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PROBLEM-BASED LEARNING (PBL) MODEL: CONCEPT, CHARACTERISTICS, AND ITS IMPLICATIONS IN SCIENCE LEARNING

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ABSTRACT

This study examines the concept, characteristics, and implications of Problem-Based Learning (PBL) in science learning, with a focus on its alignment with the Independent Curriculum in Indonesia. The background of the study is based on the need for an innovative learning model that can develop critical thinking skills, science literacy, and 21st-century competencies in students, while also overcoming the limitations of conventional teacher-centered approaches. Through a literature review method, this study synthesizes findings from academic books, national and international journals, and other relevant sources to analyze the theoretical framework, practical applications, and challenges of PBL in science learning. The results of the study revealed the student-centered nature of PBL which emphasizes authentic problem solving, collaborative learning, and the role of teachers as facilitators. The main findings showed the effectiveness of PBL in improving critical thinking skills, problem solving, and student engagement in science learning. This study also confirmed the alignment of PBL with the Independent Curriculum, especially in supporting differentiated learning and the development of the Pancasila Student Profile. However, challenges such as teacher readiness, limited resources, and the need for technology integration were identified as barriers to implementation.

In conclusion, PBL offers a transformative approach to science education that equips students with essential skills for future challenges. The study recommends teacher professional development, further research on the long-term impact of PBL, and policy support to facilitate its widespread adoption. This study contributes to the theoretical and practical understanding of PBL, and serves as a reference for educators and policy makers in improving the quality of science learning in Indonesia.

INTRODUCTION

Innovation in learning models is very important in the 21st century because global challenges require students to have critical thinking skills, scientific literacy, creativity, and the ability to adapt to technological developments. However, science learning practices in Indonesia are still dominated by a teacher-centered approach, where teachers are the center of information and students tend to be passive, so that students' critical thinking skills and scientific literacy are still low (Simamora et al., 2020). Innovative learning models such as flipped classroom, blended learning, problem-based learning, inquiry-based learning, and the use of technology-based media have been shown to increase engagement, conceptual understanding, and encourage students to be active and independent in learning (Setiyaningsih et al., 2024). This approach also helps overcome misconceptions and improve learning outcomes through direct experience and collaboration (Nsengimana et al., 2021). Thus, innovation in learning

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models is not only a necessity, but also the key to transforming science education to be more effective and oriented towards developing 21st century competencies (Pamorti et al., 2024).

Problem-Based Learning (PBL) plays an important role as a solution to the challenges of 21st-century learning and is very relevant to the spirit of the Independent Curriculum which emphasizes independence, creativity, and the development of critical thinking skills. PBL shifts the role of teachers from information centers to facilitators, so that students are more active, independent, and involved in the learning process through solving real problems (Pujol et al., 2022). In the context of the Independent Curriculum, PBL supports the implementation of project-based learning and encourages students to develop critical thinking skills, collaboration, and scientific literacy needed in the global era (Ismiati, N. 2024). Research shows that PBL is effective in increasing learning satisfaction, metacognitive skills, and problem-solving abilities, although its implementation requires teacher training and adaptation to group dynamics (Murphy et al., 2020).

State of the art, research on PBL continues to grow, with a focus on cross-disciplinary integration, active learning, and 21st century skills development, and is increasingly being applied in various educational fields, not only in health (Hallinger, P. 2023). The main challenges in implementing PBL are the need for resources, facilitator training, and adaptation to local contexts, but innovations such as the use of technology and the flipped classroom model have enriched the learning experience (Hugo, M et al., 2025). Thus, PBL is very much in line with the objectives of the Merdeka Curriculum and is a relevant learning strategy to prepare students for future challenges (Yohamintin, Y et al., 2025).

Conceptual studies related to Problem-Based Learning (PBL) in science learning are still limited, especially in explaining in depth the concept, characteristics, and implications in science classes. Many studies emphasize more on practical implementation and learning outcomes, while theoretical discussions and in-depth analysis of the characteristics of PBL in the context of science are still lacking (Ahda et al., 2022). In science learning, PBL has been shown to improve critical thinking skills, problem solving, and student learning outcomes (Meisya et al., 2023). The implications of implementing PBL in science include encouraging students to be more active, increasing learning motivation, and fostering 21st-century skills such as collaboration and communication (Samadun, S., & Dwikoranto, D. 2022). Thus, a more in-depth conceptual study is needed to strengthen the theoretical basis and practice of PBL in science learning, as well as provide guidance for teachers in implementing it effectively (Ahda et al., 2022). This article aims to examine the concept, characteristics, and implications of PBL in science learning.

METHODS

The method used in writing this article is a literature review , which aims to explore and compile a conceptual understanding of the Problem Based Learning (PBL) learning model in the context of science learning. The sources analyzed come from various trusted references, such as academic books, national journal articles, and international journals that are relevant to the topic of PBL, both in general and in its implementation in the field of science education. The analysis strategy used is thematic identification and synthesis based on four main aspects, namely basic concepts, characteristics, benefits, and challenges of implementing PBL . Through this approach, this article aims to describe the conceptual framework of the PBL model systematically and applicatively , so that it can be a theoretical and practical reference in the development of contextual science

learning that is oriented towards 21st century skills.

RESULTS AND DISCUSSION

Understanding and Basic Concepts of PBL

Problem-Based Learning (PBL) is a student-centered learning model, where the learning process begins with the presentation of real problems that are relevant to everyday life, so that students are encouraged to think critically, find solutions, and learn independently (Yuni Ahda et al., 2022).

According to some experts, PBL is a constructivist approach that places students as active subjects in learning, while teachers act as facilitators who guide the exploration and problem-solving process (Liu, Y., & Liu, G. 2022). The history of PBL began in the late 1960s at McMaster University, Canada, as a response to the weaknesses of conventional methods that emphasize memorization too much and do not develop high-level thinking skills and cross-disciplinary abilities (Liu, Y., & Liu, G. 2022) Over time, PBL has been widely adopted in various fields of education, especially in medical education, and is now expanding to various other disciplines (Medina Quizhpe Carlos Hugo et al., 2025)

The main differences between PBL and conventional learning models lie in the roles of students and teachers, learning objectives, and the learning process. In conventional models, learning is teacher-centered, emphasizing the transfer of knowledge from teacher to student, and often focuses on memorization (Nitiasih et al.2024). In contrast, PBL is student-centered, requiring active involvement of students in identifying problems, seeking information, discussing, and presenting solutions, making it more effective in developing critical thinking skills, problem solving, collaboration, and learning independence (Rahim et al.2021). Thus, PBL offers a more relevant approach to preparing students to face the challenges of the 21st century compared to traditional learning models (Yohamintin et al.2025)

Characteristics of PBL Model

The Problem Based Learning (PBL) model has unique characteristics that distinguish it from other learning models. PBL emphasizes active and participatory learning, where students are directly involved in the process of thinking, discussing, and investigating real contextual problems (Syamsidah & Suryani, 2018). Learning begins with problems that are the center of learning activities, not just the delivery of material. The process follows a scientific approach through deductive and inductive thinking (Suriasumantri, 2010). Furthermore, Barrows (in Sanjaya, 2010) explains that PBL has five main characteristics: student - *centered* , using authentic problems, encouraging self-*directed learning* , carried out in small groups (*small group learning*), and the teacher acts as a facilitator. With these characteristics, PBL is considered effective in forming students who are independent, critical, and ready to face real challenges in life, especially in science learning.

Implications of PBL in Science Learning

The application of Problem-Based Learning (PBL) is very appropriate with the character of science learning which emphasizes the scientific process, exploration, and solving real problems. PBL encourages students to actively observe, formulate problems, design experiments, analyze data, and draw conclusions, thereby strengthening scientific process skills and science literacy (Rovika Meisya et al.2023). This model has also been proven effective in improving students' critical thinking skills, problem solving, and creativity in understanding science concepts (Elok Sudibyo et al.,2021).

In the context of the Independent Curriculum, PBL is very relevant because it supports student-centered learning, differentiation, and the development of the Pancasila Student Profile, such as critical reasoning, independence, and the ability to work together (Karsono et al., 2024). Thus,

PBL not only strengthens scientific literacy and scientific process skills, but is also in line with the objectives of the Independent Curriculum in forming adaptive, creative, and character-based students (Rovika Meisya et al., 2023).

Steps of the Problem Based Learning (PBL) model

According to Barrows & Tamblyn (1980), the Problem Based Learning (PBL) model is implemented through five main steps designed to encourage students to think critically and solve problems collaboratively. First, orientation to the problem , where students are introduced to authentic and contextual problems as learning triggers. Second, organizing students to learn , namely forming study groups and discussing what is known, what needs to be known, and how to achieve it. Third, guiding independent and group investigations , where students seek information, explore, and test hypotheses actively. Fourth, developing and presenting results , namely compiling solutions based on the results of the investigation and presenting them in a discussion forum. Fifth, analyzing and evaluating the problem-solving process , where students and teachers together reflect on the effectiveness of strategies, learning content, and their respective roles in the process (Barrows & Tamblyn, 1980 in Trianto, 2010).

Table. 1 PBL Model Syntax According to Barrows & Tamblyn (1980)

PBL Steps	Teacher Activities	Student Activities
1. Problem Orientation	Presenting authentic problems that are contextual and challenging	Observe, understand, and discuss the problems given
2. Organizing Students for Learning	Forming groups, providing instructions on roles, tasks, and learning objectives	Working together in groups, identifying what is known and what needs to be looked for.
3. Guiding Independent & Group Investigations	Providing direction and facilitating information searches	Conducting investigations independently and in groups, seeking relevant information
4. Develop and Present Results	Facilitate the process of solution development and presentation	Develop solutions based on data, present problem solving results
5. Analyze & Evaluate Problem Solving	Providing feedback and leading reflection	Reflect on the process and results, evaluate the effectiveness of the solution

Implementation of the Problem Based Learning (PBL) Model in the Independent Curriculum

The Problem Based Learning (PBL) model is in line with the principles of *the Independent Curriculum* which is student-centered and oriented towards the development of 21st century competencies, such as critical thinking, creativity, and collaboration. PBL is considered effective in encouraging active student involvement in real-life problem-based learning, as well as supporting holistic education based on Pancasila values (Isnaini et al., 2024).

The implementation of PBL has been proven to increase student participation and collaboration between students, and is in line with the spirit of mutual cooperation in *the Pancasila Student Profile* (Isnaini et al., 2024). In addition, PBL trains critical thinking and problem-solving skills which are the main targets of *the Merdeka Curriculum* (Irgi et al., 2023; Rifa'i & Putra, 2024). Although effective, the implementation of PBL also faces

challenges, such as limited teacher adaptation to new methods and technology integration. Therefore, teacher training and professional development are important aspects in supporting optimal PBL implementation (Rifa'i & Putra, 2024; Damanik et al., 2024).

CONCLUSION AND SUGGESTION

Problem-Based Learning (PBL) has been proven as an effective and innovative learning model in science education, especially in developing critical thinking skills, problem solving, and student independence. This study shows the alignment of PBL with the principles of *the Independent Curriculum* which focuses on student-centered learning and the development of 21st century competencies. The implementation of PBL encourages active student participation, collaboration, and the application of scientific processes, making it very relevant for science learning.

However, challenges such as teacher readiness, resource constraints, and the need for technology integration need to be addressed to optimize the effectiveness of PBL. Therefore, it is recommended that teachers receive specific training and mentoring in designing and facilitating PBL-based learning. In addition, further research is needed to explore the long-term impact of PBL on student learning outcomes and its adaptation in various educational contexts.

In conclusion, PBL offers a transformative approach to science education, preparing students with the skills needed in the global era. Educators and policymakers need to prioritize the integration of PBL into the curriculum while providing resources and training support to ensure successful implementation.

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All authors contributed equally to the development and refinement of the manuscript.

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