Jurnal Info Sains : Informatika dan Sains
Volume 15, Number 01, 2025, DOI 10.54209/infosains.v15i01
ESSN 2797-7889 (Online)
https://ejournal.seaninstitute.or.id/index.php/InfoSains

The Application of Problem-Based Learning Model to Improve Students' Mathematical Problem-Solving Skills in Junior High School

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Article Info	ABSTRACT
Keywords: Problem-Based Learning, Mathematical Problem-Solving, Junior High School, Qualitative Research, Mathematics Education.	This qualitative study investigates the application of the Problem-Based Learning (PBL) model to enhance mathematical problem-solving skills among junior high school students. PBL is a student-centered approach that uses real-world, open-ended problems to drive learning, emphasizing collaboration, critical thinking, and self-directed study. Through observations, interviews, and document analysis in a junior high school setting, this research provides a comprehensive understanding of how PBL implementation impacts students' abilities to solve complex mathematical problems. Findings demonstrate that PBL effectively fosters improved problem-solving strategies, deeper conceptual understanding, and greater student engagement. This study supports integrating PBL as a viable pedagogical model for mathematics education at this level.
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INTRODUCTION

The teaching and learning of mathematics has long been acknowledged as vital in developing students' analytical thinking and problem-solving abilities, key competencies needed for academic and real-world success. In Indonesia, however, studies and international assessments, such as the Programme for International Student Assessment (PISA), have consistently revealed relatively low mathematical problem-solving performance among junior high school students. According to the 2018 PISA results, Indonesian students ranked 72nd out of 78 participating countries, with an average score of 394, highlighting an urgent need for effective instructional strategies that improve these skills. The mathematical problem-solving ability is not only pivotal for academic achievement but also for students to apply mathematics meaningfully in everyday life and future careers. This concern has led educators and researchers to explore innovative pedagogical models that prioritize student engagement, critical thinking, and authentic learning experiences (Alamra et al., 2024).

One promising educational approach that has garnered increased attention is the Problem-Based Learning (PBL) model. Originating within medical education in the 1960s, PBL has expanded widely across disciplines, offering a student-centered teaching method where learners actively engage in solving real-world problems as the main vehicle for acquiring knowledge and skills. Unlike traditional teacher-centered instruction that often relies on rote memorization and passive learning, PBL encourages students to be active constructors of knowledge, collaborating to analyze complex, open-ended problems and develop solution strategies. In mathematics education, PBL aims not only to foster knowledge acquisition but also to develop higher-order thinking skills—especially mathematical problem-solving, reasoning, and literacy—which are essential for conceptual understanding and practical application of mathematics (Mashuri et al., 2019).

The relevance of PBL for junior high mathematics stems from the challenges typical students face with abstract mathematical concepts and routine problem-solving tasks. It has been shown that PBL activities involving authentic and contextualized problems stimulate students' curiosity and motivation, making abstract ideas more accessible and meaningful. Such engagement reduces the passivity often reported in conventional classrooms and increases students' interest and enthusiasm in mathematics learning. Furthermore, PBL's collaborative learning environment promotes peer interaction, discussion, and multiple perspectives, which enrich students' cognitive and social skills needed for effective problem-solving. Teachers take on the role of facilitators rather than simple knowledge transmitters, guiding students' inquiry and encouraging metacognitive reflection, enabling learners to plan, monitor, and evaluate their problem-solving efforts critically (Sary & Fatimah, 2023).

Despite the documented advantages, implementing PBL in mathematics classrooms is not without challenges. Research points to practical constraints such as limited class time, uneven student readiness, insufficient instructional resources, and gaps in teacher training and preparedness for PBL facilitation. Effective deployment of PBL requires careful curriculum planning, continuous teacher professional development, and fostering a supportive learning environment that accommodates student autonomy while maintaining curricular goals. Addressing these constraints is critical to realizing PBL's full potential in enhancing mathematical problem-solving skills among junior high school students (Farhan et al., 2021).

Several studies conducted in Indonesian educational settings have demonstrated promising outcomes of PBL application in improving mathematics learning interest and achievement. For example, classroom action research in a Yogyakarta junior high school found that PBL implementation increased students' learning interest and achievement by repositioning students as active problem solvers facing concrete, real-life challenges, thus facilitating deeper conceptual understanding. Another study in Pekanbaru reported significant improvement in students' mathematical problem-solving ability, with average test scores rising markedly after PBL introduction, highlighting the effectiveness of PBL cycles involving preparation, implementation, observation, and reflection stages. Such evidence corroborates the meta-analysis findings showing that PBL has a large positive effect on Indonesian students' mathematical reasoning and problem-solving skills compared to conventional methods (Elfiyani, 2024).

Given this background, the current qualitative study aims to provide a comprehensive analysis of the application of the Problem-Based Learning model in junior high school mathematics classrooms to improve students' mathematical problem-solving skills. While quantitative studies offer evidence of effectiveness, qualitative research is instrumental in understanding the nuanced processes, interactions, and contextual factors that underpin

PBL's impact on learning. This study seeks to explore students' experiences, teacher practices, classroom dynamics, and challenges encountered during the PBL implementation, offering deeper insights into how this model influences problem-solving development and how it can be optimized in the Indonesian educational context.

Moreover, improving mathematical problem-solving skills through PBL aligns with national educational objectives in Indonesia, which emphasize critical thinking, problem-solving, and learner autonomy as 21st-century skills mandated in the 2013 curriculum. Incorporating PBL facilitates these goals by situating learning in meaningful contexts and fostering student engagement through active inquiry. This pedagogical shift also prepares students to face complex, uncertain problems beyond the classroom, equipping them with skills essential for lifelong learning and adaptability.

METHODS

This study applies a qualitative research design to investigate the implementation of the Problem-Based Learning (PBL) model in improving junior high school students' mathematical problem-solving skills. The qualitative approach aims to provide an in-depth, comprehensive analysis of the teaching and learning processes, focusing on the interactions between teachers and students, classroom dynamics, and the development of problem-solving abilities through PBL activities. The research draws from classroom observations, interviews, and document analysis as primary data sources, allowing rich contextual understanding beyond what quantitative methods alone can offer.

Research Setting and Participants

The research was conducted in a public junior high school in Indonesia, selected purposively due to its active implementation of PBL in the mathematics curriculum. The participants consisted of one junior high school mathematics teacher with experience applying PBL strategies and a class of 30 students aged 13–14 years, representing Grade 8. The class was heterogeneous in academic ability, gender, and motivation, providing a realistic context for investigating the PBL model's practical impact.

Research Procedure

The research unfolded over one semester (approximately four months) during which the PBL instructional model was integrated into selected mathematics units focused on problem-solving topics. The research followed these stages:

Preliminary Preparation:

a. The researcher conducted a preliminary meeting with the teacher to discuss the goals and procedures of PBL implementation.
b. Lesson plans were collaboratively developed based on the PBL cycle, emphasizing real-world, open-ended mathematical problems relevant to the curriculum and students' daily experiences.

Data Collection during PBL Implementation:

The core data collection activities included:

a. Classroom Observations: Conducted during the mathematics lessons where PBL was applied. The researcher used a structured observation protocol to note teacher strategies, student activities, group interactions, and engagement during key PBL phases: problem presentation, problem analysis, independent/group investigation, solution development, and reflection.

b. Semi-Structured Interviews: Held with the mathematics teacher to explore their perceptions, challenges, and strategies in facilitating PBL. Selected students were also interviewed to gain insights into their experiences, understanding of problem-solving processes, and attitudes toward the PBL model.
c. Document Analysis: Included lesson plans, teaching materials, student worksheets, group discussion notes, and assessment results focusing on problem-solving tasks. This helped triangulate findings from observation and interview data.

Throughout data collection, the researcher maintained detailed field notes capturing non-verbal cues, classroom atmosphere, and spontaneous student-teacher interactions relevant to understanding PBL's implementation.

Data Analysis

The qualitative data were analyzed thematically following the procedures outlined by Braun and Clarke in Remmen (2024), entailing:

a. Familiarization: Immersing in collected data by reading and re-reading transcripts, observation notes, and documents.
b. Generating Initial Codes: Identifying meaningful segments related to PBL's influence on problem-solving skills, student engagement, teacher facilitation, and classroom challenges. Coding was conducted manually and with qualitative data analysis software for accuracy.
c. Searching for Themes: Codes were organized into broader themes reflecting patterns, such as "enhanced conceptual understanding," "collaborative problem-solving," "metacognitive development," and "implementation challenges."
d. Reviewing Themes: Themes were refined for coherence, relevance, and richness, eliminating overlaps or redundancies.
e. Defining and Naming Themes: Clear definitions and labels were assigned to themes to capture their essence and facilitate reporting.
f. Reporting: The final thematic structure was reported with supporting verbatim quotes and observational excerpts to illustrate key findings (Remmen, 2024).

Ethical Considerations

The research adhered to ethical protocols including:

a. Obtaining permission from the school and informed consent from participants and their parents.
b. Ensuring confidentiality of participants by anonymizing names and sensitive information in all documentation.
c. Respecting voluntary participation, allowing withdrawal at any time without consequences.
d. Maintaining neutrality and minimizing researcher bias by actively reflecting on positionality and using triangulation to verify findings.

Validity and Reliability

To ensure credibility and trustworthiness of the qualitative study, several strategies were implemented:

a. Triangulation: Data were collected from multiple sources—observation, interviews, documents—to cross-validate findings.
b. Member Checking: Preliminary findings were shared with the teacher and some students to confirm accuracy and interpretation.
c. Peer Review: Colleagues with expertise in qualitative research reviewed the coding scheme and thematic analysis.
d. Thick Description: Rich, detailed accounts of classroom events and participant perspectives provide transparency and allow readers to assess transferability.

Limitations

While the qualitative approach offers in-depth insights, the study has limitations:

a. The single-class setting limits generalizability, though the findings provide valuable detailed understanding for similar contexts.
b. The researcher's presence in classroom observation could have influenced student and teacher behavior (observer effect).
c. Time constraints limited longitudinal tracking of students' problem-solving development beyond one semester.

This methodological framework ensures a robust, comprehensive qualitative analysis of PBL's application in junior high school mathematics classrooms, providing nuanced understanding of how PBL enhances students' mathematical problem-solving skills in a real educational setting.

RESULTS AND DISCUSSION

The application of PBL led to clear growth in students' problem-solving performance over the research period. This was evident in their increasing ability to analyze complex problems, identify known and unknown variables, formulate solution strategies, and present logical reasoning. Initial pretest assessment and early-cycle observations revealed students often relied on rote procedures and simple calculations without deeper understanding. However, after guided PBL activities, students showed more flexible thinking, use of multiple strategies, and reflective evaluation of their answers.

Table 1 summarizes the qualitative indicators of improvement observed in students' problem-solving skills across the two main cycles of the study.

Table 1. Improvement observed in students' problem-solving skills

Aspect of Problem-Solving	Description Before PBL Implementation	Description After PBL Cycle I	Description After PBL Cycle II
Problem Comprehension	Difficulty understanding problem context; focused on keywords only	More careful reading and group discussion to clarify problem	Full contextual understanding and rephrasing of the problem by groups

Aspect of Problem-Solving	Description Before PBL Implementation	Description After PBL Cycle I	Description After PBL Cycle II
Identification of Information	Confused by irrelevant data; struggled to separate known/unknowns	Improved ability to distinguish needed info for problem-solving	Clear identification and prioritization of relevant data
Strategy Formulation	Mostly applied memorized formulas or procedures	Began exploring alternative methods; brainstorming solutions	Strategized collaboratively using multiple approaches (graphical, algebraic)
Execution of Solution	Mechanical calculations, prone to errors	More accurate computations; checking work collaboratively	Accurate, efficient solution with error checking and estimations
Reflection & Evaluation	Limited or no reflection on solution validity	Started questioning and discussing solution reasonableness	Critical self and peer evaluation, suggesting improvements
Communication of Solutions	Presented minimal or unclear explanations	Clearer explanations within groups; some public presentations	Confident and structured presentations using mathematical language

Observational records and interview transcripts indicate that students became increasingly engaged and motivated during mathematics lessons using the PBL model. Students reported that working on real-world, open-ended problems made lessons more interesting and meaningful compared to traditional methods. Group problem-solving tasks encouraged collaboration and active participation for all members.

Excerpt from a student interview:

> “At first, I just copied from the textbook. But with PBL, we got to discuss with friends and find our own way to solve problems. It’s more fun, and I understand better.” — Student A

Classroom observations revealed a positive shift in behavior, with more students actively asking questions, sharing ideas, and taking initiative in group discussions. The teacher adapted their role from information giver to facilitator and motivator, scaffolding students’ learning rather than delivering direct solutions.

One of the pivotal results of PBL implementation was enhancement in students’ collaborative learning and communication skills. The research documented students working cohesively in small heterogeneous groups, often assigning roles such as recorder, presenter, and leader, which increased responsibility and organization within teams.

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Table 2 shows qualitative data on the observed collaborative behaviors throughout the PBL phases.

Table 2. Collaborative behaviors throughout the PBL phases

Collaboration Aspect	Observed Behaviors Before PBL	After PBL Cycle I	After PBL Cycle II
Group Interaction	Minimal sharing; often silent or off-task	Regular idea exchanges; respectful listening	Active dialogue; negotiating different viewpoints
Role Distribution	No clear roles; ad hoc participation	Roles assigned informally; some role adherence	Formal roles assigned; well-managed group processes
Conflict Resolution	Tendency to avoid disagreement	Conflicts resolved with teacher intervention	Peer-mediated resolution and consensus building
Support and Encouragement	Limited encouragement within group	Beginning of peer support when stuck	Strong mutual encouragement; constructive feedback
Joint Decision Making	Decisions dominated by a few individuals	More democratic input from several members	Collective decision-making with role consensus

Interview data from the mathematics teacher highlight the evolving facilitation role required for successful PBL. The teacher emphasized a shift from direct instruction to guiding inquiry, prompting students with strategic questions, and supporting metacognition and reflection. The teacher's facilitation helped students overcome initial difficulties related to self-directed learning and group dynamics.

Key facilitation strategies included:

a. Introducing problems that connected mathematics to everyday contexts relevant to students' lives.
b. Encouraging students to formulate their own questions before seeking solutions.
c. Monitoring group discussions to provide timely scaffolding without dominating.
d. Creating reflection sessions at lesson ends to discuss learning processes, challenges, and insights.
e. Using formative assessments aligned with PBL goals, such as evaluating reasoning and collaboration skills.

Despite positive outcomes, several challenges emerged in PBL implementation:

a. Initial Student Hesitancy: Many students were unfamiliar with open-ended problem-solving and required time to adjust. Some exhibited dependency on the teacher for answers early on.
b. Time Management: PBL required significant time for problem exploration, research, and group discussion, posing challenges in covering the full curriculum.
c. Resource Limitations: Limited availability of learning materials and digital tools constrained students' ability to investigate problems fully.
d. Group Imbalances: Some groups had dominant members overshadowing others, while quieter students occasionally under-participated. The teacher needed to intervene to manage these dynamics.

The teacher noted the need for ongoing professional development and institutional support to sustain and improve PBL effectiveness. Analysis of student worksheets, assignments, and assessment results aligned with qualitative observations, revealing progressive mastery of problem-solving skills. Student solutions became more complete, logically structured, and well-justified after PBL cycles. A summary of the student achievement progress is presented in Table 3, adapted qualitatively from assessment rubrics evaluating problem comprehension, solution strategies, reasoning, and communication.

Table 3. Assessment rubrics evaluating problem comprehension

Competency Aspect	Pre-PBL (%)* Mastery	After PBL Cycle I (%)* Mastery	After PBL Cycle II (%)* Mastery
Problem Understanding	40%	68%	85%
Problem Analysis & Strategy	45%	70%	88%
Solution Execution	50%	72%	90%
Reasoning & Justification	30%	65%	83%
Communication & Presentation	35%	66%	80%

Effectiveness of PBL in Improving Mathematical Problem-Solving Skills

The core finding from this study is that PBL significantly enhances students' mathematical problem-solving skills by shifting the learning focus from rote procedures to active inquiry, strategy development, and reflective evaluation. This confirms prior research showing that PBL enables students to better comprehend problem contexts, identify relevant information, and apply a variety of solution strategies (Ajeng Julia et al., 2025).

PBL situates students at the center of learning around contextualized problems, which fosters deeper conceptual understanding and critical thinking in mathematics . These results are consistent with this study's observation that students developed from passive recipients to active problem solvers capable of reasoning about multiple solution paths and reflecting critically on their work (Munawaro et al., 2025).

Similarly, others have demonstrated PBL's superiority over conventional teaching in improving mathematical problem-solving abilities in junior high school students. A quasi-experimental study in Pekanbaru found students exposed to PBL outperformed peers taught by traditional methods in problem-solving tests . These convergent findings reinforce the robustness of PBL as an instructional model for junior high mathematics (Marchy et al., 2022).

Development of Collaborative and Metacognitive Skills

The study also highlights how PBL facilitates collaborative learning and metacognitive development. Through structured group work, students honed communication skills and shared diverse perspectives, essential for complex problem-solving. This findings from Eka Sari et al. (2024) who assert that PBL's emphasis on group discussion strengthens students' communication, collaboration, and critical thinking abilities (Eka Sari et al., 2024).

Metacognition, involving planning, monitoring, and evaluating one's thinking processes, was distinctly nurtured through PBL's reflection phases. Students reported increased awareness of their problem-solving approaches and errors, consistent with meta-analytic findings indicating that PBL promotes reflective mathematical thinking more effectively than conventional instruction . Such metacognitive growth is vital for lifelong learning and adaptable problem-solving beyond controlled classroom settings (Salsabila & Endang, 2024).

Impact on Student Engagement and Motivation

The qualitative data showed a strong increase in student engagement and motivation during PBL activities. Authentic, real-life problems made learning meaningful and relevant, capturing students' interest—a finding widely supported in the literature. Studies have underlined that contextual problems stimulate curiosity and intrinsic motivation, which are fundamental for sustained effort in mathematical tasks . The collaborative atmosphere also helped maintain motivation by providing social support and opportunities for peer encouragement (Muho et al., 2025).

Teacher's Role and Implementation Challenges

The study illustrates the critical role of teachers in successfully facilitating PBL. Transitioning from controllers of knowledge to facilitators and scaffolds is essential but challenging. This is reaffirmed by Lentera Sriwijaya Journal's research which identified inadequate teacher training, heavy time demands, and limited resources as significant obstacles in PBL implementation . The current study found similar challenges: managing diverse group dynamics, balancing student autonomy with guidance, and time constraints related to the curriculum.

These findings suggest a strong need for comprehensive teacher professional development focused on PBL pedagogy, classroom management in active learning environments, and formative assessment aligned with problem-solving processes. Studies by Andini and Siregar (2024) confirm that experienced teachers achieve better PBL outcomes, reflecting the importance of ongoing capacity building (Yuna et al., 2025).

Moderating Factors Influencing PBL Effectiveness

Supporting meta-analytic evidence (Gufron et al., 2025), the effectiveness of PBL depends on several contextual and learner-specific factors (Gufron et al., 2025). These include:

a. Student readiness: Initial unfamiliarity with self-directed learning requires gradual scaffolding.

b. Learning duration: Longer, sustained PBL interventions yield greater gains in problem-solving ability.
c. Problem relevance: Problems connected to students' lives or interests are more engaging and effective.
d. Environmental support: Adequate classroom resources, access to digital tools, and positive school culture enhance implementation quality.

In line with this, areas where the study's school faced resource limitations or where problems were less contextualized showed comparatively slower skill development and engagement. This underscores the importance of optimizing PBL design and providing systemic support.

Theoretical Implications

The findings reinforce constructivist learning theory, particularly Vygotsky's sociocultural perspective, which emphasizes social interaction and scaffolding in cognitive development. PBL's collaborative approach provides the social context in which students internalize problem-solving skills. This is echoed in the meta-analysis by Gufron et al. , which situates PBL as an effective means to foster active construction of mathematical knowledge.

Furthermore, the study confirms that PBL's active, inquiry-based nature aligns with 21st-century educational goals, including critical thinking, creativity, collaboration, and communication. By integrating real-world mathematical problems, PBL fosters authentic learning experiences that prepare students for complex real-life challenges.

CONCLUSION

This study corroborates the significant benefits of the Problem-Based Learning model in improving junior high school students' mathematical problem-solving skills by fostering active, collaborative, and reflective learning. The findings align with extensive national and international research emphasizing PBL's role in deepening conceptual understanding, enhancing critical thinking, and motivating students through authentic problem contexts. Successful implementation requires skilled teacher facilitation, appropriate resources, and curricular alignment. By addressing identified challenges and leveraging moderating factors, educators can harness PBL's full potential, contributing to more effective mathematics education that equips students with crucial competencies for academic success and real-life problem solving.

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