



## Improving Didactic Effectiveness of Physics Teaching through Problem-Based Learning (PBL)

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### ABSTRACT

This study examines how problem-based learning (PBL) can improve the didactic effectiveness of physics teaching. Using a qualitative design, the research analyzed classroom observations, semi-structured teacher interviews, and student focus group discussions in physics lessons where PBL strategies were implemented. The findings indicate that PBL increases student engagement, strengthens conceptual understanding, and supports collaboration, inquiry, communication, and problem-solving skills. Structured problem scenarios helped students connect theoretical physics concepts with real-world situations and reduced dependence on rote memorization. However, teacher preparation and the time needed to design effective learning problems remain important challenges. The study suggests that PBL offers a practical methodology for improving physics instruction.

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## 1. INTRODUCTION

The rapid development of science and technology requires physics education to help students understand concepts, apply knowledge, and solve problems in real-life situations. However, physics is often considered difficult because it involves abstract concepts, mathematical relationships, and complex problem-solving processes. In many classrooms, physics instruction is still dominated by teacher explanation, textbook-based learning, and routine exercises. As a result, students may understand formulas without being able to relate them to physical phenomena or practical contexts. This condition shows the need for instructional approaches that encourage students to participate actively, think critically, and construct their own understanding [1-8].

Problem-based learning (PBL) is one approach that can respond to this need. PBL engages students in learning through real-world problems that require inquiry, discussion, collaboration, and solution development [9]. In physics learning, problems related to motion, energy, electricity, heat, waves, or pressure can be used to connect abstract concepts with everyday phenomena. Through this process, students are encouraged to identify relevant concepts, analyze information, communicate ideas, and apply scientific reasoning. Previous studies have shown that PBL can improve students' motivation, problem-solving skills, knowledge retention, conceptual understanding, collaboration, communication, and self-directed learning [2, 10, 11]. The didactic effectiveness of physics teaching depends on how well instructional methods support students' understanding, engagement, skill development, and practical application. PBL can contribute to this effectiveness because it shifts learning from passive knowledge reception to active investigation and reasoning. Its implementation can also be strengthened through digital simulations, interactive platforms, and collaborative tools, which help students visualize physical phenomena, test assumptions, and explore problem scenarios more effectively. These technologies are especially useful when direct experimentation is limited by time, equipment, or safety conditions. Nevertheless, PBL requires careful planning. Teachers need to design meaningful problems, guide group activities, facilitate inquiry, integrate appropriate technologies, and assess both learning processes and outcomes. Without proper preparation, PBL may become unfocused or time-consuming.

This paper examines a methodology for improving the didactic effectiveness of physics teaching through PBL, with attention to student engagement, conceptual understanding, collaboration, problem-solving, self-directed learning, technology integration, and practical implementation challenges. The novelty of this paper lies in its focus on improving the didactic effectiveness of physics teaching by integrating PBL with technology-supported instructional practices. While previous studies have discussed PBL as a strategy for improving motivation, conceptual understanding, and problem-solving skills, this paper is different. This paper emphasizes a methodological framework that connects problem design, student collaboration, teacher facilitation, digital technology, and reflective assessment in physics learning. This integrated perspective provides a more practical approach for helping teachers organize physics instruction around real-world problems while using technological tools to support visualization, inquiry, and active knowledge construction. Therefore, this paper contributes to the development of a more systematic and applicable model for implementing PBL in physics classrooms.

## 2. METHODS

This study used a qualitative research design to investigate how PBL can improve the didactic effectiveness of physics teaching. Detailed information for this method is explained elsewhere [12]. The qualitative approach was selected because the study focused on classroom processes, student engagement, teacher facilitation, and learning experiences rather than statistical measurement. The aim was to understand how PBL-based methodology works in real classroom situations and how it influences students' conceptual understanding, collaboration, and problem-solving behavior. The participants included secondary school students and physics teachers who implemented PBL strategies in physics lessons. The study focused on learning activities in which students were asked to solve structured physics problems individually and collaboratively. These problems were designed to connect physics concepts with real-world situations, such as motion, energy, electricity, heat, pressure, and other phenomena that students could observe or discuss in daily life. Data were collected through classroom observations, semi-structured interviews with teachers, and focus group discussions with students. Classroom observations were used to identify how students participated in group discussions, asked questions, explored possible solutions, and applied physics concepts during PBL activities. Teacher interviews were used to understand how problem scenarios were designed, how classroom facilitation was conducted, and what challenges appeared during implementation. Student focus group discussions provided information about learners' perceptions of engagement, motivation, collaboration, and conceptual understanding. The collected data were coded and categorized thematically. The analysis focused on recurring patterns related to student engagement, conceptual understanding, collaboration, inquiry, communication, problem-solving skills, and self-directed learning. These themes were then organized into broader categories to explain the didactic effectiveness of PBL-based physics lessons. The results are presented through narrative explanation and two summary tables in the Results and Discussion section. Triangulation was used to strengthen the trustworthiness of the findings. Data from classroom observations, teacher interviews, and student focus group discussions were compared to ensure that the interpretation did not rely on only one source. For example, observed student participation was compared with teacher reflections and student comments about their learning experience. This process helped produce a more balanced understanding of how PBL influenced physics instruction. Ethical consideration was maintained by protecting the identities of students and teachers. The study did not include full raw observation notes, interview transcripts, or focus group responses in the article. Instead, the main findings are summarized in narrative form and represented through tables. This approach allows the study to present the substance of the data while maintaining participant confidentiality.

## 3. RESULTS AND DISCUSSION

PBL improved the didactic effectiveness of physics teaching by encouraging students to participate more actively in the learning process. During PBL-based lessons, students were not only asked to receive explanations from the teacher, but also to analyze problem situations, discuss possible solutions, apply relevant concepts, and explain their reasoning. This learning process made physics instruction more interactive and meaningful. Student engagement increased because the learning activities were organized around problems that required active participation. Students became more involved in group discussions, asked more questions, and showed greater interest in solving physics-related problems. The

problem scenarios encouraged students to think about how physics concepts could be used to explain real-life situations. As a result, students were more motivated to participate in the lesson. The main indicators of student engagement observed during PBL-based physics lessons are presented in **Table 1**.

**Table 1.** Student engagement indicators in PBL-based physics lessons.

INDICATOR	OBSERVATION DESCRIPTION
Participation	Active involvement in group discussions
Motivation	Increased interest in solving physics problems
Collaboration	Effective teamwork and peer interaction
Inquiry	Asking questions and exploring solutions

Participation was one of the most visible indicators of engagement. Students were more active when they were given problems to solve rather than only listening to explanations. In group activities, they discussed ideas, divided tasks, and tried to connect the problem with relevant physics concepts. This participation helped create a more student-centered learning environment.

Motivation also improved during PBL-based activities. Students showed greater interest when the lesson began with a problem connected to real situations. Real-world problems helped students understand why physics concepts were useful. This reduced the perception that physics was only a collection of formulas and made the subject more relevant to students' daily experiences.

Collaboration was another important outcome. Students worked together to analyze problems, compare ideas, and develop solutions. This process helped them practice communication and teamwork. In physics learning, collaboration is useful because students can explain concepts to one another, correct misunderstandings, and build shared understanding through discussion.

Inquiry was also developed through PBL. Students asked questions about the causes of physical phenomena, the relationship between variables, and the possible steps for solving problems. This inquiry process encouraged students to explore solutions instead of waiting for direct answers from the teacher. It also supported critical thinking because students had to justify their ideas and evaluate whether their explanations were reasonable.

The findings also show improvement in conceptual understanding. Students were better able to explain physics concepts when they learned them through problem situations. For example, instead of only memorizing formulas, students tried to understand how concepts such as force, motion, energy, or electricity could be applied to practical cases. This process helped reduce dependence on rote memorization and supported deeper learning.

The qualitative learning outcomes observed during PBL-based physics instruction are summarized in **Table 2**. One of the key outcomes was the improvement in conceptual understanding. Students were better able to explain complex physics concepts and apply them to real-life situations. Teachers reported that PBL encouraged deeper cognitive processing and reduced reliance on rote memorization. Furthermore, students developed

essential skills such as critical thinking, communication, and teamwork, which are crucial for scientific learning [10].

**Table 2.** Qualitative learning outcomes observed

LEARNING OUTCOME	DESCRIPTION
Conceptual understanding	Ability to explain and apply physics concepts
Problem-solving skills	Improved analytical and reasoning abilities
Communication skills	Clear articulation of ideas in group settings
Self-directed learning	Increased responsibility for learning

Conceptual understanding improved because students were required to connect theory with application. PBL encouraged them to identify relevant concepts, analyze the problem, and explain why a particular solution was appropriate. This kind of learning is important in physics because students often struggle when they know a formula but do not understand when or why it should be used.

Problem-solving skills are also developed through repeated engagement with structured problem scenarios [3, 13, 14]. Students learned to read a problem carefully, identify known and unknown information, discuss possible strategies, and test their reasoning. These activities strengthened analytical thinking and helped students approach physics problems more systematically.

Communication skills improved because students had to explain their ideas during group discussions. They were encouraged to present arguments, respond to peers, and clarify their reasoning. This was useful not only for social interaction but also for scientific learning, because explaining an idea requires students to organize their thoughts and use appropriate concepts.

Self-directed learning was also observed. Students became more responsible for identifying what they needed to understand to solve a problem. Instead of depending entirely on teacher explanation, they searched for information, asked questions, and worked with peers to develop solutions. This outcome is important because students need independence and confidence when facing unfamiliar physics problems.

The role of the teacher was central in making PBL effective. Teachers guided students by presenting meaningful problems, asking guiding questions, organizing group work, and helping students reflect on their solutions. Teacher facilitation was important because students still needed support to stay focused and connect their discussions with physics concepts. Without guidance, group work could become unfocused or dominated by only a few students.

The integration of technology also supported PBL-based physics instruction. Digital simulations, visual tools, and interactive platforms helped students observe abstract phenomena and test ideas more easily. These tools made it possible to explore situations that were difficult to demonstrate in a conventional classroom. When technology was combined with problem scenarios, students could better visualize concepts and compare different outcomes.

Despite these benefits, several challenges were identified. The first challenge was teacher preparedness. PBL requires teachers to design appropriate problem scenarios, manage group discussions, guide inquiry, and assess learning outcomes. This requires more preparation than traditional lecture-based teaching. Teachers need training and practical experience to apply PBL effectively. The second challenge was time. PBL activities often require more classroom time because students need to understand the problem, discuss possible solutions, conduct an investigation, and present results. In a limited lesson schedule, teachers may find it difficult to complete all planned content. Therefore, careful planning is needed to balance curriculum coverage with deeper learning. Another challenge was unequal student participation. In some groups, more active students tended to dominate the discussion, while quieter students participated less. This shows that teachers need to monitor group work and create roles or tasks that encourage all students to contribute. Effective collaboration does not happen automatically; it must be guided and structured.

PBL can improve the didactic effectiveness of physics teaching by making learning more active, meaningful, and connected to real-world problem-solving. It supports student engagement, conceptual understanding, collaboration, communication, inquiry, and self-directed learning. However, successful implementation requires well-designed problem scenarios, teacher facilitation, sufficient time, and appropriate use of technology. This study adds new information regarding PBL, as reported elsewhere [3, 13-15]. This study also adds new information regarding physics education, as reported elsewhere [1-7].

#### **4. CONCLUSION**

PBL can improve the didactic effectiveness of physics teaching by making the learning process more active, meaningful, and connected to real-world situations. Through structured problem scenarios, students are encouraged to analyze physical phenomena, discuss possible solutions, apply relevant concepts, and explain their reasoning. This process supports deeper conceptual understanding and reduces students' dependence on rote memorization. PBL-based physics lessons can increase student engagement, motivation, collaboration, inquiry, communication, problem-solving skills, and self-directed learning. Students become more involved when physics concepts are presented through practical problems rather than only through teacher explanation and routine exercises. The integration of digital simulations, interactive platforms, and collaborative tools also supports the learning process by helping students visualize abstract concepts, test ideas, and explore solutions more interactively. However, successful implementation requires careful instructional planning. Teachers need adequate preparation to design meaningful problem scenarios, manage group activities, guide inquiry, and assess learning outcomes. Time constraints and unequal student participation should also be considered when implementing PBL in physics classrooms. Indeed, future research may develop scalable PBL-based teaching models and examine their effectiveness through broader classroom implementation.

#### **5. AUTHORS' NOTE**

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

## 6. REFERENCES

- [1] Magbarkhanovich, T.A., Akhrolivech, E.U., To'ychiyevna, F.D., Sultanova, A., Uktam, U.A., Shamsiddin, I.S., Khairulla, K.Y., and Eshbekova, M.J. (2026). Competence-based educational cluster model for developing future physics teachers toward quality education to support sustainable development goals (SDGs). *ASEAN Journal of Educational Research and Technology*, 5(2), 211-218.
- [2] Prahani, B.K., Neswary, S.B.A., Saphira, H.V., Mohd Fadzil, H.B., Mirtoshev, Z., and Uwayezu, J.C. (2027). Problem-based learning assisted by physics digital pocket book: Experimental study to enhance students' critical thinking skills completed with bibliometric analysis toward sustainable development goals (SDGs). *ASEAN Journal of Educational Research and Technology*, 6(1), 15-34
- [3] Butai, S.N., Phang, F.A., and Yulianti, E. (2027). Enhancing real-world physics problem-solving skills through mind map-based scaffolding: The role of metacomponents among pre-university students. *ASEAN Journal of Educational Research and Technology*, 6(1), 35-50
- [4] Lgu, A.O. (2023). Impact of blended learning method on secondary school physics students' achievement and retention in Lokoja, Nigeria. *ASEAN Journal for Science Education*, 2(2), 57-66.
- [5] Laguindab, M. S., and Cagas, B. L. (2026). Factors influencing senior high school students' aversion to physics. *ASEAN Journal for Science Education*, 5(1), 39-52.
- [6] Bolaji, H. O., Ahmed, A. T., Ibrahim, A., Jimba-Na'Allah, F. K., Oyeyemi, W. T., Hassan-Ibrahim, R. B., and Luwoye, A. (2025). Gender as a predictor of students' performance in physics education technology simulation of chemistry content as community service in secondary schools. *ASEAN Journal of Community Service and Education*, 4(2), 123-132.
- [7] Al Husaeni, D.N. (2022). Development analysis research on physics education by mapping keywords using the VOSviewer application. *ASEAN Journal of Physical Education and Sport Science*, 1(1), 9-18.
- [8] Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. *Educational Psychology Review*, 16(3), 235–266.
- [9] Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. *New Directions for Teaching and Learning*, 1996(68), 3–12.
- [10] Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning*, 1(1), 9–20.
- [11] Saidirasilovna, U.N. (2025). Preparing future geography teachers through problem-based learning technology: A short review. *ASEAN Journal for Science Education*, 4(1), 39-44.
- [12] Susilawati, A., Nandiyanti, S. R., Siddik, N. A. C., and Nandiyanto, A. B. D. (2025). How to do research in science and engineering education: A methodological framework with lessons learned from common research failures, bibliometric analysis, and practical insights. *ASEAN Journal of Educational Research and Technology*, 4(3), 507-522.
- [13] Sabugal, B.T., and Apellido Jr., E.E. (2025). Effectiveness of the phenomenon-based approach in enhancing senior high school students' mathematical achievement and problem-solving skills. *ASEAN Journal of Educational Research and Technology*, 4(2), 153-160.
- [14] Ogundele, A.G., Umar, I.Y., Ma'aji, S.A., and Idris, A.M. (2023). The use of structured and think-aloud pair problem-solving instructional strategies on students' interest and

- retention in machine shop practice. *ASEAN Journal for Science Education*, 2(2), 67-76.
- [15] Arifiani, I., Nurul, H. L., and Rahmawan, S. (2025). Problem based learning (PBL) learning model for increasing learning motivation in chemistry subject: Literature review with bibliometric analysis. *ASEAN Journal for Science Education*, 4(1), 17-30.