
Strengthening Environmental Awareness through Project-Based Learning: A Global and National Review, and Implications for Indonesian Primary Schools

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Abstract: Escalating environmental challenges have underscored the need to cultivate environmental awareness from primary schooling, yet classroom instruction often offers limited authentic engagement with local ecological problems. This systematic review synthesizes recent empirical evidence (2020-2025) on the effectiveness of Project-Based Learning (PBL) in strengthening primary students' environmental knowledge, attitudes, and pro-environmental behaviors, and identifies enabling and constraining conditions for its implementation. Searches of Scopus, Web of Science, ScienceDirect, and SAGE returned more than 200 records, which were screened to identify 7 empirical studies for synthesis. Across these studies, PBL consistently improved environmental outcomes in cognitive, affective, and behavioral domains, with several reports showing statistically significant pre-post or group differences and moderate-to-very-strong positive associations between PBL participation and indicators of environmental awareness ($r = 0.52-0.96$). Successful implementation was supported by school leadership and an enabling culture, teacher preparedness and collaboration, and curricular flexibility, whereas limited instructional time, resource constraints, and insufficient teacher readiness were recurring barriers. Overall, PBL is an effective approach to strengthening environmental awareness in primary education when it is institutionally supported and adapted to local contexts.

Keywords: Environmental, PBL, Primary Education, 21st-Century Skills

INTRDUCTION

The global environmental crisis in the 21st century is increasingly worrying and demands the emergence of a generation with a pro-environmental attitude and a high level of environmental awareness (López & Palacios, 2024). Environmental education from an early age is seen as crucial to instill the values of concern for nature and prepare students to become responsible global citizens for environmental sustainability (Utaminingsih et al., 2025; Lamanuskas, 2024). However, traditional pedagogical approaches are often less effective in actively engaging students to understand and address complex environmental problems (Zhang et al., 2025).

One innovative approach in education that has the potential to address these challenges is Project-Based Learning (PBL) (Markula & Aksela, 2022). PBL is a teaching method that emphasizes students' involvement in an in-depth inquiry process through real projects, designed

around complex, authentic questions or problems (Kokotsaki et al., 2016). Various studies have shown that PBL effectively improves students' motivation to learn and long-term learning outcomes (Wijnia et al., 2024). PBL has been proven to increase learning satisfaction, prepare students for real-world situations, and develop stronger independent learning skills and memory (Chen & Yang, 2019). In addition, PBL develops a range of 21st-century skills and competencies, such as collaboration, planning, communication, creativity, and critical thinking (Rehman et al., 2024). In other words, PBL creates a meaningful learning experience by placing students at the center of active learning (Dole et al., 2017).

In the context of environmental education, PBL is highly relevant because its characteristics align with the goals of Education for Sustainable Development (Karvonen, 2026; Yasin & Rahman, 2011). PBL encourages students to be directly involved in solving real environmental problems and taking impactful actions, so that it is believed to improve students' sustainability

competencies and environmental awareness (Utaminingsih, Qomar, et al., 2025; Hamid, 2025). Bramwell-Lalor et al. (2020) provide a strong argument that integrating PBL into the curriculum can strengthen sustainability education by encouraging collaborative, action-oriented learning. Their study shows that through PBL, students are empowered to take concrete environmental action while improving their knowledge and skills related to sustainability. With this kind of active engagement, environmental learning becomes more alive and meaningful, and students can feel the immediate impact of their efforts on the environment (Ardoin et al., 2020; Rimm-kaufman et al., 2021).

Although the potential of PBL in environmental education is very promising, the literature shows that few studies have examined its effectiveness in increasing environmental awareness, especially at the elementary school level (Ferrero et al., 2021; Lisa et al., 2024). Most PBL research in the field of science and environmental education was previously conducted at the secondary or higher education level (López & Palacios, 2024). Therefore, a systematic review of recent studies is needed to understand the extent to which PBL has been implemented in primary schools to increase students' environmental awareness and knowledge.

This study conducted a systematic literature review of scientific articles published from 2020 to 2025 that discuss the implementation of PBL to increase elementary school students' environmental awareness and attitudes across various countries. The primary focus is to identify empirical evidence on the impact of PBL on cognitive (knowledge), affective (attitude and awareness), and environmental behavior aspects in students. In addition, this study also highlights the factors that support and inhibit the implementation of PBL in primary education and its relevance in the Indonesian context. The results of this literature review will provide a comprehensive overview of PBL practices in environmental education globally and offer recommendations for developing learning policies and practices in elementary schools to foster a more environmentally conscious generation.

METHODS

This study employed a Literature Review conducted in December 2025. The literature

search was conducted online using four major academic databases: Scopus, Web of Science (WoS), ScienceDirect, and SAGE. These databases were selected to ensure broad international coverage and to capture high-quality, topic-relevant empirical evidence on Project-Based Learning (PBL) and environmental education in primary schooling.

Population and Sample

The review population comprised all empirical scholarly articles published between 2020 and 2025 that examined the use of Project-Based Learning (PBL) in primary/elementary education to enhance students' environmental awareness, knowledge, attitudes, and/or pro-environmental behaviors. Eligible publications included studies written in Indonesian or English, provided that the full text was accessible. The final sample was determined using the following eligibility criteria.

Literature Search and Inclusion Criteria

A comprehensive search was conducted across reputable academic databases, including Scopus, Web of Science (WoS), ScienceDirect, and SAGE. These databases were chosen for their rigorous indexing and reliability within the academic community. The literature search focused on studies published between 2020 and 2025 to ensure the review reflects the latest advancements in PBL and environmental education. The following inclusion criteria were applied:

1. Publication Date: Studies published between 2020 and 2025.
2. Study Type: Only empirical research articles, including quantitative, qualitative, and mixed-method studies, were considered. Review articles, commentaries, and theoretical papers were excluded unless directly related to the focus of the study.
3. Subject Area: The study focused on primary school students (ages 6-12), emphasizing PBL approaches to teaching environmental awareness, sustainability, and ecological topics.
4. Indexed Journals: Articles must be indexed in Scopus or Web of Science (WoS) for credibility and academic rigor.
5. Language: Only articles published in English and Indonesian were considered to ensure accessibility and relevance.

Exclusion Criteria

Studies were excluded from the review if they met any of the following conditions:

1. Non-relevant topics: Articles that did not focus on environmental education or PBL.
2. Not empirical: Articles that did not include primary data collection or analysis.
3. Non-primary school context: Studies focused on secondary or higher education.
4. Unavailable: Articles not available in full text or those that were not accessible through the selected databases.

Screening and Data Extraction

The initial search yielded over 200 articles. These articles were screened based on their titles and abstracts to eliminate non-relevant studies. After applying the inclusion and exclusion criteria, approximately 50-70 articles were reviewed in full. From these, 15 articles were selected, and then 7 articles were selected for detailed analysis based on their relevance to the study's objectives.

Data were extracted from these 7 articles, focusing on:

1. Study Design: Research methods used (survey, case study, experimental design).
2. Intervention Details: The specifics of the PBL interventions (project themes, duration, subjects involved).
3. Environmental Outcomes: Measures of ecological awareness (knowledge, attitudes, behaviors).
4. Key Findings: Main conclusions regarding the effectiveness of PBL in enhancing environmental awareness.
5. Limitations: Identified challenges in the implementation of PBL in environmental education.

Research Procedure

The review process began with the development of a search strategy using keywords relevant to PBL and environmental education, formulated in both Indonesian and English. Keyword combinations were constructed using Boolean operators (AND, OR) to optimize retrieval sensitivity and specificity. Systematic searches were then executed separately in Scopus, WoS, ScienceDirect, and SAGE. Records retrieved from multiple sources were merged, and duplicates across databases were removed.

A staged screening process was subsequently undertaken. In the first stage, titles and abstracts were examined to exclude studies that clearly failed to meet the inclusion criteria (e.g., topics unrelated to PBL or non-primary contexts). Records that passed this initial screening progressed to full-text review. In the second stage, the full texts were read and evaluated to confirm compliance with all inclusion criteria and to ensure that none of the exclusion criteria were met. This procedure progressively narrowed the evidence base to the final set of seven eligible studies.

Data from each included study were then extracted and documented systematically to support subsequent synthesis. The extracted information encompassed: (1) study design (e.g., quasi-experimental, case study, qualitative inquiry); (2) characteristics of the PBL intervention (e.g., project theme/topic, duration, and integrated subject areas); (3) environmental outcomes assessed (knowledge, attitudes/awareness, and/or pro-environmental behaviors); and (4) contextual implementation factors reported as either enablers or barriers to successful PBL enactment. The extraction process was conducted carefully to ensure completeness, comparability across studies, and analytic traceability.

Data Analysis Techniques

Data analysis followed a narrative, descriptive, and qualitative thematic approach. Findings from the seven included studies were first summarized and compared to identify convergences and divergences across contexts, designs, and outcomes. The results were then synthesized into overarching themes. Specifically, outcomes were organized into three core domains of environmental learning: the cognitive domain (environmental knowledge and understanding), the affective domain (environmental awareness, attitudes, and values), and the behavioral domain (observable or reported pro-environmental actions). In parallel, thematic analysis was applied to implementation-related evidence, classifying reported conditions into facilitating and constraining factors affecting PBL delivery in primary education. The synthesized results were presented in an integrated narrative that described patterns across the three outcome domains and explained how implementation enablers and barriers shaped the

effectiveness of PBL in environmental education at the primary school level.

Screening Process

Each article was analyzed for its methodological rigor and its contribution to the

research questions, and the results were synthesized to form a comprehensive understanding of the current state of PBL in environmental education. The screening flowchart is shown in Figure 1.

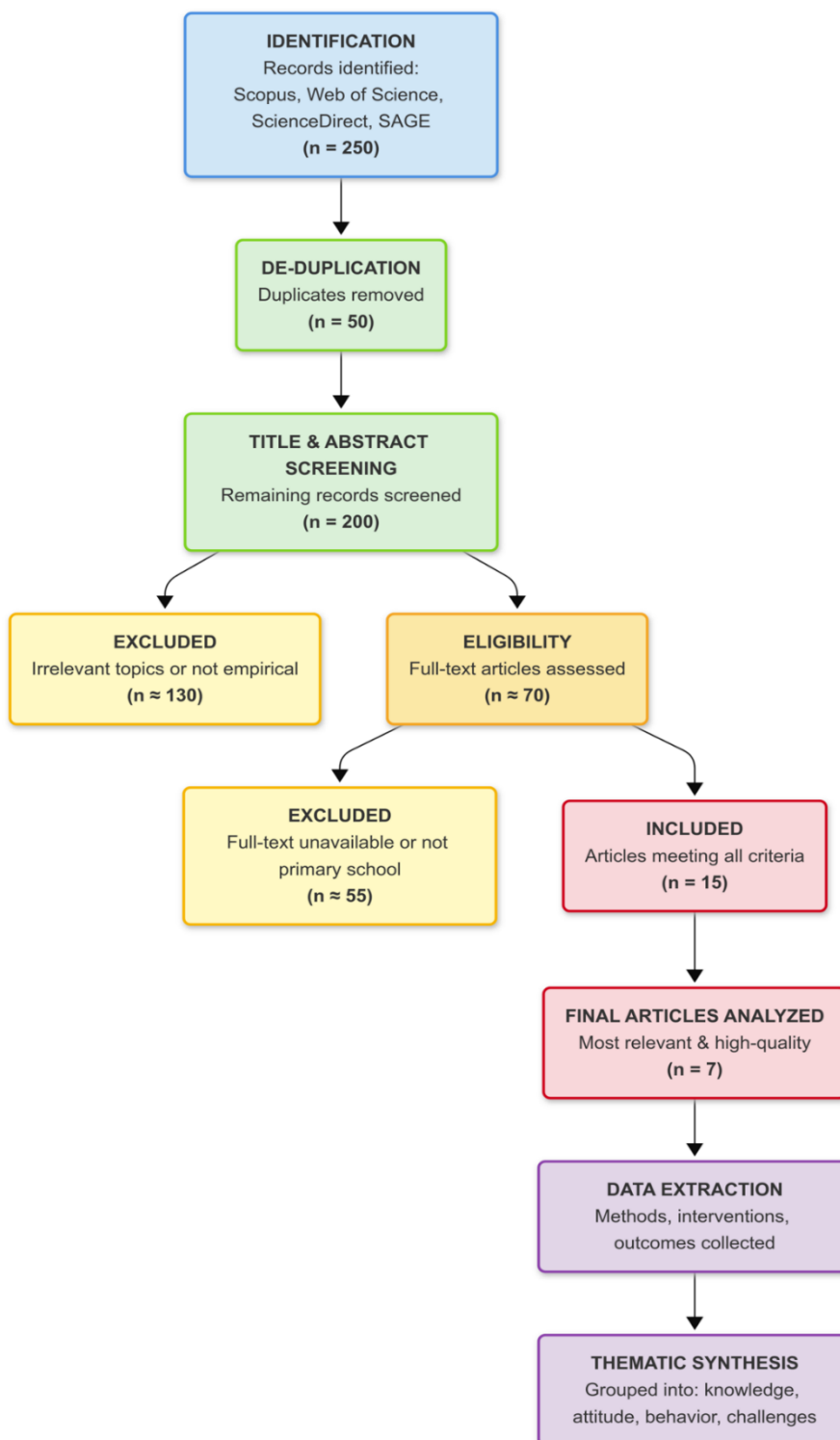


Figure 1. Flowchart Study Selection Process

RESULTS AND DISCUSSIONS

Results

Drawing on the seven empirical studies retained for in-depth synthesis after the screening process, the Findings section first consolidated the evidence base into a structured comparative map in order to enhance analytic transparency and enable cross-study interpretation. This

mapping approach juxtaposed each study by authorship and year, national/school context, the substantive focus of the PBL intervention, and the principal outcomes reported for students' environmental awareness, thereby clarifying convergent patterns of impact while making visible contextual and design-related variation across the reviewed evidence.

Table 1. Comparative Overview of Included Studies

Researcher (Year)	Context (Country)	PBL Project Focus	Key Results
Hamid (2025)	Innovative elementary school in Dhaka, Bangladesh	Four types of pollution (air, water, soil, sound)	PBL enhances students' understanding of local pollution and personal environmental responsibility; students actively collaborate to solve problems. Teachers also improve reflection and innovation in teaching, strengthening environmental-oriented professionalism.
Triyandana et al. (2024)	State Elementary School, Indonesia	Integration of green curriculum (caring for plants & animals)	The PBL group outperformed the control group in environmental awareness and eco-friendly culture scores (a difference of ±9 points; $p < 0.05$). The activity of caring for living things significantly increases students' environmental stewardship.
Maurer et al. (2020)	6th Grade Elementary, Greece	Energy saving project "GAIA" (saving electricity & CO ₂)	Environmental literacy increases significantly post-project, especially in practical knowledge. Students are more pro-environmental (preservation values go up, exploitative views go down) after being involved in projects; the biggest change is among early, knowledgeable students of lace.
López Palacios (2024)	& Junior High School, Spanish	Local urban environmental investigation project	The students' environmental awareness increased significantly, especially in the affective dimension: they became more concerned about noise pollution and about respecting the <i>hija</i> space. There has also been an increase in environmental literacy (a broader understanding of ecological concepts); students have a more realistic and critical perception of the post-PBL.
Avalos et al. (2023)	Review of 10 global studies (2020–2023)	Varied (various environmental PBL projects)	All studies support the effectiveness of PBL in increasing environmental awareness/attitude. A strong positive correlation between PBL & environmental awareness ($r = 0.52–0.96$) was reported. PBL also increases students' motivation, teamwork, and problem-solving on environmental issues; Even with a simplified project design, the effect is still optimal.
Bramwell-lalor et al. (2020)	Jamaica & Bulgaria K–12 students	Waste-focused ESD PBL (TrashedWorld).	PBL motivated action and enhanced environmental knowledge plus sustainability competencies (e.g., communication/collaboration); administrators should enable curricular infusion and teacher collaboration.
Hartanto et al. (2024)	State elementary schools, Indonesia	Adiwiyata-aligned environmental projects.	Effective implementation (principal support + whole-school participation) strengthened students' pro-environmental attitudes.

Study 1 – PBL on Pollution Issues in Elementary School, Dhaka, Bangladesh: Hamid (2025) conducted a qualitative study in a primary school in Dhaka to investigate the impact of PBL

on students' and teachers' environmental awareness. The learning project focuses on four types of pollution (air, water, soil, and sound) and involves student collaboration and teacher

mentoring in investigating local issues. Data were collected through classroom observations, in-depth interviews with four social studies teachers (supported by interviews with teachers of other subjects and principals), and students' reflection notes. Key findings: Implementing PBL has been shown to improve students' understanding of pollution issues in their neighbourhoods and foster a sense of environmental responsibility among individuals. Students demonstrate the development of pro-environmental attitudes, active participation, and group-solving skills while completing projects on pollution. From the educator side, there is an increase in teacher professionalism: PBL encourages teachers to reflect and innovate in their teaching, increase collaboration among teachers, and build a lifelong learning culture within the scindeks-clanci.ceon.rs educational environment. An important contribution of this study is to show that PBL can create a positive cycle between student learning and teacher professional development in the context of environmental education; Teachers and students together form a culture of caring for the environment in school.

Study 2 – Integration of the Green Curriculum in Indonesian Elementary Schools: Triyandana et al. (2024) developed a project-based learning strategy by integrating environmental responsibility into science lessons in Indonesian elementary schools. In the design stage, the researcher conducted a needs analysis across five elementary schools, then conducted a quasi-experiment in one selected school with an experimental and a control group. PBL projects are student-led, focusing on real activities, such as caring for plants and animals, as part of the green curriculum. Key findings: After the learning period, the experimental group showed significantly higher scores of environmental awareness and eco-friendly culture than the control group. The average improvement in students' environmental awareness was about 9 points, and the t-test yielded a p-value of 0.000 (< 0.05). These results confirm that integrating ecological responsibility in science activities (e.g., caring for living things) effectively strengthens students' environmental behaviors and attitudes. Students in the project group showed greater concern in taking care of the environment (environmental stewardship) on a daily basis. The study contributes practically and theoretically by emphasizing the importance of

incorporating environmental responsibility projects into the curriculum to form sustainable habits from an early. These findings are particularly relevant for developing countries, where this PBL model can serve as a reference for educational practices and curriculum policies to foster an environmentally friendly culture in schools.

Study 3 – Energi-Saving Project in Grade 6 Greece: In a European context, Maurer et al. (2020) investigated the impact of PBL on environmental literacy through the "Green Awareness in Action (GAIA)" project in Yunanmdpi.com. Purpose & context: The GAIA project aims to change energy consumption behaviors in schools (e.g., reducing electricity use) to increase awareness and improve energy efficiency. Participants included 132 6th-grade students (age ≈11 years) from an elementary school, with a pretest-posttest design to measure environmental knowledge, attitudes/values, and behaviors before and after the project. Key findings: PBL GAIA led to significant improvements in students' environmental literacy, particularly in action-oriented knowledge and environmental effectiveness. Interestingly, students with low initial knowledge experienced greater learning jumps than those with high initial knowledge, demonstrating the effectiveness of PBL in reaching students who previously lacked knowledge. In terms of attitudes, there is a shift in values towards pro-environment: students' preferences for nature conservation increase as utilitarian/anthropocentric views decline (mdpi.com). In other words, after the project, students value conservation efforts more and are more inclined to behave in an environmentally friendly manner, as reflected in their reduced emphasis on style. This study shows the significant contribution of PBL in transforming knowledge into student value – real projects, such as energy saving, can be an effective means of instilling long-term environmental understanding and concern in primary school students.

Study 4 – Urban Environment Project in Spanish Junior High School: (2024) examined the implementation of PBL in the context of secondary education in Spain, focusing on the urban environment. Objectives & context: They designed a project based on an urban environmental investigation in one junior high school class to increase participants' environmental awareness. The research method

was a mixed-methods study with a single-group pretest-posttest design; the instruments included environmental awareness tests (Likert scale) and open-ended questions to measure changes in cognitive and affective dimensions before and after PBL. Key findings: Results show a significant increase in students' level of environmental awareness after participating in the project. PBL has been proven to be effective, especially in improving the affective dimension of environmental awareness. For example, students become more concerned about noise pollution and more appreciate the existence of green spaces around brands. In addition, this project improves students' environmental literacy, as seen from the increase in the number and variety of environmental concepts mentioned by students in the post-project essay test compared to the pre-project. López and Palacios note that after PBL, students show a more realistic understanding of the environmental conditions of their city – their perceptions become more critical of issues such as noise and lack of green space (the effects of environmental hyperopia. This indicates a deeper environmental awareness and a more ready attitude to be involved in solutions. Overall, this study confirms that PBL is an effective strategy to improve attitudes and environmental awareness among adolescents. The researchers underline that while these findings are positive, broader generalizations require further research with more meaningful samples and context.

Study 5 – Systematic Review 2020–2024: In aggregate, the above positive findings are in line with the results of a systematic literature review by Avalos et al. (2023). They analyzed 10 indexed articles (2020–2023) that evaluated the effectiveness of PBL in increasing environmental awareness among the younger generation, involving a total of 455 students. Review findings: Almost all studies report that PBL is effective in improving students' environmental awareness and attitudes. In fact, correlation studies showed a moderate to very strong positive association ($r \approx 0.52-0.96$) between participation in PBL and level of awareness/knowledge. In addition, PBL has consistently been reported to improve students' motivation, teamwork, and problem-solving skills in the learning environment. Interestingly, the review found that even more concise PBL implementations remained effective, with some studies using simplified project stages without sacrificing

learning outcomes. This means that teachers can apply PBL flexibly and contextually, and still have a positive impact on student environmental awareness. Overall, this comprehensive study confirms that across countries and educational levels, PBL is a powerful learning method for fostering knowledge, attitudes, and environmentally friendly behaviors among the younger generation.

Study 6-The Bramwell-Lalor et al. (2020) study emphasized that schools should foster a collaborative culture among teachers and provide curriculum flexibility to enable learning projects to be carried out effectively. Teachers need support in collaborating across disciplines to design comprehensive, integrated projects. In addition, teacher training and professional development are also very important. PBL demands a different role for teachers than traditional teaching; teachers must serve as facilitators, guide inquiry, and manage group dynamics. Improving environmental literacy through PBL is not limited to the cognitive aspect of facts, but also to the ability to think critically about environmental problems. Students involved in projects tend to be more critical in identifying environmental problems around them and in seeking information to solve them. Bramwell-Lalor et al. (2020) show that learners (both students and teachers involved) become motivated to take concrete action on sustainability issues and, in the process, deepen their environmental knowledge. Even in the context of online learning, collaborative projects have improved understanding of sustainability and ecological concepts. These consistent findings reinforce the view that PBL can be an effective means of learning about environmental issues that are often abstract, making them more concrete and easier to understand for elementary school students. Students learn through hands-on experience, which, according to constructivist theory, is more firmly embedded in long-term memory and easier to apply.

7th Study - It is also vital to have policy support at a higher level. In Indonesia, for example, programs such as the Ministry of Environment's Adiwiyata encourage schools to be environmentally conscious, which aligns with the spirit of PBL. Research by Hartanto et al. (2024) shows that the effective implementation of Adiwiyata, with the support of the principal and the participation of school residents, can strengthen students' overall attitudes toward

environmental care. The integration of PBL into school policies, such as Adiwiyata or the Pancasila Student Profile curriculum (which encourages character-strengthening projects, including environmentally friendly ones), will mutually strengthen the outcomes.

In the global discussion, it is essential to acknowledge that cultural and social contexts also influence the implementation of PBL. What works in one country may require adaptation in another. For example, PBL in developed countries with access to high technology can take different forms from those in developing countries. However, the essence of PBL as a pedagogy centered on real projects seems universally beneficial for cross-contextual environmental learning.

Discussions

PBL Enhances Environmental Knowledge and Literacy

Project-Based Learning was found to significantly improve students' environmental knowledge and literacy across the reviewed studies (Papadopoulou et al., 2025). Learners involved in PBL projects demonstrated a deeper understanding of environmental issues and concepts compared to before the intervention (Winarni, 2022). For example, elementary students in a Bangladeshi PBL project gained a heightened understanding of local pollution problems and could discuss environmental topics more competently than prior to the project (Hamid, 2025). Similarly, in a Greek sixth-grade energy conservation project, students showed substantial gains in practical environmental knowledge; post-test assessments revealed an improved grasp of key concepts such as energy use and carbon. PBL's hands-on, inquiry-driven approach appeared to make abstract environmental concepts more concrete and memorable. One study found that students retained ecological knowledge more effectively and could apply it in discussions after participating in collaborative environmental projects. In summary, engaging in real-world projects not only increased factual knowledge (understanding types of pollution or energy-saving methods) but also broadened students' environmental literacy, equipping them with the terminology and context needed to analyze environmental issues critically. These findings were consistent across diverse countries and

educational settings, indicating that PBL is an effective pedagogy for strengthening the cognitive domain of environmental education (Hamid, 2025; López & Palacios, 2024; Maurer et al., 2020).

PBL Cultivates Positive Attitudes and Environmental Awareness

The literature indicated that PBL actively cultivated more positive environmental attitudes and heightened students' awareness. In multiple studies, learners developed a greater appreciation for nature and a stronger sense of responsibility towards environmental protection after completing PBL projects. Quantitative evaluations documented significant improvements in students' pro-environmental attitude scores from pre- to post-project. For instance, an experimental study in Indonesia integrating a "green" curriculum through PBL showed that students in the project group had markedly higher environmental awareness and more eco-friendly values than a control group after the intervention (Triyandana et al., 2024). Likewise, a PBL study in Spain reported a statistically significant increase in secondary students' overall environmental awareness, especially in affective dimensions such as concern for pollution and appreciation of green spaces (López & Palacios, 2024). Qualitative findings reinforced this pattern: students frequently expressed more positive attitudes toward conservation and shifted their values, moving away from viewing nature in utilitarian terms to recognizing its intrinsic value. Even students with initially low interest in the environment showed notable attitudinal gains through PBL experiences. In summary, by actively engaging with environmental challenges, students became more emotionally invested and aware of environmental issues. The collaborative and immersive nature of PBL appeared to nurture empathy towards the environment and a personal commitment to sustainability (Avalos et al., 2023; Maurer et al., 2020).

PBL Encourages Pro-Environmental Behavior and Action

Evidence from the reviewed studies showed that PBL not only influenced attitudes but also encouraged concrete pro-environmental behaviors and action-taking. Because PBL tasks are embedded in real-world problems, students

often have to perform environmentally beneficial actions as part of their projects, leading to practiced behavior change. Several interventions explicitly tracked behavioral outcomes: for example, in the GAIA energy-saving project in Greece, classes competed to reduce electricity use at school, and students adopted energy-conservation habits (such as turning off lights) as a result of the project (Bidang; Maurer et al., 2020). In Indonesia, elementary students who participated in a PBL initiative to care for plants and animals developed stronger "environmental stewardship" behaviors, consistently performing tasks such as watering plants or feeding animals responsibly (Triyandana et al., 2024). Qualitative studies similarly noted that students became more inclined to act on environmental issues after experiencing PBL. In a case from Bangladesh, pupils engaged in a pollution-focused project began taking initiative to address local waste and showed willingness to continue such actions in their daily (Hamid, 2025). Moreover, PBL often empowers students to implement solutions beyond the classroom requirements. One report described how learners, inspired by their project work, voluntarily pursued additional eco-friendly practices at home and in their community (Bramwell-Lalor et al., 2020). Through these hands-on projects, students practiced solving environmental problems and demonstrated tangible behavior changes (reducing, reusing, recycling, conserving energy). Thus, PBL served as a catalyst for translating environmental knowledge and attitudes into action, fostering young people who not only know about the environment but also actively work to improve it (Hamid, 2025; Maurer et al., 2020).

PBL Develops Environmental Education Competencies and Skills

In addition to knowledge and attitude gains, PBL was reported to develop a range of competencies and skills valuable for environmental education. Nearly all studies found that students who engaged in PBL improved their collaboration and problem-solving abilities. Working in teams on complex environmental projects required students to communicate, plan, and manage tasks together, thus strengthening their teamwork skills (Avalos et al., 2023). Observations from classroom implementations noted that students took on various roles and responsibilities during projects, learning to coordinate with peers and contribute

effectively to group objectives (Hamid, 2025). PBL's inquiry-based format also enhanced critical thinking and analytical skills. Faced with real environmental problems (such as monitoring pollution or conserving resources), students had to investigate causes, evaluate possible solutions, and make decision-making processes that sharpened their critical thinking regarding environmental issues (Bramwell-Lalor et al., 2020). For example, one study reported that after a PBL unit, students were more adept at identifying environmental problems in their community and proposing evidence-based solutions, indicating growth in problem-solving competence (Rehman et al., 2024). Creativity and self-directed learning were other noted benefits: as students designed project outputs (campaigns, experiments, models, etc.), they learned to think creatively and manage their own learning process. These competencies closely align with the goals of Education for Sustainable Development, which emphasize not only environmental knowledge but also the skills to act on it (Utaminingsih, Qomar, et al., 2025). Teachers observed that, in some cases, students became more confident in addressing environmental challenges and more capable of applying interdisciplinary skills (science, communication, civic skills) through PBL experiences (Dole et al., 2017; Rehman et al., 2024). In summary, PBL provided an authentic context for students to practice and develop key environmental competencies ranging from scientific inquiry and systems thinking to collaboration and leadership preparing them to be active and skilled participants in sustainability efforts (Winarni, 2022).

Enabling and Constraining Factors in Implementing PBL in Environmental Education

Implementing PBL in environmental education proved most effective when certain enabling factors were present, and researchers also identified common constraints. A supportive school culture and administrative backing emerged as crucial enablers. In successful cases, school leadership provided teachers with the flexibility and resources needed to run projects, and environmental initiatives (such as eco-school programs) were integrated into the curriculum to reinforce PBL activities. For instance, a study on Indonesia's Adiwiyata program (a national eco-school initiative) found that schools with strong

principal support and active participation of the whole school community achieved more robust improvements in students' environmental care attitudes through project-based activities (Hartanto et al., 2024). Another key enabling factor was teacher preparedness and collaboration. Teachers often need training and planning time to adopt the facilitator role that PBL requires. One international review noted that when teachers received professional development and worked together to design interdisciplinary projects, PBL implementation was smoother and more impactful (Rehman et al., 2024). Flexible curricula and assessment practices also helped; when curricula allowed adaptation, teachers could tailor projects to local environmental contexts, making them more relevant and feasible (Bramwell-Lalor et al., 2020). Conversely, several constraining factors were documented. A lack of time within a crowded school schedule was frequently mentioned as a barrier, as high-stakes exams and rigid syllabi can leave little room for extended projects. Limited resources or funding for materials and field work can also hinder PBL, especially in under-resourced schools (Hamid, 2025). Some teachers were initially resistant or felt unprepared for the shift away from traditional teaching, indicating that without adequate training and support, PBL may not reach its full potential. Additionally, studies emphasized the importance of contextual adaptation: what works in one cultural or educational context may need to be modified in another. For example, a PBL approach successful in a technology-rich school in one country might need to be simplified for a rural school elsewhere and indeed, the literature showed that even scaled-down PBL models (with shorter duration or fewer resources) still yielded positive outcomes when well-designed (Avalos et al., 2023). Despite these challenges, the overall evidence suggests that, with supportive conditions such as policy encouragement, teacher training, and resource allocation, the implementation of PBL in environmental education can be highly successful. Educators and policymakers should work to strengthen these enabling factors and mitigate constraints to harness the full benefits of PBL in fostering environmentally literate and engaged students.

CONCLUSIONS

This systematic review indicated that Project-Based Learning had functioned as a

substantive pedagogical lever for advancing elementary students' environmental awareness by fostering measurable gains in environmental knowledge, strengthening pro-environmental attitudes, and promoting action-oriented behaviors through authentic problem engagement, with multiple studies reporting statistically meaningful improvements and strong positive associations between PBL participation and environmental awareness outcomes. However, the evidence also suggested that impact had not been solely attributable to project design; rather, it had depended on ecosystem conditions particularly administrative support and an enabling school culture, teacher preparedness and interdisciplinary collaboration, and curricular flexibility while persistent constraints such as limited instructional time, inadequate resources for materials and fieldwork, and insufficient teacher readiness had restricted scalability in many contexts. Consequently, effective institutionalization in Indonesian primary schools would have required embedding environmental projects within curricular and school-program structures and strengthening teacher professional development and resourcing so that PBL could be implemented consistently and adapted responsively to local contexts.

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