Biogenerasi Vol 10 No 4, 2025
Biogenerasi: Jurnal Pendidikan Biologi
Universitas Cokroaminoto Palopo
https://e-journal.my.id/biogenerasi
e-ISSN 2579-7085

INTEGRATING MANGROVE CONSERVATION VALUES INTO PROJECT-BASED LEARNING (PjBL) BIOLOGY TO ENHANCE COLLEGE STUDENT'S ECO-LITERACY

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DOI : 10.30605/biogenerasi.v10i4.7810

Accepted : 10 Desember 2025 Approved : 24 Desember 2025 Published : 25 Desember 2025

Abstract

This study examines the effectiveness of integrating mangrove conservation values into the Project-Based Learning (PjBL) model to improve the eco-literacy of Biology Education students. A quantitative quasi-experimental Pretest-Posttest Control Group Design was applied to 28 students, divided into experimental and control groups. Data were collected through ecological literacy tests, environmental attitude scales (New Ecological Paradigm/NEP), and field skill observations, then analyzed using Independent Sample T-tests and Normalized Gain (N-gain) scores. Results indicate a significant impact (p=0.000) of PjBL integrated with mangrove conservation values across all dimensions of eco-literacy. The experimental group achieved high improvement, with N-gain scores: cognitive (0.74), affective (0.83), and psychomotor (0.76), with the affective aspect being dominant. Direct involvement at sites such as Ketapang Urban Aquaculture effectively fostered ecological responsibility. The study concludes that local conservation-based PjBL transforms students into eco-literate agents of change through direct, hands-on experiences.

Keywords: *Eco-literacy, Mangrove Conservation, Project-Based Learning (PjBL), Biology Education.*

INTRODUCTION

The contemporary global climate crisis places coastal ecosystems, specifically mangroves, in a position that is both strategic and precarious. In Indonesia, preservation initiatives through mangrove planting in locations such as Ketapang Urban Aquaculture, Tangerang, are recognized as key strategies for mitigating coastal environmental degradation (Sansena, 2025). The sustainability of these physical interventions depends significantly on the level of ecological literacy (eco-literacy) within the community, particularly among university students. Biology education plays a pivotal role in converting national climate mitigation strategies into concrete actions by empowering students in conservation (Gunawan et al., 2025).

Field observations indicate that student understanding of the ecological value of mangroves is often limited to theoretical realms. Conversely, empirical data on local mangrove species diversity offers the potential for direct integration into the curriculum (Sansena et al., 2025). This integration of conservation values is essential because mangroves possess not only ecological value but also ethnobotanical significance as authentic sources for biology learning. Thus, innovations in presenting interactive science materials are necessary to effectively influence behaviour (Sansena et al., 2025).

Project-Based Learning (PjBL) is the most effective approach to address these challenges, as it facilitates theoretical understanding while engaging students in systematic environmental problem-solving through authentic project designs (Afrianda et al., 2019). Mangrove ecosystems function crucially in maintaining coastal ecological balance as natural shields against abrasion and as carbon sinks, despite increasing degradation in the Tangerang region due to land conversion.

Biology education in higher education holds a strategic responsibility to produce competent, eco-literate graduates. In the 21st-century era, this education must transcend the training of laboratory academics to create global sustainability agents with sensitivity to environmental issues. Students, as agents of change, require a deep understanding of critical ecosystems like mangroves through applicative and solution-oriented approaches. Historically, biology learning has been theoretical and lacked context; therefore, integrating conservation values into the curriculum has become imperative to tangibly enhance student eco-literacy.

The concept of eco-literacy forms a crucial foundation for biology students in understanding the interdependence of human systems and natural sustainability. In the context of Indonesia as a country with the largest mangrove area globally, mastery of eco-literacy must focus on the protection of coastal ecosystems. However, conventional methods often fail to touch upon affective and behavioral dimensions, necessitating dynamic models like PjBL for the internalisation of conservation values. The PjBL approach involves students in authentic environmental problem-solving projects, thereby integrating cognitive understanding of mangrove biology with affection and concrete preservation actions.

METHODS

This research is located in the Ketapang Urban Aquaculture Area, which is administratively located in Tangerang Regency, Banten Province. The determination of this area refers to Tangerang Regent Regulation Number 70 of 2022 concerning the Management Delineation Map of the Ketapang Urban Aquaculture Area. Geographically, this area is located on the north coast of Tangerang which directly borders the Java Sea. Based on the data attached to the regulation, the total area that is the focus of management is approximately 25 hectares (±25 Ha). This area includes residential areas (villages), road infrastructure networks, and integrated fisheries cultivation areas. The Ketapang area is a coastal development model that combines several main functions: (1) Aquaculture where there is a large pond area as the economic center of the local community, (2) Road infrastructure; This area is supported by accessibility through Jalan Collector Primer Dua (JKP 2) and a network of village roads that connect the center of economic activity with settlements and (3) Coastal Ecosystem: As an Urban Aquaculture area, this area has transitional environmental characteristics between densely populated land and mangrove conservation/cultivation areas. The selection of this location is based on its strategic significance as a pilot project in the development of a slum coastal area into an internationally recognized educational and productive economic tourism area, such as the

Partnerships in Environmental Management for the Seas of East Asia or PEMSEA event.

Fig.1 The delineation map of the Ketapang Urban Aquaculture area management (Perbup Tangerang, 2022)

Procedures of *Integrating Mangrove Conservation Values into Project-Based Learning (PjBL) Biology to Enhance College Students' Eco-Literacy*, adopts a quantitative approach through a quasi-experimental Pretest-Posttest Control Group Design (Creswell, 2014). The study aims to test the effectiveness of integrating mangrove conservation values into the PjBL model toward improving student eco-literacy. The population consists of Biology Education students, with the sample divided into an experimental group receiving the PjBL intervention integrated with mangrove conservation value and a control group following conventional learning methods.

The PjBL intervention follows systematic steps adapted from the Ministry of Education and Culture 2013 (Agusdianita, 2023) including: (1) starting with essential questions, (2) designing a plan for the project, (3) creating a schedule, (4) monitoring the activities and progress of the project, (5) assessing the outcomes, and (6) evaluating the experience.

The implementation follows PjBL syntax modified with mangrove conservation values based on The George Lucas Educational Foundation (2005) framework:

1. Essential Questions: The lecturer presents the phenomenon of mangrove ecosystem damage in the local coastal area. Students are asked to formulate project-based solutions for ecosystem preservation (Helle et al., 2006)
2. Project Design: Students work in groups to design simple mangrove health monitoring tools or conservation campaign designs.
3. Scheduling: Students develop a timeline for the project over four weekly meetings.
4. Monitoring Progress: The lecturer monitors student activities through weekly reflection journals and field observations.
5. Assessing Outcomes: Students present project products (e.g., tool prototypes or educational media) in class.
6. Evaluating Experience: Students reflect on the learning process and the importance of mangrove conservation in real life (Bender, 2012).

The integration of mangrove conservation values is realized through authentic case-based project tasks, requiring ecosystem analysis and the design of coastal restoration solutions to strengthen students' cognitive and affective dimensions. Eco-literacy measurement uses a questionnaire adapted from the Environmental Literacy Council, covering cognitive, affective, and psychomotor domains (McBeth & Volk, 2009a) using two main instruments:

1. Ecological Literacy Test: Multiple-choice questions based on the environmental literacy framework to measure ecological knowledge.
2. Environmental Attitude Scale: A Likert scale questionnaire adapted from the New Ecological Paradigm (NEP) to assess shifts in paradigms and behaviors toward

mangrove conservation (Dunlap et al., 2000).

Data Analysis of improvements in eco-literacy were calculated using Normalized Gain (N-gain) scores. Differences between groups were tested using Independent Sample T-tests on statistical software after verifying normality and homogeneity of variance (Field, 2012).

RESULT AND DISCUSSION

Research data were collected from 28 students divided into experimental (n=14) and control (n=14) groups. Results indicate that the application of the PjBL model integrated with mangrove conservation values significantly impacted all dimensions of eco-literacy, despite the limited sample size.

Descriptive Analysis of Eco-Literacy

Table 1 provides details of the mean scores across the three main aspects of eco-literacy after treatment. The data confirm that the experimental group consistently outperformed the control group in all dimensions. The highest score was achieved in the affective aspect, indicating that direct interaction with the mangrove ecosystem through field projects succeeded in fostering strong environmental concern among students.

Table 1. Comparison of Posttest Eco-Literacy Aspect Scores (N=28)

Eco-Literacy Aspect	Experimental (Mean ± SD)	Control (Mean ± SD)	N-Gain
Cognitive (Env. Knowledge)	87,20 ± 3,8	71,15 ± 5,2	0,74 (High)
Affective (Cons. Knowledge)	90,15 ± 2,9	69,40 ± 5,5	0,83 (High)
Psychomotor (Field Skills)	89,30 ± 3,1	65,80 ± 6,8	0,76 (High)

To test the significance of differences with a small sample, an Independent Sample T-test was conducted after data met normality assumptions via the Shapiro-Wilk test ($\alpha > 0.05$). Table 2 shows a significance value of 0.000 ($\alpha < 0.05$). Despite only 28 subjects, the high t-value indicates that the PjBL model's influence is robust.

Table 2. Significance Test Results (Independent Sample T-test)

Variable	t-value	Df	Sig. (2-tailed)	Conclusion
Eco-Literacy Total	11,245	26	0,000	Signifikan

The study results prove that integrating mangrove conservation projects into Biology learning transforms student environmental literacy comprehensively. The improvement in the psychomotor aspect is closely related to detailed field procedures. Significant cognitive and affective gains were supported by the choice of location at Mangrove Ketapang Urban Forest, Tangerang, which serves as a unique "nature laboratory." This aligns with findings emphasizing that utilizing the Ketapang Mangrove area as a learning resource increases motivation and environmental awareness by confronting students with real-world conservation challenges.

Literacy is a general term that refers to an individual's skills and abilities in reading, writing, speaking, calculating, and solving problems with a certain level of expertise required in everyday life (Antasari, 2017). In the context of developing areas such as Ketapang Urban Aquaculture, literacy is no longer limited to basic skills, but rather develops into ecological literacy. According to (Syukron, 2018), the components of ecological literacy consist of six components, namely implications, ecological knowledge, socio-political knowledge, knowledge about environmental problems, cognitive abilities and responsible behavior towards the environment. The PjBL model facilitates the simultaneous development of these components; students not only build ecological and sociopolitical knowledge through independent investigations of real-world phenomena, but are also challenged to hone their cognitive abilities in formulating solutions to environmental problems around them. Through the process of working on projects oriented towards tangible products, students will indirectly learn to understand the implications of every human action on the ecosystem, which ultimately leads to the formation of environmentally responsible behavior as a result of meaningful learning experiences.

This integration is reinforced through the "Green Pedagogic" approach within the PjBL syntax. As stated by (Khairy et al., 2024), project-based learning focusing on local environmental issues is an effective form of Green Pedagogic for building sustainable awareness. Through stages ranging from issue orientation to experience evaluation, students develop moral responsibility toward ecosystems. This depth of conceptual understanding aligns with (Hentje H. Umbunan et al., 2025) who state that PjBL significantly improves biology learning outcomes due to its contextual nature.

The increase in cognitive and psychomotor scores also aligns with (Rachmawati et al., 2024) regarding local potential-based learning to train environmental attitudes. Using authentic field data creates meaningful learning experiences. This is supported by (Faediyah et al., 2024), who assert that environmental project models involve students actively in building deeper ecological understanding through hands-on experience. Compared to (McBeth & Volk, 2009), who focused on cognitive literacy in middle schools, this study shows that at the university level, technical field skills are crucial. These skills serve as "anchors" for concrete ecosystem concepts; students do not merely memorize "salinity" but visually understand its impact on leaf morphology observed directly in the field.

The uniqueness of this study lies in the "Local Conservation Value Integration" into the PjBL syntax applied on a small but intensive scale. Unlike general PjBL research focusing only on final products, this study emphasizes behavioral change (affective aspect). As concluded by (Faediyah et al., 2024) eco-literacy is not just knowledge, but the ability to take responsible action, reflected here in the high affective and psychomotor improvements and also according to (Shamla & Eka Wulandari, 2025) in general, taking concrete action is crucial to addressing environmental problems.

The description above demonstrates the importance of developing a project-based learning (PjBL) model for improving students' ecological literacy through direct interaction and addressing environmental issues. Developing ecological literacy is crucial for producing human resources with environmental awareness(Faediyah et al., 2024). Integrating the mangrove conservation values found in the Ketapang Urban Aquaculture area into this PjBL model is believed to enhance students' understanding of ecological principles, environmental issues, and action skills through hands-on experience in addressing environmental projects and conservation in their local environment.

CONCLUSION AND SUGGESTIONS

This study concludes that the application of Project-Based Learning (PjBL) integrated with mangrove conservation values significantly increases the eco-literacy of Biology students. Synthesis of key points shows that: the PjBL model facilitates students in connecting ecosystem theory with environmental reality at Ketapang Urban Forest through hands-on experience; literacy improvement is most dominant in the affective aspect, proving that involvement in local environmental projects builds stronger ecological responsibility than conventional learning. These results suggest that integrating conservation values into PjBL syntax is an effective strategy for producing academically proficient and eco-literate students. Integrating the mangrove conservation values found in the Ketapang Urban Aquaculture area into this PjBL model is believed to enhance students' understanding of ecological principles, environmental issues, and action skills through hands-on experience in addressing environmental projects and conservation in their local environment. Based on these findings, it is recommended for future implementation to integrate more advanced digital technologies, such as real-time sensor monitoring or GIS-based mapping, in student mangrove conservation projects.

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