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Implementation of The Project Based Learning Model in Science Learning To Improve Scientific Literacy on The Issue of Global Climate Change

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ABSTRAK

Global climate change is a pressing issue that demands scientific literacy among young people to enable them to understand, analyze, and formulate scientifically based solutions. However, the low scientific literacy achievement of Indonesian students based on the PISA results indicates the need for pedagogical innovation in science learning. This study aims to examine the relevance of Project Based Learning (PjBL) in improving scientific literacy through the integration of climate change issues. The method used is a qualitative literature review approach of scientific articles, books, and research reports from the last ten years. Data analysis was carried out through reduction, presentation, and synthesis of findings to confirm the connection between PjBL, scientific literacy, and climate change issues. The results of the study indicate that PjBL effectively encourages active, collaborative, and experience-based learning that is relevant to global challenges. This model develops critical thinking skills, scientific communication, and ecological awareness through real-life projects such as waste management, reforestation, and experiments on the greenhouse effect. The theoretical implications are aligned with constructivism and the inquiry approach, while the practical implications include the transformation of teacher roles, authentic assessment, and applicable curriculum design. Despite constraints on facilities and teacher competencies, collaborative strategies and the use of technology can be a solution. In conclusion, PjBL is a strategic approach to strengthening scientific literacy while forming a critical, creative, and environmentally conscious generation.
Kata Kunci: Pembelajaran Berbasis Proyek, Literasi Ilmiah, Perubahan Iklim.

ABSTRACT

Global climate change is a pressing issue that demands scientific literacy among young people to enable them to understand, analyze, and formulate scientifically based solutions. However, the low scientific literacy achievement of Indonesian students based on the PISA results indicates the need for pedagogical innovation in science learning. This study aims to examine the relevance of Project Based Learning (PjBL) in improving scientific literacy through the integration of climate change issues. The method used is a qualitative literature review approach of scientific articles, books, and research reports from the last ten years. Data analysis was carried out through reduction, presentation, and synthesis of findings to confirm the connection between PjBL, scientific literacy, and climate change issues. The results of the study indicate that PjBL effectively encourages active, collaborative, and experience-based learning that is relevant to global challenges. This model develops critical thinking skills, scientific communication, and ecological awareness through real-life projects such as waste management, reforestation, and experiments on the greenhouse effect. The theoretical implications are aligned with constructivism and the inquiry approach, while the practical implications include the transformation of teacher roles, authentic assessment, and applicable curriculum design. Despite constraints on facilities and teacher competencies, collaborative strategies and the use of technology can be a solution. In

conclusion, PjBL is a strategic approach to strengthening scientific literacy while forming a critical, creative, and environmentally conscious generation.
Keywords: *Project Based Learning, Scientific Literacy, Climate Change.*

INTRODUCTION

Global climate change is one of the major challenges facing humanity in the 21st century due to its widespread impacts on ecosystems, health, and the sustainability of social and economic life. This phenomenon requires not only a conceptual understanding of the accompanying scientific processes, but also scientific literacy skills to interpret data, understand cause-and-effect relationships, and develop mitigation and adaptation measures. Unfortunately, various international surveys, such as the Programme for International Student Assessment (PISA), show that the level of scientific literacy of students in Indonesia is still below average, thus their ability to analyze global issues, including climate change, is still limited (Wardhani, 2025). This condition shows that science learning in schools needs to be directed not only at mastering concepts, but also at developing scientific thinking that is relevant to real life.

Students' low scientific literacy has implications for their weak critical thinking and sensitivity to increasingly complex environmental issues. Science learning often stops at a theoretical level, emphasizing mastery of formulas and definitions, while the application aspects that enable students to connect knowledge to global issues receive less attention (Nursofa et al., 2025). Learning practices that are more oriented toward test results tend to neglect opportunities for students to build understanding through empirical experience. As a result, students lack the skills to connect scientific concepts to real-world phenomena, including global warming, pollution, and changes in extreme weather patterns.

These limitations demonstrate that conventional, teacher-centered learning models are not fully capable of meeting 21st-century demands. Teachers' dominant delivery often limits students' opportunities to explore, discuss, and develop their own ideas (Agustina et al., 2025). Yet, global demands emphasize the importance of 21st-century skills such as critical thinking, collaboration, communication, and creativity, all of which require innovative pedagogical strategies. If this traditional approach persists, students will struggle to understand the relevance of science to the environmental problems they face.

Within this framework, Project-Based Learning (PjBL) emerges as a learning model that offers a more participatory, active, and applicable alternative. PjBL emphasizes real-life project-based learning activities relevant to students' daily lives, encouraging them to solve problems through in-depth investigations, group discussions, and the creation of solution-oriented products (Peny et al., 2022). This model inherently integrates critical, collaborative, and creative thinking skills, which are essential for improving scientific literacy. Through active involvement in projects, students not only memorize concepts but also build contextual scientific understanding.

The advantage of PjBL lies in its ability to connect theory with practice, making science more alive and meaningful for students (Nafidiah et al., 2023). Throughout the process, students are encouraged to identify problems, design solutions, conduct experiments, and present results scientifically. All these stages foster a scientific attitude, curiosity, and social responsibility towards global issues. Furthermore, project activities that highlight environmental issues, such as global warming, deforestation, or waste management, can strengthen students' ecological awareness and foster their commitment to contributing to climate change mitigation efforts.

Integrating climate change issues into science learning is not only academically relevant but also strategic for developing a generation that is responsive to global challenges. With a project-based approach, teachers can design learning activities that link basic scientific concepts to their impacts on the environment and human life. This provides a significant opportunity to foster a holistic understanding that science is not simply a collection of theories but a vital instrument in decision-making and environmental policy formulation (Meo et al., 2024). This understanding can strengthen scientific literacy while sharpening students' social awareness of planetary issues.

On the other hand, the implementation of PjBL also provides ample space for students to develop scientific communication skills through presentations, reports, and discussions of project results. These activities not only train their ability to convey ideas logically but also strengthen their cross-group collaboration skills (Pratama et al., 2025). The collaborative process that is developed mimics the dynamics of multidisciplinary scientific research, so that students are accustomed to working from different perspectives in solving environmental problems. Thus, PjBL serves a dual function as a science learning medium and a means of training 21st-century skills needed to face global complexity.

Ultimately, the challenge of global climate change demands that education systems adopt more adaptive, innovative, and real-life learning strategies. Project-Based Learning offers an approach that not only improves scientific literacy but also instills environmental values and prepares for global change. Through project-based learning in science subjects, students can be guided to become individuals capable of scientific thinking, acting in solutions, and contributing positively to the sustainability of the earth. Therefore, the integration of Project-Based Learning (PjBL) in the context of climate change issues is not merely a methodological choice but an urgent need for achieving educational goals relevant to this century.

METHDOLOGY

This study uses a qualitative approach with a literature review method to explore, analyze, and synthesize various scientific sources related to the application of the Project Based Learning (PjBL) model in science learning and its relevance to improving scientific literacy on the issue of global climate change. The qualitative approach was chosen because it is able to provide an in-depth and interpretive understanding of the phenomena studied, not only producing numerical data, but also revealing meaning, conceptual relationships, and practical relevance in the context of science education.

The literature sources analyzed included indexed national and international journal articles, academic books, research reports, and educational policy documents relevant to the research theme. Inclusion criteria were publications within the last ten years, covering topics such as Project-Based Learning, scientific literacy, science learning, and climate change issues in educational contexts. Sources that did not meet academic standards or were irrelevant to the research focus were excluded from the analysis process.

The data collection process was conducted by searching electronic databases such as Google Scholar, ScienceDirect, SpringerLink, and national journal portals such as Garuda. Keywords used in the search included "Project-Based Learning," "science literacy," "science learning," and "global climate change." All relevant literature was then collected, organized, and categorized based on thematic relevance.

Data analysis was conducted through three main stages: data reduction, data presentation, and conclusion drawing. Data reduction was performed by selecting important information from each literature source according to the research focus. Data presentation was conducted in the form of narrative descriptions that emphasized the relationship between PjBL, increased scientific literacy, and the context of climate change issues. Conclusions were drawn by synthesizing the findings to formulate theoretical and practical implications for science learning.

To enhance the credibility of the research results, source triangulation was conducted by comparing findings from various literatures with different backgrounds, both in terms of context, methodology, and research area. Furthermore, data validity was strengthened by critically analyzing the strengths and limitations of each literature analyzed, ensuring academically sound research results.

DISCUSSIONS AND RESULT

The Relevance of Project Based Learning to Improve Scientific Literacy

The relevance of Project-Based Learning (PjBL) to improving scientific literacy can be seen in the shift in learning paradigms that emphasize active student involvement in constructing knowledge. Scientific literacy is not only understood as the ability to memorize facts or explain concepts, but also encompasses critical thinking skills, evidence-based reasoning, and decision-making skills related to scientific issues. The PjBL model provides opportunities for students to engage directly in an authentic inquiry process, which requires them to understand scientific phenomena by exploring, investigating, and connecting them to everyday life (Khatimah et al., 2020). This learning process encourages a more meaningful internalization of knowledge.

The implementation of PjBL places real-world problems as the starting point for learning, encouraging students to formulate questions, seek information, and develop collaborative problem-solving strategies. When they encounter real-life problems, such as environmental or health issues, their scientific understanding is no longer purely theoretical. Students are trained to analyze data, evaluate information, and generate applicable solutions. This activity fosters higher-order thinking skills, a core component of scientific literacy, as students learn to connect scientific knowledge with the realities they face (Nuraini et al., 2023).

Project-Based Learning (PjBL) also strengthens analytical skills through project-based learning experiences that require deeper reasoning. When students are confronted with a phenomenon, they need to understand the influencing variables, make observations, and draw conclusions supported by empirical evidence (Adriyawati et al., 2020). This process differs significantly from conventional learning, which tends to emphasize memorization. With Project-Based Learning (PjBL), students are accustomed to asking reflective questions, such as "why did this happen?" or "how can this phenomenon be explained by scientific theory," thus developing their analytical and synthesis skills systematically.

Scientific literacy also encompasses scientific communication skills, which can be strengthened through project presentations, report writing, and group discussions. In PjBL, students are encouraged to express ideas using appropriate scientific language, develop arguments based on evidence, and communicate research results to an audience. These skills are crucial for building students' capacity to convey scientific information accurately and responsibly (Suryandari et al., 2018). With strong communication skills, students not only understand scientific concepts but are also able to act as agents of information dissemination to the wider community.

The collaborative process fostered in Project-Based Learning (PjBL) adds value to scientific literacy because students learn to collaborate, share ideas, and resolve intellectual conflicts within a team. The interactions that occur during project work train students to appreciate differences of opinion and integrate diverse perspectives. This experience creates a social learning space that strengthens scientific understanding while also instilling the social skills needed to address complex real-world problems. Thus, scientific literacy develops not only as an individual ability but also as a collective competency.

Empirical research shows that implementing PjBL in science learning can significantly increase student engagement. Students become more motivated because they perceive learning science as directly relevant to their lives (Bangun et al., 2023). Authentic project-centered learning sparks curiosity and fosters scientific attitudes, such as objectivity, rigor, and openness to new ideas. These findings reinforce the notion that PjBL not only enhances conceptual understanding but also shapes scientific dispositions, which are essential for scientific literacy.

Compared to traditional lecture methods, PjBL is superior because it encourages active, reflective, and problem-solving-oriented learning. Lecture methods often fragment scientific knowledge and lack practical application, while PjBL provides students with the opportunity to build a holistic and continuous understanding (Lestari & Rahmawati, 2020; Della & Dahlan, 2024). This makes the acquired knowledge more durable because it is embedded in critical thinking patterns, rather than simply stored in short-term memory. Thus, PjBL serves as an effective approach to ensuring the sustainable development of scientific literacy.

The application of PjBL is also relevant to the demands of 21st-century education, which emphasizes critical thinking skills, creativity, collaboration, and technological literacy. Students who learn through PjBL not only master scientific content but also become accustomed to using technology to search for information, analyze data, and present findings. These skills are crucial for preparing the younger generation to face global challenges, where scientific literacy is the foundation for rational and responsible decision-making. Thus, PjBL can be viewed as a learning strategy that is not only relevant for improving scientific literacy but also in line with the needs of the times.

Integration of Climate Change Issues in Science Learning

Integrating climate change issues into science learning through a Project-Based Learning (PjBL) approach is a strategic effort to make science both contextual and meaningful. Climate change issues, including global warming, air pollution, land degradation, water crises, and the increasing frequency of natural disasters, are not merely theoretical knowledge but real challenges faced by humans worldwide. By incorporating these issues into learning, students are guided to understand that science is not just a school subject but a vital tool for analyzing complex phenomena that directly impact their lives (Thinh et al., 2024). This brings the science concepts learned closer to the social and environmental realities they experience daily.

The Project-Based Learning (PjBL) approach provides students with a platform for real-world learning, where projects based on environmental issues can serve as both a means of scientific exploration and concrete action. The learning process extends beyond theoretical classroom discussions to include field observations, data collection, and analysis of findings related to climate issues. Through these activities, students develop critical thinking, scientific communication, and collaboration skills. Project-Based Learning (PjBL) also fosters a sense of responsibility, as each project requires systematic planning, implementation, and reflection. Thus, science learning transforms into a vehicle for developing knowledge, attitudes, and skills relevant to global challenges.

A concrete example of this application can be a simple experiment on the greenhouse effect using a plastic bottle, a light, and a thermometer, allowing students to directly observe the mechanism of temperature increase, which mimics the conditions in Earth's atmosphere. Such activities not only clarify scientific concepts but also raise awareness of the serious impact of greenhouse gas accumulation on global warming. In addition to experiments, school greening projects, waste management using the 3R principle, or creating educational posters on disaster mitigation can also be effective ways to connect theory with real-world action. In this way, students are actively involved in activities that support environmental sustainability while internalizing ecological values.

Science education literature confirms that the link between global environmental issues and science learning strengthens students' scientific literacy. Bybee (2013) states that scientific literacy encompasses the ability to use scientific knowledge to make informed decisions in everyday life, including decisions concerning social and environmental issues. This means that science learning that focuses on climate change not only trains conceptual understanding but also builds skills in connecting scientific knowledge with sustainable living practices. Such scientific literacy is an important provision for the younger generation to face an era of global complexity.

The implementation of climate change-based projects also strengthens students' metacognitive skills. They are not simply asked to memorize concepts but are also encouraged to design research steps, evaluate data, and reflect on the results. These reflective skills encourage students to understand the scientific process holistically, including the dynamics of error and improvement. This learning process fosters a deeper scientific mindset, enabling students to become accustomed to analyzing, evaluating, and constructing arguments based on evidence. Well-designed projects can train students to manage complex information while fostering independent learning.

The integration of climate change issues into science also impacts the affective domain, as project-based learning fosters empathy for the environment and ecological awareness. Tilbury (2011) explains that education oriented toward sustainable development can build the character of a generation committed to maintaining ecosystem balance. By engaging in projects that emphasize environmental action, students develop attitudes of caring, discipline, and social responsibility. These values serve as an important moral foundation for creating sustainable, environmentally friendly behavior. Such education produces individuals who are not only academically intelligent but also possess strong character in facing global issues.

Another significant impact is the connection between science learning and 21st-century skills. Projects addressing climate change require students to master critical thinking, communication, collaboration, and creativity. For example, when developing alternative solutions to reduce carbon emissions, students need to convey ideas argumentatively, work in teams, and design simple innovations that can be implemented in school or at home (Putri et al., 2025). These skills are not only useful in academic contexts but are also relevant for future professional and social life. The integration of science and global environmental issues with Project-Based Learning (PjBL) makes learning more holistic and multidimensional.

The development of climate change-based science learning through PjBL ultimately aims to shape students who are aware, critical, and responsible for global environmental challenges. Students are positioned as active subjects capable of linking scientific concepts to real-world problems, thereby fostering the ability to formulate creative, impactful solutions (Priyono et al., 2024). Learning is no longer limited to the transfer of knowledge from teacher to student, but has become a transformative process that emphasizes participation, collaboration, and concrete action. Thus, science education contributes directly to the development of a generation capable of preserving the earth's sustainability while also being prepared to face the complexities of the modern world.

Theoretical and Practical Implications for the Development of Science Learning

Project-Based Learning (PBL) has significant theoretical implications for science learning because it is rooted in constructivism, which emphasizes the formation of knowledge through real-world experiences. The learning process in this model positions students as active subjects constructing concepts through observation, experimentation, and scientific reflection. This principle also aligns with the inquiry approach, which views science as a process of seeking answers, not simply a collection of facts. Cognitive-situative theory asserts that knowledge learned in real-world contexts is more easily transferred to everyday life problems. Project-Based Learning (PBL) strengthens critical and creative thinking skills through challenges that require complex problem-solving. Collaborative skills develop through group dynamics that require coordination, communication, and negotiation of ideas. This model also fosters metacognition as students are asked to plan, monitor, and evaluate the progress of their projects (Mulia & Murni, 2022). Thus, Project-Based Learning (PBL) not only supports the achievement of cognitive goals but also builds readiness to face the demands of the 21st century.

The implications of Project-Based Learning (PjBL) for the science curriculum require a shift in orientation from simply transferring material to developing competencies. The curriculum cannot simply focus on conceptual content; it must also provide space for science process skills. Project-based curriculum design encourages integration across topics such as physics, biology, and chemistry through broad themes relevant to students' lives. Syllabus development needs to accommodate success indicators that measure the application of concepts to real-world problems, not simply memorization. Time allocation must be more flexible to ensure optimal project planning, investigation, and presentation. Assessment of learning outcomes cannot be limited to written tests but must utilize portfolios, scientific reports, and project products (Muzanni et al., 2024). Project-Based Learning (PjBL) integration also encourages schools to facilitate learning activities based on local issues, such as the environment or energy issues. With this design, the curriculum becomes more relevant, applicable, and meaningful for students.

The role of teachers in the implementation of PjBL has transformed from instructors to facilitators. Teachers are no longer merely conveyors of information, but also mentors who design projects, provide direction, and provide methodological support. Learning success is largely determined by teachers' ability to design projects that are realistic, challenging, yet appropriate to students' developmental levels (Sudirman et al., 2024). Teachers must also be able to manage group dynamics so that collaboration is balanced and each student contributes. Required pedagogical competencies include the ability to facilitate discussions, provide scaffolding, and integrate digital technology to support data collection and analysis. Project planning requires teachers to develop clear assessment rubrics so students understand the standards of success. Teachers play a crucial role in fostering students' intrinsic motivation by providing freedom to explore ideas. With proper management, teachers can ensure PjBL becomes a productive and meaningful science learning tool.

The assessment system in Project-Based Learning (PjBL) must be authentic to align with the complex nature of projects. Authentic assessment encompasses both process and product measurements, including written reports, presentations, and real-life projects. Detailed performance rubrics enable teachers to assess students' conceptual understanding, process skills, teamwork, and scientific attitudes. Formative evaluation is essential throughout the project to provide students with feedback and strategies to refine. Self- and peer-assessment provide students with opportunities to develop reflective awareness and a sense of collective responsibility. Portfolio instruments can record project progress, providing greater transparency regarding learning outcomes. Challenges arise when the national evaluation system still emphasizes standardized tests, which are less aligned with Project-Based Learning (Barus et al., 2022). Therefore, policies are needed that provide space for schools to recognize project-based learning outcomes as part of official assessments.

Schools often face implementation challenges when implementing PjBL. Limited laboratory facilities and experimental materials often hinder teachers from optimally implementing projects. A dense curriculum and limited time allocation also complicate projects that require lengthy stages. Large student populations in a single class create challenges in supervision and role allocation. Not all teachers have the experience or skills to design and implement projects, necessitating ongoing training. Mitigation strategies include developing simple projects based on local resources for easier implementation. Collaboration between schools or with external parties, such as universities and communities, can expand access to resources. The use of digital technologies, such as virtual simulations or online laboratories, can be an alternative to limited physical equipment. With these strategies, implementation barriers can be minimized without compromising the quality of learning.

The sustainability of PjBL requires policy support and further research. Institutional support is needed to ensure teachers have the legitimacy to allocate learning time to projects (Ahmad Apriliyanto et al., 2024). The government and education offices can encourage the development of thematic project banks relevant to local and global issues. Sustainable teacher training programs should be facilitated to improve pedagogical and methodological skills. Further research is needed to assess the impact of PjBL on cognitive, affective, and psychomotor learning outcomes. Empirical studies should also examine variations in PjBL's effectiveness across schools with different socioeconomic backgrounds. System-level evaluations will provide insight into the extent to which policies support or hinder project implementation. With research support, PjBL practices can evolve into evidence-based science learning models. These efforts will strengthen PjBL's position as a strategic approach to 21st-century learning.

CONCLUSION

In conclusion, Project-Based Learning (PBL) has strong relevance in improving scientific literacy because it can shift learning from rote learning to understanding based on real experiences. This model provides space for students to develop critical thinking skills, data analysis, and decision-making based on scientific evidence. The integration of climate change issues through PjBL further enriches science learning because students are invited to face real global challenges that are relevant to everyday life. Environmental-based projects not only deepen conceptual understanding but also foster ecological awareness and a sense of social responsibility. The theoretical implications confirm that PjBL aligns with constructivism, inquiry, and cognitive-situative approaches that emphasize meaningful learning. The practical implications are seen in the transformation of teacher roles, more applicable curriculum designs, and authentic assessment systems that emphasize both process and product. Implementation challenges remain, particularly limited resources, time, and teacher competency, but these can be overcome with innovative strategies based on technology and collaboration. Empirical research also shows that PjBL can improve students' motivation, scientific attitudes, and critical dispositions. With appropriate policy support, PjBL can become a pillar of science learning that is adaptive to the needs of the 21st century. Students not only learn science as theory, but also internalize scientific values, skills, and attitudes to address global issues. Therefore, PjBL deserves to be seen as a strategic approach that contributes to the formation of a generation of intelligent, critical, collaborative, and responsible scientists. With consistent implementation, PjBL will strengthen the connection between science, life, and sustainability.

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