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From Mangrove to the Classroom: Integrating Ethnopedagogical Values into Biology Education through the Muara Gembong Mangrove Ecosystem

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Abstract

Background: Biology learning at the secondary education level still tends to be oriented towards abstract concepts that are poorly connected to students' real-life situations. This study aims to explore the ecological, sociocultural, and ethnopedagogical potential of the Muara Gembong mangrove ecosystem for integration into biology learning within the Merdeka Curriculum framework.
Method: A qualitative descriptive approach was applied in Pantai Mekar Village and Pantai Sederhana Village, Muara Gembong District, Bekasi Regency. Data collection was conducted through literature review, field observations, and semi-structured interviews with local residents and biology teachers. The collected data were then analyzed using thematic analysis techniques.
Results: Local knowledge and practices of coastal communities are closely linked to biological concepts such as biodiversity, ecosystems, conservation, adaptation, biotechnology, and plant growth. Local practices such as vegetation identification, traditional food/medicine utilization, nursery cultivation, bird migration observation, and ecotourism have significant potential for integration in Phases E and F. However, interviews indicated that this potential has not been optimally utilized because school learning is still dominated by general examples from textbooks.
Conclusion: Integrating the Muara Gembong mangrove ecosystem into biology lessons can help students understand concepts concretely and meaningfully while fostering ecological awareness and appreciation for local culture. To optimize the implementation of the Independent Curriculum, educators need to shift from a textual model to contextual, environment-based learning. Further research should focus on developing ethnopedagogy-based teaching materials and evaluating their effectiveness in promoting students' ecological awareness and understanding of local wisdom.

INTRODUCTION

Biology learning at secondary education level still faces fundamental challenges, namely the tendency to focus on abstract concepts that are not closely linked to the real lives of students (Ramadhani et al., 2025; Yemini et al., 2023). This condition results in low conceptual understanding

and weak connections between the knowledge acquired at school and the environment around students (Harmelayati et al., 2026). Meaningful learning requires students to connect science content to authentic contexts, but this connection is rarely realized in conventional biology instruction. As a result, students tend to understand biology as a collection of facts disconnected from the realities of their lives, rather than as a living and relevant science.

Responding to these challenges, the Independent Curriculum is present as a policy framework that opens up significant opportunities to transform biology learning (Habibah et al., 2025). This curriculum is designed to provide flexibility and autonomy for schools in creating learning experiences that are aligned with the local context and individual needs of students (Islawati, 2025). In this framework, local potential and wisdom, which include the natural, social, and cultural resources of a region, become a strategic foundation in designing contextual and meaningful biology learning (Sura et al., 2026). In addition, it also fosters students' character traits such as cooperation, tolerance, and concern for the environment.

One innovative approach to realizing the vision of the Independent Curriculum in biology learning is ethnopedagogy (Nurlaila et al., 2025). Ethnopedagogy is a learning approach that uses culture and environment as the foundation of education, emphasizing local wisdom values and involving the development of these values to achieve educational goals (Sugara & Sugito, 2022). Through this approach, biological concepts are meaningfully connected to traditional community practices so that students better understand the relevance of these concepts in everyday life (Rahmawati et al., 2020). Besides that, Hasanah et al. (2021) suggests that the integration of local cultural values in learning through ethnopedagogy can foster students' appreciation of cultural heritage while supporting their academic and character development.

Although its potential has been widely recognized, Indonesia's cultural richness offers various opportunities to be integrated into learning, but much of this potential has not been explored and utilized optimally in the context of science education (Sriyati et al., 2021; Sudirman et al., 2024). The Muara Gembong mangrove area, located on the north coast of Bekasi Regency, West Java, is a prime example of underutilized local potential for learning. This area is home to 32 bird species, including four with conservation status (Gantini et al., 2020). Besides that,Mangrove forest areas function as ecological buffers to prevent abrasion, reduce seawater intrusion, and maintain the stability of coastal land (RP Sari & Nugraha, 2021). This reflects the extraordinary ecological richness of this coastal area. In addition to its ecological value, the Muara Gembong mangrove area also offers social and economic potential for the surrounding community, including the use of mangrove products for food, traditional medicines, and the development of conservation-based ecotourism (Yuliani & Herminasari, 2017).This potential makes this area very relevant to be used as a contextual learning resource in biology learning, as well as a means to foster environmental awareness and sustainable attitudes in students.

Integrating the local potential of mangrove ecosystems into biology learning is beginning to be widely developed in various regions of Indonesia as an effort to create contextual and meaningful learning. Utilizing mangrove ecosystems in learning can help students understand the material through its connection to the surrounding environment while simultaneously fostering positive character traits (Nugroho et al., 2022). In line with that, (Sulistyowati et al., 2020) stated that learning tools based on the local potential of mangrove forests have the potential to improve students' critical thinking skills and environmental awareness, as students are directly engaged with real ecological phenomena, encouraging them to observe, analyze, and reflect on the relationships between organisms and their environment.

However, studies on the integration of mangrove ecosystems into biology learning are still dominated by research in specific regions and have not explored the ecological and sociocultural characteristics of the Muara Gembong mangrove area as a learning resource. This area, however,

possesses unique ecological and social potential relevant to ethnopedagogy-based biology learning. Therefore, this study aims to explore the ecological and sociocultural potential of the Muara Gembong mangrove ecosystem and identify ethnopedagogical values relevant to biology learning at the secondary education level. This research is expected to contribute to the development of contextual biology teaching materials based on local wisdom within the Merdeka Curriculum framework.

METHODS

This study uses a qualitative descriptive approach that aims to explore in depth the ecological and sociocultural potential of the Muara Gembong mangrove forest area as a source of ethnopedagogy-based biology learning (Creswell, 2023). This approach was chosen because it allows researchers to understand phenomena contextually based on the experiences, perspectives, and knowledge of local communities. The research focused on exploring the local potential of mangrove forest areas in Pantai Mekar Village and Pantai Sederhana Village, Muara Gembong District, Bekasi Regency. This exploration included the diversity of mangrove plants and animals, community activities related to the mangrove area, and environmental conservation efforts undertaken by the local community.

Data collection was carried out through literature studies, field observations, and semi-structured interviews (Creswell, 2023). Literature review was used to obtain a theoretical basis for ethnopedagogy, local-based biology learning, and mangrove ecosystems. Field observations were conducted to identify the condition of the mangrove area, the types of flora and fauna found, and community activities related to mangrove utilization and conservation. Meanwhile, semi-structured interviews were conducted with biology teachers to explore learning needs and curriculum relevance, as well as local residents who have experience and direct involvement in mangrove management, namely mangrove educational tourism managers and river school community activists in Muara Gembong. The interviews were conducted to gather information about the ecological potential of the mangrove area, environmental conservation practices, and local values that have developed in the community.

In addition, interviews were conducted with biology teachers to obtain information regarding the integration of local potential and wisdom into biology learning, particularly in ecosystems. These interviews aimed to identify the extent to which the local potential of mangrove areas has been utilized in the learning process and to explore the challenges teachers face in integrating local contexts into biology learning within the Independent Curriculum. The use of semi-structured interviews enabled researchers to obtain in-depth and flexible data, while remaining focused on the research focus.

The data obtained were then analyzed using thematic analysis techniques (Braun & Clarke, 2006). The analysis process included data reduction, grouping data based on main themes, data presentation, and drawing conclusions. The analysis focused on identifying the ecological potential of the Muara Gembong mangrove area and its relationship to biological concepts, particularly ecosystems. Furthermore, the analysis also focused on identifying ethnopedagogical values embedded in the activities of the communities surrounding the mangrove area, thus providing a basis for developing contextual and relevant biology learning for students.

RESULT AND DISCUSSION

Ethnopedagogy represents a learning approach that integrates cultural values, local wisdom, and the local potential of a region into the educational process. Ethnopedagogy-oriented learning is important to implement because Indonesia possesses a wealth of diverse local potential in each region (Oktavianti & Ratnasari, 2018). The diversity of local potential reflects the close relationship between the community and its surrounding environment, so it can be utilized as a contextual learning resource that is relevant to the lives of students. In the context of this research, the Muara Gembong mangrove ecosystem serves as a form of ethnopedagogy for coastal communities, demonstrating the relationship between local knowledge and scientific biological concepts. Education through an ethnopedagogical approach views local knowledge as a source of innovation and skills that can be empowered (Subrata & Rai, 2023). This research contributes to the development of ethnopedagogical studies through the identification and analysis of local values contained in the Muara Gembong mangrove ecosystem, and demonstrates its potential as a biology learning resource that aligns with the principles of contextual learning in the Merdeka Curriculum. The Muara Gembong mangrove area is located at the northern tip of Bekasi Regency, West Java, and is one of the remaining mangrove ecosystems on the north coast of Java facing Jakarta Bay.Mangrove forests are forests that grow in coastal areas with muddy or sandy soil conditions, and are inhabited by various types of unique mangrove plants.(Hutahean et al., 2023).

Figure 1. Condition of the Muara Gembong mangrove ecosystem as a coastal area with high biodiversity (Personal Documentation, 2026)

This ecosystem is inhabited by various true mangrove species such as Rhizophora sp., Avicennia sp., Sonneratia sp. and other mangrove association species (Gantini et al., 2020; Marsudi et al., 2018; PT Pertamina, 2019).

Figure 2. Mangrove vegetation in the Muara Gembong area (Personal Documentation, 2026)

In addition to vegetation, this area is also home to various fauna, including water birds, monitor lizards, Javan langurs, and long-tailed monkeys. The presence of these animals demonstrates the importance of mangrove ecosystems in maintaining coastal balance.

a) Blekok Sawah (Personal Documentation, 2026)

b) Javan Langur (Beadle, 2018)

c) Long-tailed Monkey (Personal Documentation, 2026)

Figure 3. Diversity of fauna in the Muara Gembong mangrove area

The Muara Gembong mangrove forest ecosystem has enormous local potential to be used as a contextual biology learning resource, by linking various phenomena and practices of coastal community wisdom that occur in the mangrove area to classroom learning activities. Learning that stems from local wisdom and potential is essentially an effort to present local cultural values as an integral part of the educational process (Sriyati et al., 2023). Learning becomes more meaningful because students don't have to search far for examples or objects of study; they're readily available in their immediate environment and easily understood. Furthermore, when the subject matter feels relevant to everyday life, students tend to show greater interest and engagement (Amaliyah et al., 2023).

Table 1 presents the relationship between the indigenous science of the Muara Gembong community and the scientific knowledge found in various activities and local knowledge developed in the mangrove forest area. This relationship demonstrates that coastal community practices and knowledge are related to scientific biology concepts, thus offering the potential for integration into contextual biology learning that is relevant to students' lives. This integration of local knowledge and scientific science also supports the implementation of the Independent Curriculum, which emphasizes the use of local potential as a learning resource. Furthermore, the analysis in the table demonstrates the relationship between community activities in the Muara Gembong mangrove area and biology material at the secondary education level, enabling local potential and coastal community wisdom to be utilized as a foundation for developing ethnopedagogy-based biology learning.

Table 1. An Ethnoscience Study on the Potential and Local Wisdom of the Muara Gembong Mangrove Forest

Local Knowledge and Practices	Indigenous Community Science	Scientific Science	Biology Material
Mangrove Vegetation	The community recognizes various types of mangroves and uses a naming system such as bako-bako (Rhizophora sp.), api-api (Avicennia sp.), and pidada/bogem (Sonneratia sp.) based on the shape of the roots, leaves, and location where they grow.	The differences in mangrove morphology and zonation are a form of adaptation to salinity, mud substrates, and low oxygen levels in coastal ecosystems (Safitri et al., 2023).	Biodiversity, Plant Morphology, Ecosystem
Diversity of Fauna	People recognize various fauna such as monitor lizards, Javan langurs, water birds, snakes and otters as part of the mangrove ecosystem based on direct daily observations.	The mangrove ecosystem functions as a habitat, feeding ground, and reproductive area for various coastal fauna, thus supporting biodiversity (Rahardi & Suhardi, 2018).	Biodiversity, Ecosystem
Utilization of mangrove plants as traditional food	People use mangrove fruit as food ingredients such as syrup, dodol, chips and other processed foods based on experiences passed down through generations.	Several types of mangroves, such as Avicennia sp. and Sonneratia sp., contain protein, carbohydrates, and vitamins that have the potential to be used as food sources (Paramita, 2012; Santoso et al., 2005).	Conventional Biotechnology, Digestive System and Nutrition
Bird migration	People recognize the arrival of migratory birds from Australia every January–February as a marker of a particular season that influences fishing activities.	Bird migration is influenced by seasonal changes, food availability, and habitat conditions. The Muara Gembong mangrove area is an important habitat for migratory birds and birds with conservation status (Lisovski et al., 2021).	Biodiversity and Conservation
Mangrove nursery	People use used gallon jugs or polybags as a nursery medium because they are considered more practical and increase the success of seedling growth.	The use of specific nursery media maintains soil moisture and aeration; polybags allow optimal control of the salinity and pH of the planting medium for the growth of young mangrove seedlings (Basyuni et al., 2021).	Plant Growth and Development

Mangrove ecotourism	The community develops mangrove tourism such as river tours and Saung Alas as an educational facility and source of income for the community.	Ecosystem-based ecotourism can support environmental conservation while increasing the empowerment and economy of local communities (Rahim et al., 2022).	Biodiversity and Conservation
Endemic fauna	The community recognizes the existence of typical coastal fauna such as Javan langurs, long-tailed monkeys, and various types of water birds that are rarely found in other areas.	The existence of endemic fauna and protected animals shows the high conservation value and importance of the mangrove ecosystem as a natural habitat (Suryono et al., 2023).	Biodiversity, Ecosystem
Traditional medicinal knowledge	Pidada fruit is consumed to relieve stomach disorders; api-api leaves are applied to treat wounds and skin itching according to traditional knowledge.	Sonneratia sp. fruit contains saponins and antioxidants that have gastroprotective properties; Avicennia sp. leaves contain flavonoids, saponins, and tannins that have antibacterial and anti-inflammatory properties (Alhaddad et al., 2019; Putri et al., 2015).	Biotechnology, Digestive System

The local knowledge and practices of the Muara Gembong community reflect a system of local knowledge, or indigenous knowledge, that has developed through long-term interactions between coastal communities and the mangrove ecosystem. Various community activities, such as the use of mangrove plants for food and traditional medicine, mangrove nurseries, bird migration observations, and traditional naming systems for mangrove species, demonstrate a strong connection between local knowledge and scientific concepts in biology. These practices represent how the community utilizes its natural resources adaptively and sustainably based on empirical experience passed down through generations (Turyani et al., 2024).

a) MSMEs Are Happy to Work (Bekasi Regency Government Communications, Informatics, and Sanitation Office, 2023)

b) Mangrove Nursery (Personal Documentation, 2026)

c) Saung Alas Ecotourism, Simple Beach Village(Personal Documentation, 2026)

Figure 3. Local Practices of the Muara Gembong Community

The data analysis results show that the local knowledge of the Muara Gembong community is related to various biological concepts, particularly those related to biodiversity, ecosystems, interactions between living things, adaptation, conservation, and environmental change. The integration of indigenous and scientific knowledge demonstrates that local practices in coastal communities can be used as a concrete context in biology learning, helping students understand abstract concepts in a more concrete and meaningful way (Kusuma Sari et al., 2025). Unlike biology learning, which generally still uses general examples from textbooks, this study emphasizes the use of the local potential of the mangrove ecosystem as a contextual learning resource based on ethnopedagogy. This approach provides opportunities for students to connect biological concepts with the surrounding environment and the lives of local communities. In addition to improving conceptual understanding, the integration of local potential can also foster ecological awareness, environmental concern, and students' appreciation of the local richness of their region. Furthermore, Table 2 explains the form of integration of the local potential of the Muara Gembong mangrove forest adapted to specific phases of biology learning.

Table 2. Integrating Local Potential of Mangrove Forests in Biology Learning

Learning Outcomes	Learning objectives
Applying the principles of classification and strategies for biodiversity conservation; describing the role of viruses, bacteria, and fungi in life; analyzing interactions between ecosystem components and their effects on ecosystem balance; using measurement systems in scientific work; analyzing two-dimensional motion; analyzing the use of alternative energy to overcome energy availability problems; analyzing the constituent particles of matter and applying the concept of stoichiometry in various quantitative aspects of chemical reactions; and applying science concepts to overcome problems related to climate change.	a. Students can identify various types of mangrove vegetation in Muara Gembong based on their morphological and zoning characteristics. b. Students can explain the relationship between the diversity of mangrove fauna and the balance of coastal ecosystems. c. Students can identify endemic and protected fauna in the Muara Gembong mangrove ecosystem such as the Javan Langur (Trachypithecus mauritius) and relate them to the concepts of biodiversity and conservation. d. Students can analyze the interactions between biotic and abiotic components in the mangrove ecosystem. e. Students can construct food webs in the Muara Gembong mangrove ecosystem, starting from producers, consumers, to decomposers, and analyze the flow of energy and the cycle of materials within it. f. Students can analyze the relationship between bird migration and seasonal changes and coastal environmental conditions. g. Students can explain the role of mangrove ecotourism in supporting environmental conservation and empowering local communities. h. Students can analyze the relationship between mangrove damage and climate change, abrasion, and decreased biodiversity.
Linking the relationship between the structure and function of organelles in cells; applying the principles of bioprocesses that occur in cells; analyzing the relationship between organ systems in the body to respond to internal and external stimuli; applying the principles of inheritance; linking the mechanisms of evolution with the processes of diversity and survival of organisms; applying the principles of growth and development; and analyzing modern biotechnology processes.	a. Students can analyze the differences between eukaryotic and prokaryotic cells through the study of decomposer microorganisms that play a role in the detritus cycle of the mangrove ecosystem. b. Students can explain the mechanism of substance transport (osmosis and diffusion) through cell membranes in the context of mangrove plant adaptation to high salinity environments. c. Students can identify the bioactive compounds (flavonoids, tannins, saponins) in mangrove plants such as Avicennia sp. and Sonneratia sp. and their relationship to plant secondary metabolism. d. Students can connect the viviparous nature of mangrove propagules (Rhizophora mucronata) with the principles of plant growth and development and reproductive strategies in extreme environments.

Based on the ethnopedagogical potential identified in the Muara Gembong mangrove ecosystem, several practical topics can be integrated into biology learning at the senior high school level, particularly in Phases E and F of the Independent Curriculum:

1. Biodiversity and Ecosystem

Students can directly observe mangrove vegetation zonation, coastal fauna diversity, and endemic species such as the Javan Langur, and analyze the interactions between biotic and abiotic components in the mangrove ecosystem.

2. Food Web and Energy Flow

Students can construct food webs in the mangrove ecosystem, starting from producers, consumers, to decomposers, and analyze the flow of energy and the cycle of materials within it.

3. Plant Adaptation and Growth

Students can study mangrove propagule vivipary and the mechanism of osmosis and diffusion in mangrove plants as a strategy for adaptation to high salinity environments.

4. Biotechnology and Traditional Medicine

Students can identify bioactive compounds in mangrove plants such as *Avicennia* sp. and *Sonneratia* sp. and connect them to the concepts of secondary metabolites and traditional medicine practices of coastal communities.

5. Biodiversity Conservation

Students can analyze the role of mangrove ecotourism and community conservation practices in maintaining coastal biodiversity and relate them to the concept of environmental sustainability.

However, based on interviews with teachers, the local potential of the Muara Gembong mangrove ecosystem has not been optimally utilized in biology lessons at school. Learning generally uses general examples from textbooks and does not often relate the material to the students' surrounding environment. Teachers also have not integrated local knowledge of coastal communities into the learning process, even though various community activities are related to biological concepts. As a result, students tend to be less familiar with the local potential in their own environment and do not understand the connection between biology material and the lives of the coastal communities of Muara Gembong. However, ethnopedagogy-based learning is contextual, thus helping students understand concepts more concretely than using general examples in textbooks (Masihu & Augustyn, 2021).

This condition underscores the need for a more contextual learning approach. This is consistent with the findings of Maria et al. (2026) which demonstrate that ethnopedagogy-based learning through ethnoscience-based electronic modules produced greater learning outcome improvements (N-Gain = 0.7479) compared to conventional learning (N-Gain = 0.4592). These findings indicate that integrating local cultural and environmental contexts can make learning more relevant, meaningful, and comprehensible for students. Beyond improving conceptual understanding, the integration of local wisdom and local potential also contributes to the development of critical thinking skills. Various studies report that ethnopedagogical electronic modules, local wisdom-based student worksheets (LKPD), and the Contextual Teaching and Learning (CTL) model grounded in local wisdom are all capable of significantly improving students' critical thinking skills compared to conventional learning (Awaluddin & Muharyati, 2026; Saenab et al., 2025; Siregar et al., 2026). These results indicate that ethnopedagogy-based learning not only strengthens conceptual understanding but also promotes the development of higher-order thinking skills.

Nevertheless, the limited availability of learning resources based on local potential and the suboptimal application of contextual learning remain among the key reasons why mangrove potential is still rarely utilized as a learning resource (Reka Nurjanah et al., 2024). In the learning process, teachers tend to use learning resources found in textbooks without connecting them to real-world phenomena in the students' environment. This situation indicates that the implementation of ethnopedagogy-based biology learning is still suboptimal. Yet, local community knowledge is linked to scientific concepts and has the potential to create more relevant and meaningful learning for students.

In this case, integrating the local potential of the Muara Gembong mangrove ecosystem into biology learning can be an alternative to support the implementation of the Independent Curriculum through contextual, environmentally based learning that is oriented towards preserving local wisdom (Tasya, 2025). The Independent Curriculum gives teachers the freedom to develop learning according to the characteristics of students and the potential and local wisdom of their respective regions (Widyawati et al., 2025). Therefore, utilizing mangrove ecosystems as a learning resource can be a form of learning implementation that is relevant to students' surroundings. This approach not only helps students understand biological concepts but also fosters environmental awareness, concern for coastal ecosystems, and a sustainable appreciation for local culture and knowledge.

CONCLUSION

The Muara Gembong mangrove ecosystem has great potential for integration into biology learning through an ethnopedagogical approach. Various local knowledge and practices of coastal communities, such as the use of mangroves for food and traditional medicine, observation of bird migration, mangrove nurseries, and conservation activities, show a close relationship with the biology concepts in Phases E and F of the Independent Curriculum. The integration of this local potential not only helps students understand biology concepts in a more contextual and meaningful way but also encourages the formation of ecological awareness, concern for the coastal environment, and appreciation for local wisdom. Furthermore, this study shows that the use of mangrove ecosystems as a learning resource can be a form of implementation of the Independent Curriculum, which gives teachers the freedom to develop learning according to the characteristics of the local environment and culture. This research contributes to the development of ethnoscience-based biology learning that is more relevant, contextual, and oriented towards environmental and local cultural preservation. For future research, several recommendations are proposed based on the findings of this study. In the field of learning methods, further research is needed to explore the effectiveness of field-based and project-based learning methods that directly utilize mangrove ecosystems as a learning environment, particularly in fostering students' scientific inquiry and collaborative skills. In the field of teaching materials, it is recommended that researchers develop and validate ethnopedagogy-based biology teaching materials, such as modules, student worksheets, or digital learning media, that specifically integrate the local potential of mangrove ecosystems in accordance with the Independent Curriculum framework. In the field of learning evaluation, future studies should design authentic assessment instruments that are capable of measuring not only students' conceptual understanding but also their ecological awareness, environmental attitudes, and appreciation for local wisdom as outcomes of contextual biology learning.

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