

# Project-Based Learning as a Strategy for Strengthening Ecological Literacy in Higher Education

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## Abstract

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Ecology plays a crucial role in maintaining ecosystem balance, public health, food security, and the economic stability of society. Ecological literacy has become an essential competency in responding to global challenges such as climate change, pollution, and environmental degradation. Education serves as an effective vehicle for fostering ecological awareness by providing knowledge, skills, and values oriented toward sustainability. Nevertheless, higher education institutions in Indonesia still encounter significant obstacles in integrating ecological literacy into their curricula. Project-Based Learning (PBL) emerges as an innovative, student-centered instructional strategy that emphasizes real-world projects to enhance critical, collaborative, and creative thinking skills. Through a literature-based study, this research aims to elaborate on the potential of PBL as a medium for strengthening ecological literacy among university students. Findings indicate that PBL offers an alternative solution to overcome limited learning resources, improve ecological competencies, and cultivate environmental responsibility. Thus, PBL has the capacity to support sustainable education while preparing students as agents of change in addressing complex ecological issues.

## **1. Introduction**

Ecology has a fundamental role in maintaining the balance of life on earth. As a science that discusses the reciprocal relationship between living things and their environment, ecology highlights the importance of ecosystem sustainability, which has direct implications for people's health, food, and economy. By understanding the principles of ecology, humans can manage biodiversity and natural resources wisely and sustainably, while also solving environmental problems such as land degradation, pollution, and the energy crisis. Not only that, ecology also emphasizes a moral dimension: human responsibility as an integral part of the environment to ensure sustainability for future generations. In line with the importance of ecology, ecological literacy is a competence that individuals in the 21st century must have. This literacy refers to a deep understanding of ecological principles, the human-environment relationship, and the ability to make decisions oriented toward nature conservation.

Ecological literacy requires individuals not only to understand the knowledge aspects but also to build an environmentally conscious attitude and design innovative and sustainable solutions. In the context of modern issues such as global warming, climate change, and increasing pollution, ecological literacy plays a strategic role in equipping society to act as an agent of change (Powers et al., 2021). Education plays a vital role in shaping ecological awareness. Through education, society is introduced to values, knowledge, skills, and attitudes oriented toward sustainability. Environmental education allows students to understand the importance of preserving natural resources, train their ability to manage the environment, and

shape eco-friendly values. This approach has long been promoted through Education for Sustainable Development (ESD), a global agenda compiled by UNESCO to support the goals of sustainable development. ESD emphasizes that the younger generation must have learning opportunities that allow them to understand the relationship between social, economic, cultural, and environmental aspects in their daily lives.

However, in Indonesia, the integration of ecological literacy into the higher education curriculum faces various challenges. The lack of relevant learning resources, limited use of technology, minimal field experience, and suboptimal readiness of lecturers and facilities are the main obstacles. In addition, local environmental issues, which are rich in learning potential, are often not well integrated into the formal education process. As a result, students do not get an authentic experience that can connect theory with real practice in environmental management (Sotiriadou et al., 2020). In this context, Project-Based Learning (PBL) is one of the relevant innovative approaches. PBL is a student-centered learning model that emphasizes active involvement through real projects to solve real-world problems (Karan & Brown, 2020). Through PBL, students not only master academic content but also develop critical thinking skills, problem-solving, collaboration, and creativity. These characteristics are in line with the demands of ecological literacy, as students are involved in research, experiments, and environmental projects that connect ecological aspects with daily life.

Several previous studies show the effectiveness of PBL in improving learning outcomes. Rasyid et al. (2023), for example, found that the application of STEM-

based PBL significantly improved students' science skills. Hawari and Noor (2020) added that the integration of art in PBL-STEAM can train creativity through product design activities. Indahwati et al. (2023) reported that the application of PjBL-STEAM increased students' cognitive, emotional, and psychomotor scores. These results indicate that PBL has great potential to be used as a medium to increase students' ecological literacy. Thus, the urgency of this research lies in an effort to explore how the PBL model can be effectively implemented to increase ecological literacy in higher education. This study will discuss the relevance of PBL as an innovative learning strategy in answering the challenges of integrating ecological literacy, while also contributing to shaping a generation that is not only knowledgeable but also responsible for environmental sustainability.

## **2. Literature Review**

Ecological literacy is a concept that has been widely researched by environmental experts and educators. Kelly et al. (2020) state that ecological literacy helps individuals understand environmental problems at local, regional, and global levels. Setiawati et al. (2020) emphasize the need for ecological literacy to be introduced from an early age so that the younger generation can internalize the value of sustainability. Nesterova (2020) also supports the idea that environmental education should start at school age to form strong ecological habits. According to Hadjichambis and Paraskeva-Hadjichambi (2020), education plays an important role in building ecological literacy because it can provide the knowledge, skills, attitudes, and values needed to protect the environment. Tiwari (2023) add that ecological

literacy must be developed through an interdisciplinary approach so that individuals can connect environmental issues with social, political, and economic aspects. This is in line with the Education for Sustainable Development framework launched by UNESCO.

The components of ecological literacy include six main aspects: implications, ecological knowledge, socio-political knowledge, knowledge about environmental problems, cognitive skills, and responsible behavior. These six aspects form a comprehensive framework for building individual capacity so that they not only understand the environment conceptually but are also able to act concretely. In line with this, Project-Based Learning (PBL) emerges as an innovative learning model that is oriented toward real projects. Loyens et al. (2023) states that PBL emphasizes complex and authentic questions that encourage students to conduct in-depth investigations. Zhao et al. (2020) adds that PBL allows students to gain meaningful learning experiences through collaboration, problem-solving, and involvement in a real-world context. Several studies highlight the link between PBL and the development of creative thinking skills. Hendrik et al. (2022) identifies four main indicators of creative thinking: fluency, flexibility, originality, and elaboration.

PBL can stimulate these skills through planning activities, data processing, and presenting project results. Thus, PBL not only improves academic achievement but also supports the formation of critical and innovative attitudes. In the context of environmental education, PBL can be integrated with the STEM or STEAM approach. Rasyid et al. (2023) proves that STEM-based PBL improves students' science skills. Hawari and Noor (2020) adds that the STEAM approach in PBL

trains students' creativity through environmental issue-based product design activities. Indahwati et al. (2023) shows that the application of PjBL-STEAM has a positive impact on students' cognitive, affective, and psychomotor aspects. These results indicate that PBL has great potential as a learning strategy for ecological literacy. Referring to this literature, it can be concluded that PBL is not only an innovative pedagogical approach but also an effective strategy for integrating ecological literacy into the higher education curriculum.

### **3. Methods**

This study uses a literature study method (library research), which is a research approach carried out through the collection, analysis, and interpretation of various relevant literature sources. The literature study was chosen because the topics of ecological literacy and Project-Based Learning (PBL) have been widely discussed in previous studies, both in the form of journal articles, books, and research reports, so a deep analysis can be carried out without direct experiments. The research stages begin with identifying the main topics that are the focus of the study, namely the role of PBL in increasing the ecological literacy of higher education students. After that, a literature search was carried out through international academic databases through Google Scholar, Elsevier, and other journal database.

The criteria for selecting literature include relevance to the topic, publication recency (especially in the last ten years), and its contribution to discussing PBL and ecological literacy. After the literature is collected, the next stage is to conduct content analysis. The analysis was carried out by examining the concept of ecological

literacy, the components that form it, and the challenges of its integration into the curriculum. Furthermore, the concept of PBL, the steps for its implementation, and empirical evidence supporting its effectiveness in education, especially in the context of environmental literacy, were also analyzed.

To maintain the validity of the data, source triangulation was carried out by comparing findings from various studies. International literature was used to provide a global perspective, while national literature was used to emphasize the local Indonesian context. The analysis was also directed at identifying the research gap, namely the gap between the results of existing research and the real needs in the implementation of PBL in Indonesian higher education. The results of the analysis are then presented in the form of a systematic descriptive narrative. The report is structured according to a scientific article that includes an introduction, literature review, methods, results and discussion, and conclusions. By using the literature study method, this research is expected to provide a comprehensive understanding of the relevance of PBL in increasing students' ecological literacy, as well as providing practical recommendations for curriculum development in higher education.

## **4. Results and Discussion**

### **4.1 The Relevance of Project-Based Learning in Increasing Ecological Literacy**

Ecological literacy is a multidimensional skill that demands mastery of ecological knowledge, critical thinking skills, attitudes, and eco-friendly behavior. In

the context of higher education, this literacy is not enough to be taught through conventional methods such as lectures or class discussions, but must be developed through authentic experiences. Project-Based Learning (PBL) is a relevant approach because it emphasizes student involvement in real projects that are directly related to environmental issues. Thus, students do not just get theory, but also have the opportunity to practice the theory in the form of direct practice. PBL allows students to understand the complexity of the environment through exploration, investigation, and decision-making activities. For example, when students carry out an organic waste management project around the campus, they not only learn about the concept of recycling but also face the dynamics of the social community, limited facilities, and technical aspects of waste processing. This experience contributes to the development of the dimensions of ecological literacy: ecological knowledge, socio-political knowledge, and cognitive skills. This is in line with Zhao's (2020) view that PBL provides a meaningful learning experience by placing students in authentic situations.

In addition, PBL also strengthens the indicators of creative thinking which are an important part of ecological literacy. Hendrik et al. (2022) explains that creative thinking includes fluency, flexibility, originality, and elaboration. In environmental projects, students can develop fluency of ideas when looking for solutions, flexibility in adjusting methods to field conditions, originality in creating new ideas, and elaboration in designing detailed implementation. This process builds a divergent mindset that is very much needed to deal with complex environmental issues. The relevance of PBL to ecological literacy can also be seen from its

relationship with Education for Sustainable Development (ESD). UNESCO emphasizes that ESD must train students to become agents of change with the ability to think systemically, critically, and act responsibly toward the environment. PBL supports this goal by presenting projects that require students to consider ecological, social, economic, and cultural aspects as a whole. In other words, PBL not only produces ecological knowledge but also fosters awareness of the multidimensional relationship of sustainability issues.

Empirical research supports the effectiveness of PBL in increasing ecological literacy. Rasyid et al. (2023) shows that the integration of PBL with the STEM approach is able to significantly improve students' science skills. Hawari and Noor (2020) adds that the STEAM approach in PBL trains students' creativity through environmental issue-based product design activities. Indahwati et al. (2023) reported that the application of PjBL-STEAM increased cognitive scores by 82.11, emotional scores by 85.5, and psychomotor scores by 74.6. These results indicate that PBL is effective in increasing various dimensions of ability that are also relevant to ecological literacy. Thus, the relevance of PBL in increasing ecological literacy lies in its ability to present contextual learning, encourage creative thinking skills, develop critical attitudes, and foster responsible behavior. Through real projects, students not only become recipients of information but also agents of change who are directly involved in environmental conservation.

## **4.2 Implementation and Challenges of PBL in the Context of Indonesian Higher Education**

Although PBL has a strong relevance to the development of ecological literacy, its implementation in Indonesian higher education faces a number of challenges. One of the main obstacles is limited resources. Many campuses do not have adequate facilities to support environmental projects, such as a complete ecology laboratory, supporting technology, or operational funds for field activities. This condition often limits the space for students to carry out complex and sustainable projects. In addition, the readiness of lecturers is also an important factor. Most lecturers are accustomed to conventional methods based on lectures and discussions. The transition to PBL demands a new role as a facilitator who assists students in planning, implementing, and evaluating projects (Rees Lewis et al., 2019). This requires training, commitment, and adaptation to the changes in the learning paradigm. Without this readiness, the implementation of PBL is often hampered and does not run optimally.

Another challenge is limited time. PBL requires a longer duration than traditional methods because it involves the stages of problem identification, research, planning, implementation, and evaluation (Chen et al., 2021). In a dense lecture system, with limited face-to-face time allocation, PBL implementation is often not maximized. As a result, students only carry out projects on a small or limited scale, so they do not fully get an in-depth experience. However, these challenges do not mean that PBL cannot be applied. These obstacles actually open up opportunities for innovation. One strategy is to integrate PBL with the STEAM

approach which allows projects to be multidisciplinary. Through this integration, students from various study programs can work together to develop more creative and comprehensive environmental solutions. For example, education students can collaborate with engineering students to design a clean water management system based on renewable energy.

The use of digital technology can also be a solution. Online platforms can be used for project coordination, data collection, and even publishing research results. Students can use applications to conduct field surveys, analyze environmental data, or even create digital simulations as a prototype solution. This approach not only reduces the limitations of physical facilities but also enriches students' digital skills. The integration of local wisdom in PBL is also an important opportunity. Many communities in Indonesia have traditional practices that are in line with the principles of sustainability, such as the *subak* system in Bali or forbidden forests in Sumatra. By making local wisdom part of the project, students can learn that ecological literacy comes not only from modern science but also from cultural values that have been passed down from generation to generation. This is in line with Tiwari (2023) view that ecological literacy must be developed through an interdisciplinary approach.

The results of the research show that when implementation challenges are successfully overcome, PBL can provide significant results. Students not only understand ecological theory but also directly experience environmental dynamics. They learn to work together, manage conflict, and build a sense of social responsibility. Furthermore, this experience fosters awareness that protecting the

environment is not just an academic task but a moral and social obligation. Therefore, higher education institutions need to place PBL as the main strategy in environmental learning. Policy support, funding, and the development of lecturer capacity are the keys to successful implementation. With the right support, PBL has the potential to produce a generation of students who are ecologically literate, innovative, and ready to become agents of change in facing the global environmental crisis.

## **5. Conclusion**

Ecological literacy is a fundamental competence that students must have to face global environmental challenges while realizing sustainable development. Higher education institutions have a great responsibility to shape a generation with ecological awareness by integrating ecological literacy into the curriculum. However, implementation challenges such as limited learning resources, minimal field experience, and lecturer readiness demand an innovative learning strategy. Project-Based Learning (PBL) has proven to be a relevant alternative. PBL emphasizes learning based on real projects that allow students to interact directly with environmental issues, while also developing critical thinking, creative, collaborative, and ecological responsibility skills.

This literature study shows that the integration of PBL with the STEM/STEAM approach strengthens student learning outcomes in cognitive, affective, and psychomotor aspects. Thus, it can be concluded that PBL has great potential to increase the ecological literacy of higher education students in Indonesia.

The implementation of PBL must be carried out systematically with resource support, lecturer training, and the integration of local wisdom to be more contextual. This effort is expected to produce a generation of young people who are not only knowledgeable but also have an attitude and behavior that is responsible toward the environment.

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