



Exploring student biodiversity literacy in Indonesian coastal areas: implications for education for sustainable development

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ABSTRACT

This study is driven by the degradation of Indonesia's coastal ecosystems, leading to a decline in biodiversity and increase disaster risk for coastal communities. Addressing this issue necessitates the engagement of multiple stakeholders, particularly educational institutions. This study aims to describe the profile of biodiversity literacy of high school students in coastal areas of Sumbawa Island, Indonesia, across cognitive, attitude, and behavioural dimensions and to discuss its relevance to Education for Sustainable Development (ESD). A descriptive survey was conducted involving 535 high school students from coastal areas of Sumbawa Island. Biodiversity literacy was assessed using a 30-item multiple-choice test for the knowledge dimension and a 30-item questionnaire measuring attitude and behavioral dimensions. The instruments were validated and tested for reliability before data collection. Data were analyzed descriptively by classifying students' scores into low, moderate, and high categories. The results showed that biodiversity literacy was generally at a moderate level across all three dimensions. In the knowledge dimension, 65 students (12.15%) were categorized as high, 384 (71.78%) as moderate, and 86 (16.07%) as low. In the attitude dimension, 63 students (11.78%) were categorized as high, 415 (77.57%) as moderate, and 57 (10.65%) as low. In the behavioral dimension, 76 students (14.21%) were categorized as high, 399 (74.58%) as moderate, and 60 (11.21%) as low. These findings indicate the need for contextual and biodiversity-oriented learning that integrates knowledge, attitudes, and conservation behavior. The biodiversity literacy profile provides an empirical basis for strengthening biodiversity education and supporting education for sustainable development in coastal communities.

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INTRODUCTION

Indonesia is acknowledged by the international community as a megadiverse nation. Indonesia is recognized as the second most biodiverse country globally, following Brazil, and is part of the Coral Triangle, which contains the highest-grade coral reefs in the world (Rintelen et al., 2017). Moreover, Indonesia boasts a diverse array of flora and fauna, encompassing 31,902 plant species, 7,841 marine creatures, 1,883 bird species, 790 reptile species, 786 mammal species, and 403 amphibian species (BAPPENAS, 2024). Despite Indonesia's remarkable biodiversity, the sustainability of its environment and natural resources is at risk from a range of grave threats. According to Global Forest Watch data, Indonesia has lost 9.75 million hectares of primary forest over the last 20 years, resulting in the loss of wildlife habitat (Global Forest Watch, 2021). Global wildlife populations have decreased by 73% between 1970 and 2020, according to the World Wildlife Fund (2024). Freshwater, marine, and terrestrial ecosystems have seen the biggest losses.

The people of Sumbawa Island, Indonesia, are also experiencing the negative impacts of forest destruction. In April 2022, an algae bloom emerged around Bima Bay. Initial analysis indicates that the algae blooms in Bima Bay is caused by forest destruction, excessive use of nitrogen fertilizers and pesticides, and marine waste disposal. According to Namsaraev et al. (2020) and Oh et al. (2023), the accumulation of algae in marine environments can have significant environmental, social, and economic repercussions, including toxicity to humans and animals and the mortality of vital marine creatures. These problems demonstrate how crucial biodiversity is to many facets of human existence, including prosperity, security, food supply, and health. To address current human needs and preserve biodiversity for future generations, protection is essential (Aslan Efe & Efe, 2022). Biodiversity loss stems from human activities. Therefore, the solution also lies in changing human attitudes and behaviors regarding biodiversity (Borg et al., 2024; Milfont & Duckitt, 2010; Schultz, 2011).

The decline in biodiversity raises alarms among multiple stakeholders, including scientists, governmental bodies, and local communities (Schneiderhan-Opel & Bogner, 2020). In 2015, the United Nations established the Sustainable Development Goals, comprising 17 distinct objectives (United Nations, 2015). The SDGs represent a concerted effort to tackle pressing global challenges, including social, economic, and environmental/climate concerns (Schmidt-Traub et al., 2017; Wu et al., 2018). SDGs are designed to address the needs of today's global population while ensuring that future generations can meet their own needs (Mahat & Idrus, 2017). The present generation is expected to develop the knowledge, skills, values, and attitudes essential to enhancing awareness and proficiency in sustainability, thereby addressing both their own needs and those of future generations (Cebrián & Junyent, 2015; Vareda, 2020).

Educational institutions are the most strategic places to instill and implement the values of sustainable development (Kusumaningrum et al., 2023). Education for Sustainable Development (ESD) seeks to improve public understanding of the significance of sustainable development through forward-thinking education that includes safeguarding natural resources, sustainable consumption practices, global citizenship education, and gender equality (Yuan et al., 2022). ESD contributes to the cultivation of skills, values, and attitudes that prepare students to lead healthy lives and effectively address a range of challenges, both locally and globally (Vilmala et al., 2022). The ESD approach involves equipping individuals with the knowledge needed to make informed choices and take responsible actions regarding global challenges, ultimately fostering sustainable change (Vareda, 2020; Yuan et al., 2022). This is consistent with principles of ecological integrity, economic viability, and social justice (Li et al., 2023).

Science education plays a vital role in the overall framework of school education. The process of learning science fosters a range of skills and values as specified in educational goals, while also equipping students to solve scientific problems and make informed decisions that effectively integrate both scientific and social dimensions (Holbrook & Rannikmae, 2007). It is essential for students to acquire interdisciplinary skills that enable them to apply scientific literacy to comprehend and formulate strategies to address environmental challenges such as biodiversity loss, climate change, and sustainability (Lee, 2023; You et al., 2021).

The scientific literacy of Indonesian students is perceived to be lower than that of neighboring countries such as Singapore and Vietnam. In a study conducted by the Organization for Economic Cooperation and Development (OECD) in 2022, Indonesian students achieved a scientific literacy score of only 366, significantly lower than Singapore's 561 and Vietnam's 472 (OECD, 2023). An essential aspect of scientific understanding that students should develop, particularly to cultivate a sense of

responsibility and care for the environment, is biodiversity literacy (Williams et al., 2021). Biodiversity literacy refers to an individual's ability to understand biodiversity and to know specific actions that can be taken to support its conservation (Paradise & Bartkovich, 2021). This understanding encompasses not only knowledge but also awareness of the importance of biodiversity, the development of attitudes that support conservation efforts, and engagement in concrete actions to maintain biodiversity sustainability (Du & Hu, 2026). Based on these definitions, biodiversity literacy can be understood as a capacity encompassing the dimensions of knowledge, awareness or attitudes, and behavior oriented toward the conservation and sustainability of biodiversity. In this context, integrating biodiversity conservation education into primary and secondary school curricula is essential for fostering biodiversity literacy, particularly by strengthening students' knowledge, awareness, and attitudes toward biodiversity conservation (Delector, 2023; Kideghesho et al., 2007).

At present, there is a notable lack of targeted studies examining students' biodiversity literacy skills in coastal regions, both within Indonesia and globally. Frequently conducted research is related to scientific literacy (Almeida et al., 2023; Hartono et al., 2023; Sharon & Baram-Tsabari, 2020; Uslan et al., 2024; Valladares, 2021), biological literacy (Darmastuti et al., 2025; Semilarski & Laius, 2021; Suwono et al., 2017) environmental literacy (Husamah et al., 2022; Kinslow et al., 2019; Maurer & Bogner, 2020; Szczytko et al., 2019), climate literacy (Hakim et al., 2023; Kolenatý et al., 2022; Pan et al., 2023; Rahmawaty et al., 2024), and ecological literacy (Abdullah, 2023; Hartono, 2020; Murti et al., 2025; Nawawi & Wardhani, 2023). These five literacies have a different focus than biodiversity literacy. For example, environmental literacy typically focuses on general environmental issues such as forest fires, mining, and waste. (Suryawati et al., 2020). Likewise, in ecological literacy research, the focus is on animals, plants, factory waste, electricity use, transportation use, greenhouse gases, and the ozone layer (McGinn, 2014).

A systematic literature review conducted over the past decade (2015-2025) indicates growing interest in biodiversity literacy across regions, including Europe, Africa, the Americas, Asia, and Australia (Aminullah et al., 2025). Biodiversity literacy includes the understanding, perspectives, consciousness, and behaviors necessary for the conservation of biodiversity (Cleary & DeVantier, 2011). The understanding of biodiversity that students should have encompasses not just the concept itself, but also the ability to exhibit attitudes and behaviors that support conservation efforts, based on the knowledge they acquire (Barbett et al., 2020; Kleespies et al., 2024).

One concrete manifestation of biodiversity literacy is biodiversity care behavior, which refers to behaviors consciously undertaken to minimize the negative impacts of human activities on nature while contributing to the protection and sustainability of biodiversity. Such behavior can be demonstrated through various actions, including appreciating and observing the beauty of nature, advocating for biodiversity protection, participating as volunteers in conservation activities, producing compost, reducing the consumption of natural resources and energy, using non-toxic substances, and reducing waste generation (Akkaya et al., 2024; Miller et al., 2022; Richardson et al., 2020; Williams et al., 2024). Therefore, biodiversity care behavior can be regarded as a behavioral dimension of biodiversity literacy, as it reflects the extent to which individuals translate their knowledge and awareness of biodiversity into actions that support its conservation and sustainability.

Understanding biodiversity is crucial for students, particularly in nations rich in plant and animal life like Indonesia, enabling them to address issues related to biodiversity conservation (Kleespies et al., 2024). Empowering biodiversity literacy in schools helps students understand the impacts of global environmental change, including land conversion and climate change, which threaten endemic species and unique ecosystems in Indonesia (Katili & Rahmat, 2020). This study was undertaken to examine the biodiversity literacy of high school students in coastal areas of Sumbawa Island, Indonesia. Specifically, the study addressed the following research question: How is students' biodiversity literacy characterized across cognitive, attitude, and behavioral dimensions in Indonesian coastal areas? Accordingly, this study aims to describe the profile of students' biodiversity literacy across cognitive, attitude, and behavioral dimensions and discuss its relevance to Education for Sustainable Development (ESD).

METHODS

Research Design

This study employed a cross-sectional descriptive survey design to describe the biodiversity literacy profile of high school students in coastal areas of Sumbawa Island, Indonesia. The study focused



on three dimensions of biodiversity literacy: (1) knowledge, representing students' understanding of biodiversity concepts and issues; (2) attitudes, representing students' sensitivity, values, and beliefs concerning biodiversity conservation; and (3) behavior, representing students' individual and social actions related to biodiversity conservation. The indicators for the knowledge and attitude dimensions were adapted from the World Wildlife Fund & Wisconsin Center for Environmental Education (1996), while the indicators for the behavior dimension were adapted from Barbett et al (2020). The study was descriptive in nature. Therefore, the analysis was intended to describe the distribution and category of students' biodiversity literacy rather than to examine causal relationships or correlations among the three dimensions.

Population and Samples

The population in this study was all high school students on Sumbawa Island, Indonesia, which consists of Bima Regency, Bima City, Dompu Regency, Sumbawa Regency and West Sumbawa Regency. The sampling technique was random sampling from a representative sample of high school students on Sumbawa Island. A cluster random sampling technique was employed to select senior high school students representing different areas of Sumbawa Island. Data were collected from March 10 to April 5, 2025. A total of 535 students on Sumbawa Island responded to the questions and questionnaire. This topic was selected in recognition of the essential skills students at this level have related to biodiversity. Consequently, they ought to be able to provide relevant empirical data for analysis focused on improving conceptual understanding, promoting positive attitudes towards biodiversity, and motivating behaviors that contribute to biodiversity conservation.

Instrument

The tools employed to assess students' understanding of biodiversity consisted of a multiple-choice assessment and a survey. The assessment used a multiple-choice format to evaluate students' understanding of biodiversity, comprising 30 items. The questionnaire measured attitudes and behaviors related to biodiversity and consisted of 30 items. The research instruments were tested for validity and reliability before being distributed to students. The content validity test was conducted by two validators and yielded Aiken's V values of 0.875 for the cognitive aspect, 0.905 for the attitude aspect, and 0.875 for the behavior aspect. All of these values fall within the acceptable range, indicating that the instrument is appropriate for application. The reliability test was performed using SPSS, yielding Cronbach's alpha values of 0.909 for the cognitive aspect, 0.807 for the attitude aspect, and 0.776 for the behavior aspect. The three values demonstrate that all elements fall within the reliable category.

Procedure

Data were collected using a biodiversity literacy instrument developed in Google Forms and distributed online to students with assistance from teachers. Prior to completing the instrument, students were informed about the study's objectives, procedures, and participation requirements. Participation was voluntary and conducted after obtaining students' consent. The confidentiality of participants' identities and personal information was maintained, and the collected data were used solely for research purposes. Throughout the study, ethical principles were upheld, including the protection of personal data, confidentiality of information, and the prevention of any potential risks or harm to participants.

Data Analysis Techniques

The research data were analyzed using descriptive statistics in Microsoft Excel, including calculating mean scores, percentages, and score distributions to describe the students' biodiversity literacy profile. The results were subsequently classified into three categories: high, moderate, and low, based on predetermined criteria.

RESULTS AND DISCUSSION

The analysis of data regarding students' biodiversity literacy skills on Sumbawa Island, Indonesia, revealed that most students fall within the moderate category across cognitive, attitudinal, and behavioral dimensions (Figure 1).

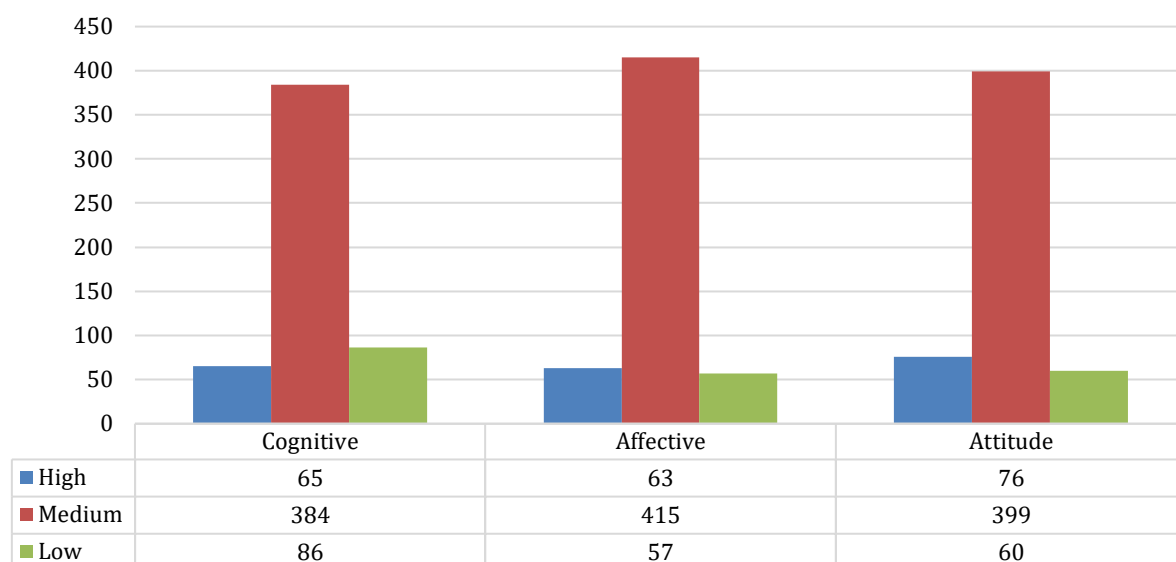


Figure 1. Student Biodiversity Literacy Data

In this study, the cognitive aspect indicators measured were: 1) knowledge of processes and principles related to biodiversity, 2) knowledge of issues and problems related to biodiversity, and 3) Knowledge of strategies and actions to save biodiversity. In the cognitive aspect, 65 students (12.15%) obtained high scores, 384 students (71.78%) obtained moderate scores, and 86 students (16.07%) obtained low scores. Thus, the average value of the students' cognitive aspects was classified as moderate. The attitude aspect indicators including: 1) sensitivity and positive values for preventing and improving biodiversity problems and issues, and 2) beliefs about individuals and communities related to Biodiversity. In this study, the average value of students' attitude aspects was classified as moderate with 63 students (11.78%) obtaining high scores, 415 students (77.57%) obtaining moderate scores and 57 students (10.65%) obtaining low scores. Behavioral aspects were measured based on the following indicators: 1) individual and social involvement, 2) conservation, and 3) land management. It was found that 76 students (14.21%) obtained high scores, 399 (74.58%) moderate, and 60 (11.21%) low. From these data, it is known that students' behavioral aspects are also classified as moderate, as are the other two aspects of biodiversity literacy. Anderhag et al. (2016) indicate that low learning outcomes in biology can be attributed to many students' perception that current biology teaching methods are unengaging and lack relevance. Students perceive biology learning as irrelevant due to the lack of connection and integration between biology and their everyday lives and the socio-cultural backgrounds they navigate (Childs et al., 2015). The subject of Biodiversity in secondary education in Indonesia is included in Biology curriculum. Irwansyah et al., (2019) research established that the bad quality of education on Sumbawa Island, Indonesia, was attributable to the continued employment of the direct learning model by certain teachers. Direct learning is a teacher-centered learning activity and involves lower-level cognitive skills such as reading and writing. Students are less involved in investigative activities, resulting in passive students (Eppley & Dudley-Marling, 2019; Snider & Schumitsch, 2006). One-way learning often encourages passive and less in-depth learning (Bransford et al., 2000), and fails to stimulate student motivation and self-confidence (Weimer, 2002). In traditional learning models, knowledge is perceived as a set of facts and concepts passed from instructor to learner, rather than as something actively built through experiential learning. This approach often fails to foster higher-order thinking skills, including critical thinking, problem-solving, and deep reflection (Prince, 2004). As a consequence of traditional learning, many students complete formal education without possessing the essential skills needed to face real-world challenges (Armbruster et al., 2009).

The study found an unusual phenomenon: 9 students (1.68%) had high cognitive scores but low attitudes and behaviors (Figure 2). However, according to Mendes et al. (2025), Nahavandian et al. (2022), and Simiyu et al. (2022), the greater an individual's cognitive understanding of biodiversity, the more favorable the effect on their attitudes and behaviors towards nature conservation, as these attitudes and behaviors are shaped by knowledge. It is widely recognized that an understanding of the surrounding environment enhances our connection with nature. Knowledge of biodiversity

conservation enables students to appreciate the value of biodiversity, maintain ecosystem function, and safeguard ecological health and integrity (Iwan et al., 2025). This comprehension is essential for promoting environmental consciousness, responsible mindsets, and sustainable practices, empowering students to engage meaningfully in conserving natural resources. Moreover, this understanding encourages participation in activities aimed at conserving biodiversity, thereby enhancing awareness of biodiversity and the environment (Mackay & Schmitt, 2019; Prévot et al., 2018; Whitburn et al., 2020).

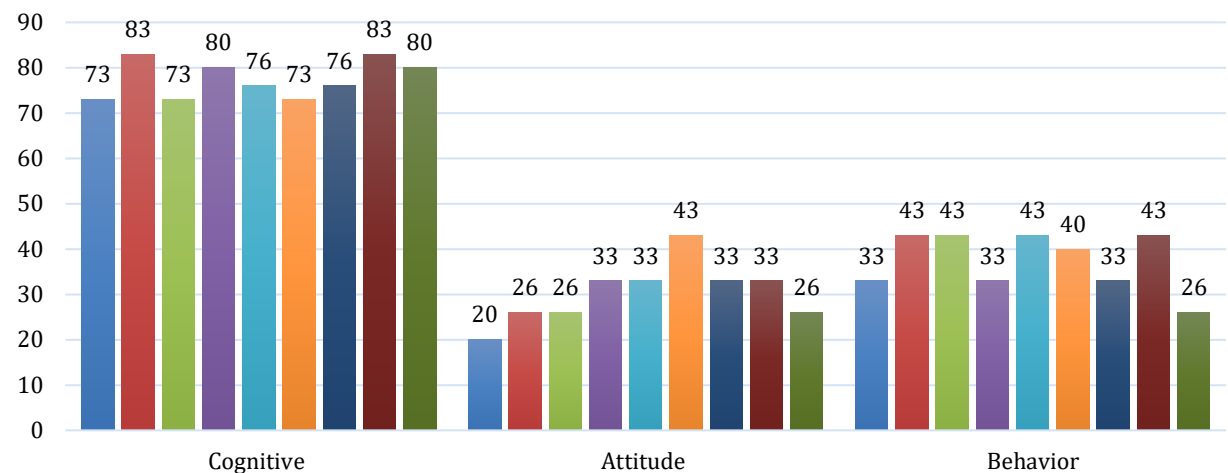


Figure 2. Distribution of Students Across Cognitive, Attitude, and Behavioral Categories

The low biodiversity conservation attitudes and behaviors observed in the nine students can be attributed to the use of a theoretical learning model, limited direct engagement with nature, and insufficient incorporation of real-world environmental issues into the educational framework. This situation led to a significant gap between the cognitive and attitudinal aspects of biodiversity learning. Although students were able to understand the concept of biodiversity theoretically, this knowledge was insufficient to develop a comprehensive ecological awareness and concrete conservation behavior. According to Quijano et al. (2023) and UNESCO (2014), education must be designed holistically, with students' emotional involvement, direct experience in nature, and the integration of relevant, current local issues. If students are not actively involved and directly see the problems in the field, they tend to view biodiversity material as an abstract concept and not as part of everyday life that requires real action.

Another interesting finding from the data analysis was that 12 students (3.40%) scored highly on the attitude and behavior aspects of biodiversity care but low on the cognitive aspect (Figures 3 and 4). Students' attitudes of caring for biodiversity include feeling more comfortable on the coast than in the city and committing to protecting coastal biodiversity. Meanwhile, caring for biodiversity involves obeying local coastal regulations and signing petitions to protect biodiversity.

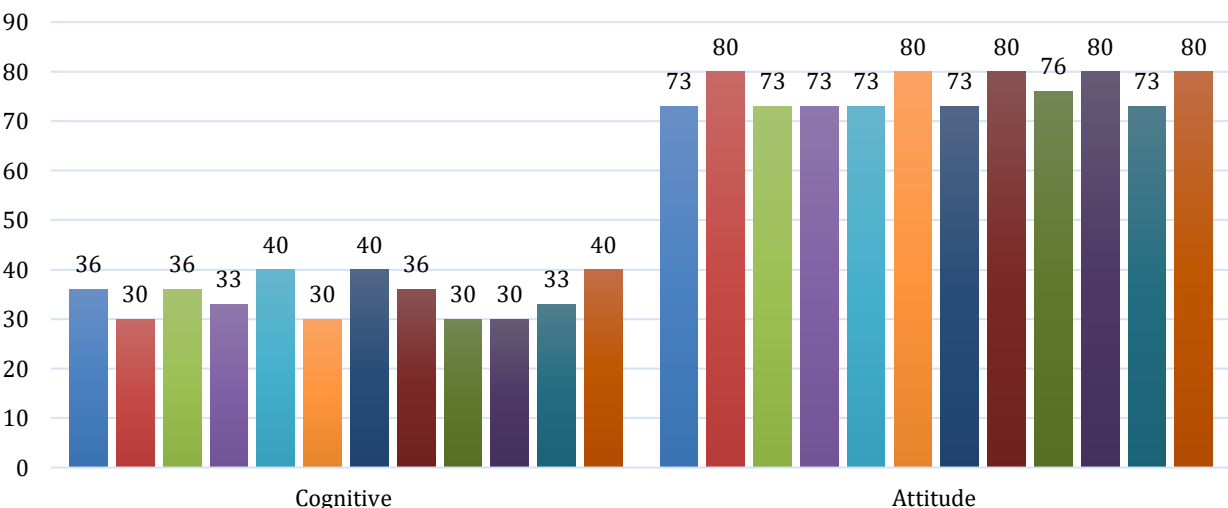


Figure 3. Distribution of Students by Cognitive and Attitude Categories

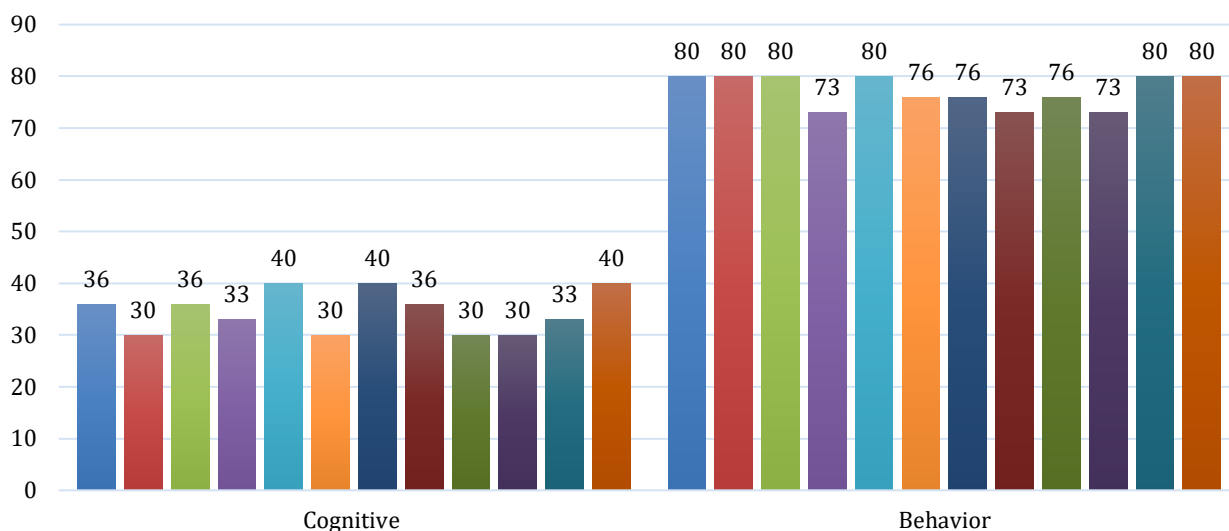


Figure 4. Distribution of Students by Cognitive and Behavioral Categories

Factors contributing to students' concern for biodiversity include childhood experiences (Evans and Achiam, 2021), school-based nature learning (Boeve-de Pauw and Van Petegem, 2018), and direct experience (Liefländer and Bogner, 2018). Currently, on Sumbawa Island, the local government is conducting a massive campaign related to biodiversity conservation through face-to-face activities and social media. However, according to Kollmuss and Agyeman (2002); and Rickinson (2001), this emotional awareness does not last long because the information obtained is only superficial and not the result of in-depth analysis. Similarly, Olsson et al. (2016) stated that students can demonstrate concern for environmental issues, but their conceptual knowledge can remain low without a comprehensive approach to sustainable education.

Adnan et al. (2021) indicate that a thorough examination of various categories reveals that enhancing high school students' biology skills requires a learning paradigm aligned with a constructivist approach. The constructivist paradigm asserts that learners actively organize and interpret information, crafting their own understanding in the process. Through this process, learners build their understanding and meaningful concepts by linking new information to their existing knowledge and experiences (Haruthaihanasan, 2010). Constructivist learning highlights the significance of social and cultural interactions in students' cognitive development (Mishra, 2023).

Models that align with constructivist learning theory include project-based learning (PjBL) and problem-based learning (PBL). PjBL is a student-focused learning model in which the teacher serves as a facilitator, designing inquiry-based activities that lead to the production of various products (Chiazzese et al., 2019; Chiu, 2020; Yang et al., 2018). The findings from Gani et al. (2024) indicate that project-based ethnobotanical learning, augmented by augmented reality, can effectively deepen students' understanding of ethnomedicinal practices. The research conducted by Hernawati et al. (2018) indicates that implementing project-based learning can enhance self-efficacy and science process skills in vertebrate zoology education.

The PBL model serves as an educational framework that introduces challenges to learners, facilitating their exploration of problem-solving techniques (Suci et al., 2022). In application, PBL is implemented within educational frameworks to reveal authentic challenges (Orozco & Yangco, 2016). According to findings from 2018-2022, numerous Asian countries have begun adopting the PBL model in their educational practices (Anggraeni et al., 2023). The implementation of the PBL model enables students to enhance their communication skills, cultivate critical thinking and problem-solving abilities, and acquire a solid understanding of biological concepts (Asyari et al., 2016; Deep et al., 2019; Fitriani et al., 2020; Suci et al., 2022).

Furthermore, to enhance students' understanding of biodiversity, educators should leverage local opportunities for biodiversity education (Aripin et al., 2021). The connection between local wisdom and the SDGs is significant in pursuing a sustainable environment. Local wisdom includes the knowledge, practices, and values that have evolved over generations through empirical observation, playing a crucial role in defining the identity of local communities. (Hasriyanti et al., 2021; Lestari et al., 2024; Mazzocchi, 2020; Sandoval-Rivera, 2020). Integration of local knowledge in the education and

governance sectors is crucial to achieving inclusive and sustainable societal transformation (Assefa et al., 2025). Local knowledge can provide relevant context in science learning, especially for students who live in the local area (Zidny et al., 2021).

Indonesia possesses distinctive local wisdom and embodies environmental conservation values that are significant and applicable in daily life (Febrian et al., 2024; Sriyati et al., 2021). The incorporation of local wisdom into educational activities helps impart concepts, enhance critical thinking skills, and foster character values rooted in local traditions that reflect the nation's identity (Sakti et al., 2024; Zahroh et al., 2022).

CONCLUSION

This study describes the biodiversity literacy profile of 535 high school students in coastal areas of Sumbawa Island, Indonesia, across cognitive, attitude, and behavioral dimensions. Overall, students' biodiversity literacy was classified as moderate across all three dimensions. The cognitive dimension consisted of 65 students (12.15%) in the high category, 384 (71.78%) in the moderate category, and 86 (16.07%) in the low category. For the attitude dimension, 63 students (11.78%) were classified as high, 415 (77.57%) as moderate, and 57 (10.65%) as low. For the behavioral dimension, 76 students (14.21%) were classified as high, 399 (74.58%) as moderate, and 60 (11.21%) as low. The observed variation across the three dimensions indicates that cognitive understanding, attitudes, and reported conservation behaviors do not necessarily develop uniformly among students. However, because this study employed a descriptive survey design, it does not establish causal relationships or statistically determine correlations among the three dimensions. The findings, therefore, provide a descriptive profile of biodiversity literacy rather than direct evidence of SDGs achievement. From an educational perspective, the findings highlight the potential importance of contextual, experiential, and locally relevant biodiversity learning within Education for Sustainable Development. Future research should examine the effectiveness of specific instructional approaches, including project-based, problem-based, and local-wisdom-based learning, through appropriate intervention designs and should further investigate relationships among cognitive, attitudinal, and behavioral dimensions.

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