, ease of use, visual appeal, and relevance to students' learning needs. The validation sheet indicators included content alignment with learning objectives, structural coherence, accuracy of mathematical concepts, integration with PBL syntax, and linguistic clarity.

The validity of the student worksheets was assessed using the average score from five expert validators, based on a 4-point Likert scale. The average score was calculated using formula 1.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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$$R = \frac{\sum X}{n} \quad \ldots (1)$$

where R is the validity score, $\sum X$ is the total score assigned by validators, and n is the number of assessment items (Winarni, 2021). The resulting value was categorized according to the criteria in Table 1. This table indicates that the closer the score is to the maximum (4.00), the more valid the student worksheets is in terms of content, construction, and language. Such validity is essential to ensure the theoretical and pedagogical soundness of the product before its application in the classroom.

Table 1. Validity criteria of the student worksheet

Mean Score (R)	Interpretation
$3.40 \leq R \leq 4.00$	Very Valid
$2.80 \leq R < 3.40$	Valid
$2.20 \leq R < 2.80$	Fairly Valid
$1.60 \leq R < 2.20$	Less Valid
$1.00 \leq R < 1.60$	Not Valid

The practicality of the student worksheets was measured through student responses and teacher observations during the field test. Practicality scores were converted into percentages using formula 2.

$$P = \frac{R}{SM} \times 100\% \quad (2)$$

where P represents the practicality percentage, R is the total actual score, and SM is the maximum possible score. The interpretation of results follows the criteria in Table 2. The table implies that the higher the practicality percentage, the easier the student worksheets is to use by students and teachers. High practicality indicates that the student worksheets can be implemented smoothly in a real classroom setting without technical or pedagogical barriers.

Table 2. Practicality criteria of the student worksheet

Practicality Score (%)	Interpretation
$85 < P \leq 100$	Very Practical
$70 < P \leq 85$	Practical
$55 < P \leq 70$	Fairly Practical
$40 < P \leq 55$	Less Practical
$25 \leq P \leq 40$	Not Practical

The effectiveness of the student worksheets was evaluated using a mathematical problem-solving test designed according to Polya's four stages: understanding the problem, planning the solution, carrying out the plan, and interpreting the results. The test was in the form of essay questions, scored with an analytical rubric as shown in Table 3. This rubric offers a structured and objective assessment of student responses based on key problem-solving indicators. It ensures consistency across different evaluators and reflects the depth of students' mathematical thinking.

Table 3. Analytical rubric for assessing mathematical problem-solving skills

Assessed Aspect	Score	Description
Understanding the Problem	0	Does not state what is known and what is being asked
	1	States what is known but not what is being asked, or vice versa
	2	States what is known and what is being asked, but inaccurately
	3	Accurately states what is known and what is being asked

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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Assessed Aspect	Score	Description
Planning the Solution	0	Does not write any problem-solving plan
	1	Writes a problem-solving plan, but it is inaccurate
	2	Writes an accurate problem-solving plan
Executing the Solution Plan	0	Does not write anything
	1	Writes an answer, but it is mostly incorrect or contains only a few correct elements
	2	Writes an answer that is partially complete, or mostly correct
	3	Writes a complete and accurate answer
Interpreting the Results	0	Does not write a conclusion
	1	Writes a conclusion, but it is inaccurate
	2	Writes an accurate conclusion

Source: (Mawaddah & Anisah, 2015)

Students were considered to have achieved mastery if they scored at least 7 out of 10. The level of effectiveness was determined by the percentage of students who reached this threshold, calculated using formula 3.

$$N = \frac{S}{I} \times 100\% \qquad (3)$$

where N denotes the student's final score, S is the score obtained, and I is the maximum score. The percentage of students achieving the minimum mastery criterion was calculated using the following formula 4.

$$EL = \frac{P}{N} \times 100\% \qquad (4)$$

where EL is the effectiveness level, P is the number of students who reached the minimum score (≥ 7), and N is the total number of students in the class. Table 4 provides the criteria for effectiveness. It shows that a higher percentage of students reaching mastery reflects greater instructional effectiveness of the developed student worksheets. All data collection procedures adhered to ethical guidelines, including securing formal permission from the school and maintaining the confidentiality of.

Table 4. Effectiveness criteria of the student worksheet

Percentage of (EL)	Interpretation
$80 < EL \leq 100$	Very Effective
$60 < EL \leq 80$	Effective
$40 < EL \leq 60$	Fairly Effective
$20 < EL \leq 40$	Less Effective
$EL \leq 20$	Not Effective

RESULTS AND DISCUSSION

Findings of Preliminary Research

Findings from the preliminary phase of the study served as the foundational reference for constructing the Student Worksheet grounded in Problem-Based Learning, with the aim of improving students' mathematical problem-solving competencies. The needs analysis, however, indicated that the mathematics teaching at SMPN Lembah Gumanti was still very conventionally conducted, with the teacher explaining the material first, giving examples, and giving the students exercises. This has led students to show lesser interest, with several students regarding mathematics as a difficult subject. Apart from this, insufficient learning resources inhibit students from taking their own learning initiatives as they struggle to compre-hend the subject material when the teacher is unable to present it clearly.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.13743

From the observations, teachers found less interesting mathematics classes, not employing a model that involved students in discovering concepts through meeting real-life situations. The students preferred real-life problems illustrated pictorially, which assisted them in integrating the material. Furthermore, the students were interested in materials using bright colors and different learning media which could increase their interests and their involvement in the lesson.

According to the Kurikulum Merdeka implemented at SMPN Lembah Gumanti, the researcher concentrated on the material of number patterns for Grade VIII students. The curriculum analysis proved that the topic of number patterns such as odd and even numbers, square and rectangular patterns, triangular patterns, Pascal's triangle, Fibonacci numbers, arithmetic sequences and series, and geometric sequences and series, is highly compatible for development using the Problem-Based Learning model that will lead students to understand concepts in a more contextual way concerning their real-life experiences.

The concept of analysis targeted the identification of essential concepts in the topic of number patterns. Among these are different types of number patterns that students are required to comprehend, such as odd and even patterns, square and rectangular patterns, triangular patterns, Fibonacci numbers, as well as arithmetic and geometric sequences and series. A concept map was then constructed to assist the students in understanding the linkages of these concepts to real-life contexts.

Development or Prototyping Phase Results

This section presents the results of the development of the Student Worksheet based on Problem-Based Learning, designed to enhance students' mathematical problem-solving skills

1) Table of Contents

As shown in Figure 1,the Table of Contents outlines the structure of the document, starting with the Preface, followed by the Guidelines for Using the Student Worksheets, and the Number Patterns section, which includes the Concept Map and six parts of the Student Worksheets, concluding with the References.

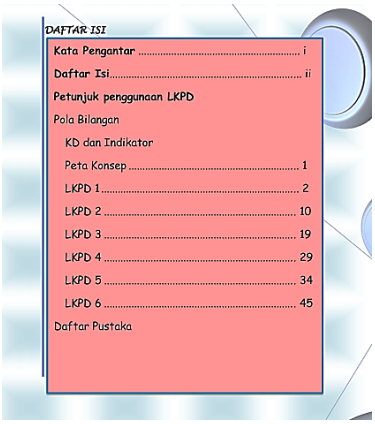

Figure 1. Display of the table of contents.

2) Instructions for use

Figure 2 presents the instructions for use included in the worksheet. The instructions for use emphasize the importance of carefully reading and understanding each instruction and problem presented. Students are encouraged to discuss problems with their group members, thoroughly comprehend and answer all questions, and seek help from the teacher if any difficulties arise.

AKSIOMA: Jurnal Program Studi Pendidikan Matematika
Volume 14, No. 4, 2025, 1097–1111
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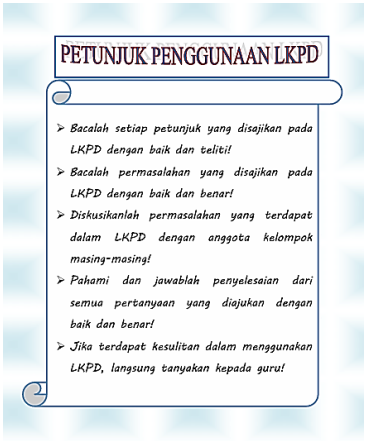

Figure 2. Display instructions for use

3) Learning Concept Map

As shown in Figure 3, the Learning Concept Map illustrates the structure of number pattern topics, starting from authentic problems that lead to the main concept of Number Patterns.

Figure 3. Display learning concept map

4) Learning Activities

As shown in Figure 4, the learning activity shown is based on the Problem-Based Learning model. Students are presented with a real-life problem scenario involving number patterns, which they must explore and solve through guided steps.

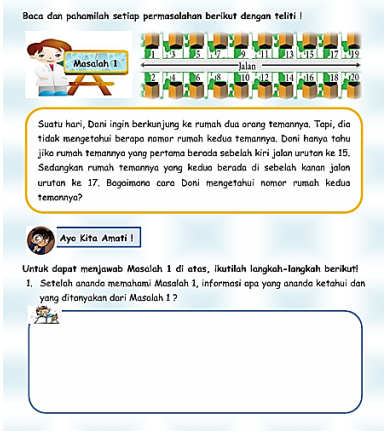

Figure 4. Display learning activity

Validity Test

At the expert review stage, the Student Worksheet developed based on the Problem-Based Learning approach for number patterns was validated by three mathematics experts, one language expert, and one educational media expert.

The mathematics experts recommended that the problem-solving steps be described in greater detail for each number pattern question, using clear and age-appropriate language for junior high school students. The language expert suggested adjusting certain mathematical terms to be more familiar and relevant to the students' everyday context. Meanwhile, the educational media expert advised improvements to the layout of illustrations, better page composition, and the use of softer background colors to ensure readability.

All feedback was accommodated in the second revision of the Student Worksheet prototype. The complete results of the Student Worksheet validation are presented in Table 5. The table shows that all assessed aspects obtained average scores in the very valid category, with an overall mean of 3.71, indicating that the Student Worksheet is considered feasible for use in learning activities.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.13743

Table 5. Validation results of the student worksheet

Aspect Assessed	Average Score	Validity Criteria
Presentation	3.75	Very Valid
Content and Material	3.68	Very Valid
Language	3.80	Very Valid
Visual Design & Layout	3.60	Very Valid
Average	3.71	Very Valid

Practicality test

The practicality test was carried out through four stages, namely individual evaluation (*one-to-one evaluation*), small group evaluation, teacher response, and student response during the field test. Practicality was measured based on the same four aspects: usability, clarity of instructions, visual attractiveness, and content integration.

1) One-to-One Evaluation

At the individual evaluation stage, the Student Worksheet was tested on three students with different levels of ability (high, medium, and low). The results showed that the product was considered highly practical across all aspects, although some students suggested minor improvements to the clarity of instructions and visual presentation. The details are presented in Table 6. Table 6 shows that all practicality aspects achieved scores in the practical to very practical categories, with an overall average of 85.8%, indicating that the Student Worksheet is easy to use, clearly understood by students, and well integrated with the learning content, even though the slightly lower score for visual attractiveness suggests that the layout and visual elements still have room for refinement.

Table 6. Practicality Test One-to-One Evaluation

Aspect Evaluated	Average Score (%)	Practicality Criteria
Usability	88.5%	Very Practical
Clarity of Instructions	86.0%	Very Practical
Visual Attractiveness	83.0%	Practical
Content Integration	85.5%	Very Practical
Average	**85.8%**	**Very Practical**

2) Small Group Evaluation

During the small group evaluation During the small group evaluation stage, six students with heterogeneous abilities were involved in testing the Student Worksheet. The results indicated a high level of practicality, especially in terms of usability, although some students suggested adjustments to the layout of images to make them more proportionate. The results are shown in Table 7.

Table 7. Practicality test small group evaluation

Aspect Evaluated	Average Score (%)	Practicality Criteria
Usability	87.0%	Highly Practical
Clarity of Instructions	85.0%	Highly Practical
Visual Attractiveness	82.5%	Practical
Content Integration	84.0%	Practical
Average	**84.6%**	**Practical**

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.13743

Table 7 indicates that all evaluated aspects fall into the practical to very practical categories, confirming that the Student Worksheet can be effectively used in small-group settings, while the rela-tively lower score on visual aspects is consistent with students' suggestions for improving image layout and proportion.

3) Teacher Response

Teacher responses were obtained from mathematics teachers involved in the trial classes. The teachers assessed the Student Worksheet as highly practical, although they suggested that some instructions could be made more concise to facilitate classroom imple-mentation. These results are presented in Table 8.

Table 8. Practicality test teacher response

Aspect Evaluated	Average Score (%)	Practicality Criteria
Usability	85.5%	Very Practical
Clarity of Instructions	83.0%	Practical
Visual Attractiveness	80.5%	Practical
Content Integration	82.0%	Practical
Average	**82.8%**	**Practical**

Table 8 shows that all evaluated aspects fall within the practical to very practical categories, with an overall average score of 82.8%, indicating that the Student Worksheet is feasible for classroom use, while the relatively lower scores on clarity of instructions and visual attractiveness point to the need for simplifying wording and refining the visual layout.

4) Student Response (Field Test)

During the field test stage, practicality was also assessed through student responses collected via questionnaires. The majority of students stated that the Student Worksheet was easy to use and engaging, although some recommended adding more varied example questions. The detailed results are shown in Table 9.

Table 9. Practicality test student response (field test)

Aspect Evaluated	Average Score (%)	Practicality Criteria
Usability	86.0%	Very Practical
Clarity of Instructions	84.5%	Practical
Visual Attractiveness	81.5%	Practical
Content Integration	83.0%	Practical
Average	**83.8%**	**Practical**

Table 9 shows that all aspects fall within the practical to very practical categories, with an overall average score of 83.8%, indicating that the Student Worksheet is generally feasible and enjoyable for classroom use, while the relatively lower scores on visual attractiveness and clarity of instructions suggest the need for improving the visual layout and enriching the examples provided.

Effectiveness test

The effectiveness of the Student Worksheet based on the Problem-Based Learning approach was measured through a mathematical problem-solving test designed according to

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.13743

Polya's four stages: understanding the problem, devising a plan, carrying out the plan, and interpreting the results. Students' answers were assessed using an analytical rubric with a maximum possible score of 10 points. A student was considered to have achieved mastery if they scored at least 7 points.

After the learning activities were completed, the test was administered to 35 eighth-grade students. The results showed that 10 students achieved the maximum score, 12 students scored 9, 7 students scored 8, 3 students scored 7, and 3 students scored 6. This means that 32 students reached the minimum required score, while 3 students did not achieve mastery.

Overall, the percentage of students who met the minimum criteria for problem-solving ability reached 91.4% of the total students who took the test. Based on the effectiveness criteria, this percentage indicates that the Student Worksheet developed in this research is categorized as very effective for enhancing students' mathematical problem-solving skills on the topic of number patterns. The distribution of students' mastery is summarized in Table 10, which shows that only a small proportion of students did not reach mastery, confirming that the worksheet can effectively support most students in achieving the expected level of performance.

Table 10. Distribution of students' mastery and effectiveness level

Category	Number of Students	Percentage
Mastery	32	91.4%
Not Mastered	3	8.6%
Total	35	100%
Effectiveness Level		**91.4%**
Effectiveness Criteria		**Very Effective**

The present study concluded that the design of Learner Worksheets based upon Problem-Based Learning considerably improves students' abilities to solve mathematical problems on the topic of number patterns. The product developed in this research was found to be valid in terms of content and construct, practical in classroom implementation, and effective in enhancing student outcomes. Thus, these findings support that systematically developed instructional materials based on real-world problem-solving contexts can directly impact and measure students' cognitive competencies within mathematics.

Problem-Based Learning refers to a learning model that promotes active thinking, independent investigation, and reflective resolution of the problem at hand. This model encourages students to identify problems, devise solution strategies, apply logic in problem-solving, and examine solution outcomes. Such understanding is directly correlated with the cognitive structure considered essential to the development of mathematical problem-solving skills, as argued by Agustinsa et al. (2023).

The design of the Learner Worksheets employing the Problem-Based Learning framework directs students to construct mathematical knowledge through guided inquiry and authentic problem-solving. The worksheets in this study went beyond exercises and periods of explanation; rather they were designed to promote conceptual discovery. Nugroho & Jailani (2019) explained that concrete problem scenarios maintain a link between an abstract mathematical concept and its real-life application, thereby facilitating meaningful learning.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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The developed Learner Worksheets' validity was then confirmed by the evaluation of experts, who concurred that the content, structure, and pedagogical flow corresponded to the principles of Problem-Based Learning and the cognitive characteristics of junior secondary students. Rani et al. (2024), in their research, established that teaching instruments incorporating the defining principles of Problem-Based Learning enable a greater degree of enhancement of students' problem-solving abilities, particularly when the problems mandate higher-level thinking processes.

The practicality of the worksheets was perceived positively by both teachers and students. Teachers regarded them easy to use and conducive to instructional goals, while students reported a boost in motivation and cognitive engagement during learning activities. These findings corroborate the argument of Gozali et al. (2022) that in Problem-Based Learning, an environment in which students actively involve themselves in solving problems cultivates motivation and confidence in dealing with complex mathematical activities.

Furthermore, the worksheets effectively produced improved performance of students in post-test assessments. According to Karlina (2022), worksheets based on Polya's problem-solving steps assist students to enhance formally their analytic reasoning in handling mathematical tasks.

In addition to this, Priyanto and Permatasari (2022) state that quite a developing trajectory of Learner Worksheets for exploratory learning favors students to build their conceptual understanding by independent knowledge construction. Rather than passively receiving the information, students actively formulate meaning throughout their problem-solving experiences.

Murwanto et al. (2022) provide further empirical evidence that the Learner Worksheets are validated, practically employed, and effectively enhancing students' capacity to independently resolve mathematical problems through guided discovery and contextualization systems of problem-solving.

According to Hafizatunnisa et al. (2024), learning processes structured in such a way that challenge students to think reflectively and systematically shape problem-solving behaviors greatly. Problem-Based Learning used as a basis for the Learner Worksheets empowers such exposure and provides cognitive scaffolding to produce robust problem solvers.

In the same way, Lestari et al. (2025) highlighted the huge impact on enhancing the mathematical problem-solving capabilities of students found in being structured learning instruments based on the Principles of Problem-Based Learning. The importance of problem-based learning is witnessed through the plurality of cognitive domains.

In finality, Faricha et al. (2024) advance that those mathematical learning tools developed from systematic backgrounds with embedded guided problem-solving steps substantially contribute to enhanced analytical capacity and reasoning to solve non-routine problems.

To summarize, the findings of the study presented herein put on record the evidences that Learner Worksheets based on Problem-Based Learning are grounded both in theory and in practice and, despite such a grounding, are proven to be extremely effective in shaping the mathematical problem-

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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solving behavior of students. They act not only as aids for instruction but also as cognitive structuring frameworks that stimulate the students to think critically, autonomously, and systematically on matters related to mathematics learning.

CONCLUSIONS AND SUGGESTIONS

This study concludes that the Learner Worksheets using Problem-Based Learning are actually valid, practical, and effective for improving the students' mathematical problem-solving skills concerning number patterns. The worksheets possess structured steps in the problem-solving process, promoting active learning and critical thinking. Future research can use these worksheets for a broader classroom application and attempt to integrate with the digital platform to maximize student participation and performance.

REFERENCES

Abdillah, D. M., & Astuti, D. (2021). Pengembangan lembar kerja peserta didik (LKPD) berbasis problem-based learning (PBL) pada topik sudut. *Pythagoras: Jurnal Pendidikan Matematika*, *15*(2), 190–200. https://doi.org/10.21831/pg.v15i2.36444

Agusman, A., Purwanto, P., & Rahardi, R. (2025). An exploration of critical thinking stages of junior high school students in solving contradictory mathematical problems. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, 200–217. https://doi.org/10.23917/jramathedu.v10i3.8911

Agustinsa, R., Anjasari, V., & Yensy, N. A. (2023). The Effect of Problem Based Learning Models Using Contextual Worksheets on Middle School Students' Mathematical Problem Solving Ability. *Edumatica : Jurnal Pendidikan Matematika*, *13*(1), 48–56. https://doi.org/10.22437/edumatica.v13i01.24387

AlAli, R., & Wardat, Y. (2024). Low PISA Performance Students: Factors, Perceptions, and Improvement Strategies. *International Journal of Religion*, *5*(9), 334–348. https://doi.org/10.61707/nve8gj33

Alashwal, H. A., & Barham, A. I. (2025). Sustaining problem-based learning: A mixed-methods exploration of its long-term effects on primary students' mathematical problem solving. *Social Sciences & Humanities Open*, *12*, 101717. https://doi.org/10.1016/j.ssaho.2025.101717

Alsmadi, H., Kandasamy, G., Al Kafri, A., & Zahirah, K. F. (2024). Empowering computing students through multidisciplinary project based learning (PBL): Creating meaningful differences in the real world. *Social Sciences & Humanities Open*, *10*, 101180. https://doi.org/10.1016/j.ssaho.2024.101180

Andeswari, S., Sholeh, D. A., & Zakiyah, L. (2021). Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Problem Based Learning dalam Pembelajaran Matematika Kelas IV Sekolah Dasar. *Prima Magistra: Jurnal Ilmiah Kependidikan*, *3*(1), 48–61. https://doi.org/10.37478/jpm.v3i1.1313

Barana, A., Boetti, G., & Marchisio, M. (2022). Self-Assessment in the

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.13743

Development of Mathematical Problem-Solving Skills. *Education Sciences*, *12*(2), 81. https://doi.org/10.3390/educsci12020081

Diniyah, E. N., Wiryanto, W., Ekawati, R., & Hendratno, H. (2021). Development of scale learning tools on map based on problems to improve problem solving skills. *Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis Ilmiah Di Bidang Pendidikan Matematika*, *7*(2), 121–134. https://doi.org/10.29407/jmen.v7i2.16153

Edwards Jr, D. B., Asadullah, M. N., & Webb, A. (2024). Critical perspectives at the mid-point of Sustainable Development Goal 4: Quality education for all progress, persistent gaps, problematic paradigms, and the path to 2030. *International Journal of Educational Development*, *107*, 103031. https://doi.org/10.1016/j.ijedudev.2024.103031

Faricha, N. A., Kurniawan, A. P., Yanti, A. W., & Prayitno, L. L. (2024). Mathematics Learning Instrument Development Based On Rme Assisted By Live Worksheet to Develop Problem Solving Skills. *Matematika Dan Pembelajaran*, *12*(1), 49–64. https://doi.org/10.33477/mp.v12i1.7118

Gozali, I., Syamsuri, S., Nindiasari, H., & Fatah, A. (2022). The Effect of Problem Based Learning on Mathematical Disposition and Students' Problem Solving Ability. *Edumatica : Jurnal Pendidikan Matematika*, *12*(2), 102–110. https://doi.org/10.22437/edumatica.v12i02.15772

Hafizatunnisa, Harisman, Y., Armiati, & Amiruddin, M. H. (2024). Analysis of Problem-Solving Behavior of Senior High School Students. *Mathematics Education Journal*, *18*(2), 181–198. https://doi.org/10.22342/jpm.v18i2.pp181-198

Karlina, A. (2022). Students' Problem-Solving Ability In Solving Mathematical Problems Based On Polya's Method As A Criterion For Measuring Learning Results. *Alifmatika: Jurnal Pendidikan Dan Pembelajaran Matematika*, *4*(2), 176–191. https://doi.org/10.35316/alifmatika.2022.v4i2.176-191

Lestari, N. A. P., Dewi, M. S. A., Astuti, N. P. E., Dikta, P. G. A., Artini, N. P. J., Sudewiputri, M. P., & Muhsam, J. (2025). The Effect Of The Problem Based Learning Model On Science Problem Solving Ability And Self Regulated Learning. *Prima Magistra: Jurnal Ilmiah Kependidikan*, *6*(2), 92–99. https://doi.org/10.37478/jpm.v6i2.5564

Mawaddah, S., & Anisah, H. (2015). Kemampuan pemecahan masalah matematis siswa pada pembelajaran matematika dengan menggunakan model pembelajaran generatif (generative learning) di SMP. *EDU-MAT: Jurnal Pendidikan Matematika*, *3*(2). https://doi.org/10.20527/edumat.v3i2 .644

Murwanto, A., Qohar, A., & Sa'dijah, C. (2022). Pengembangan LKPD Daring Pendekatan Guided Discovery Berbasis HOTS Materi Persamaan dan Fungsi

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.13743

Kuadrat. *Mosharafa: Jurnal Pendidikan Matematika*, *11*(3), 391–402. https://doi.org/10.31980/mosharafa.v11i3.730

Muslim, M., Nusantara, T., Sudirman, S., & Irawati, S. (2024). The causes of changes in student positioning in group discussions using Polya's problem-solving and <i>commognitive</i> approaches. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(9), em2506. https://doi.org/10.29333/ejmste/15148

My, N. H., Huong, N. T. C., Ngoc, T. T. B., Hai, P. T., Tham, N. T., Long, P. T., & Hai, D. T. (2025). Understanding mathematical learning difficulties in early primary grades in Vietnam: A contextualized contribution to global insights. *Multidisciplinary Science Journal*, *7*(11), 2025608. https://doi.org/10.31893/multiscience.2025608

NG, Y. X., & TOH, T. L. (2023). A framework for designing problem solving task for secondary school mathematics classroom. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, 74–86. https://doi.org/10.23917/jramathedu.v8i2.3137

Nilimaa, J. (2023). New Examination Approach for Real-World Creativity and Problem-Solving Skills in Mathematics. *Trends in Higher Education*, *2*(3), 477–495. https://doi.org/10.3390/higheredu2030028

Novikasari, I., Muttaqin, A., & Elebiary, N. (2024). Teaching Math and Preserving Culture: The Intersection of Values in Indonesian Pedagogy. In *Values and Valuing in Mathematics Education* (pp. 361–379). Springer Nature Singapore. https://doi.org/10.1007/978-981-99-9454-0_17

Nugroho, S. A., & Jailani, J. (2019). The effectiveness of concrete representational abstract approach (CRA) approach and problem solving approach on mathematical representation ability at elementary school. *KnE Social Sciences*, 27–36. https://doi.org/10.18502/kss.v3i17.4620

Nurmeidina, R., Zaqiyah, N. N., Nugroho, A. G., Andini, A., Faiziyah, N., Adnan, M. B., & Syar'i, A. (2025). Analysis of students' problem-solving abilities in solving contextual problems of Linear Equations with Three Variables in terms of Habits of Mind. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, 117–135. https://doi.org/10.23917/ijolae.v7i1.23550

Priyanto, M., & Permatasari, D. (2022). Students' Worksheets Based on Problem Based Learning In Composition and Inverse Functions to Enhance Conceptual Understanding. *JRPM (Jurnal Review Pembelajaran Matematika)*, *7*(1), 73–88. https://doi.org/10.15642/jrpm.2022.7.1.73-88

Putra, A., Nasution, M. D., & Harahap, T. H. (2024). Pengaruh Model Pembelajaran Problem Based Learning dan Contextual Teaching and Learning Terhadap Kemampuan Pemecahan Masalah Matematis dan Self-Efficacy Siswa

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.13743

SMK Kesehatan Galang Insan Mandiri. *Teorema: Teori Dan Riset Matematika*, *9*(1), 15. https://doi.org/10.25157/teorema.v9i1.13844

Rani, T. P., Sutiarso, S., & Firdaus, R. (2024). Integrating problem-based learning in e-lkpd: Enhancing problem-solving ability and adversity quotients. *Al-Jabar : Jurnal Pendidikan Matematika*, *15*(2), 505. https://doi.org/10.24042/ajpm.v15i2.23302

Wardani, D. S., & Sugandi, A. I. (2024). The Effectiveness of Live Worksheets-Assisted Problem Based Learning to Improve Students' Mathematical Problem Solving Abilities. *(JIML) JOURNAL OF INNOVATIVE MATHEMATICS LEARNING*, *7*(2), 115–126. https://doi.org/10.22460/jiml.v7i2.19655

Winarni, E. W. (2021). *Teori dan praktik penelitian kuantitatif, kualitatif, PTK, R & D*. Bumi Aksara.

Yue, M., Jong, M. S.-Y., Dai, Y., & Lau, W. W.-F. (2025). Students as AI literate designers: a pedagogical framework for learning and teaching AI literacy in elementary education. *Journal of Research on Technology in Education*, 1–22. https://doi.org/10.1080/15391523.2025.2449942