Development of a Science Literacy–Based Teaching Module on Biodiversity for Grade X Students at MAS Darul Ihsan Aceh Besar

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Abstract: The low level of scientific literacy among Indonesian students, as reflected in the results of the Programme for International Student Assessment (PISA), highlights the need for innovative learning strategies that connect biological concepts with real-life phenomena. One alternative is the development of a science literacy–based teaching module. This study aims to develop a teaching module on biodiversity for Grade X students at MAS Darul Ihsan Aceh Besar and to evaluate its feasibility in terms of validity, readability, and practicality. The research employed a Research and Development (R&D) approach using the 4D model. The defining stage was carried out through observation and interviews to analyze learning needs. The design stage produced a draft module, which was then validated by subject matter experts, language experts, and media experts. The revised product was subsequently tested on a limited scale with students and teachers. The results showed that the module obtained an average score of 89% for content, 87% for language, and 90% for presentation and graphics, all categorized as "highly feasible." The student readability test yielded an average score of 86% (highly feasible), while the teacher practicality test achieved an average score of 88% (highly practical). These findings indicate that the developed module is theoretically valid, practically applicable, and supports contextual learning aligned with the Merdeka Curriculum. In conclusion, the science literacy–based teaching module on biodiversity is considered feasible as an alternative learning resource that can enhance students' scientific literacy skills, critical thinking, and ecological awareness.

Keywords: Biodiversity; Biology; Instructional development; Scientific literacy; Teaching module

Introduction

Integrate scientific activities such as observing, asking questions, reasoning, experimenting, and communicating learning outcomes (Indrawati et al., 2022; Katil et al., 2021; Hosnan, 2014; Anugrah et al., 2019; Sya'ban & Wilujeng, 2016; Youlida et al., 2021; Yuliati, 2017). This encourages students to construct knowledge through direct experience and connect biological concepts to real-world phenomena.

Previous research supports the urgency of developing such modules. Sufi et al. (2025), Marpaung et al. (2021), and Ivaningtias et al. (2024) found that the use of scientific literacy-based modules improved

students' critical thinking skills and scientific awareness. Dalaila et al. (2022), Illah et al. (2025), Wijaya et al. (2025), and Muzakki et al. (2025). Also reported that scientific literacy-based learning significantly improved biology learning outcomes while fostering positive attitudes toward the environment. Ibrahim et al. (2025), Aqil (2018), Nurhayati (2018), Adipura (2012), Zahra (2019) Hadi et al. (2020) Nofiana et al. (2018) Pratiwi et al., (2019) Saptasari et al. (2019), and Narieswari (2022) added that scientific literacy-based modules help students connect biology material to global issues such as climate change and natural resource conservation, making learning more relevant and meaningful.

In the context of the Independent Curriculum, which emphasizes literacy and numeracy-based learning, scientific literacy-based learning modules also align with the spirit of differentiated learning. This module allows students to learn according to their individual interests, abilities, and pace, while also providing opportunities to explore local issues relevant to their lives. For example, Aceh's biodiversity, such as Sumatran elephants, hornbills, and the Leuser forest, can serve as case studies that encourage student engagement in critical discussions and conservation activities.

Therefore, this research focuses on developing a scientific literacy-based teaching module on biodiversity for grade 10 students at MAS Darul Ihsan Aceh Besar. This research has two main objectives. First, to design and develop a scientific literacy-based teaching module that aligns with student characteristics, curriculum needs, and available local potential. Second, to test the module's feasibility through expert validation and limited trials, resulting in valid, practical, and effective teaching materials for use in learning.

Academically, this research contributes to the growing literature on the development of scientific literacy-based biology learning tools, particularly on biodiversity. It also emphasizes that scientific literacy can be developed not only through specific learning strategies but also through innovative teaching materials that are contextual, structured, and oriented toward strengthening 21st-century skills. Practically, the results of this research are expected to provide tangible benefits for students, teachers, and schools. For students, this module is expected to improve conceptual understanding, critical thinking skills, and ecological awareness. For teachers, this module can serve as an alternative, varied and contextual teaching material to support the learning process. For schools, this module has the potential to strengthen the quality of biology instruction and support the government's scientific literacy program.

Therefore, the research, "Development of a Scientific Literacy-Based Teaching Module on Biodiversity for Grade X Students at MAS Darul Ihsan

Aceh Besar," is relevant and important to implement. This research not only addresses empirical needs in schools but also contributes to national efforts to improve the scientific literacy of Indonesia's young generation.

Method

This research employed a Research and Development (R&D) method with the primary goal of producing a scientific literacy-based teaching module on biodiversity and testing its feasibility. The development model used was the 4D model developed by Thiagarajan, which includes four stages: Define, Design, Develop, and Disseminate. The definition stage was conducted to analyze needs through initial observations and interviews with biology teachers at MAS Darul Ihsan Aceh Besar to identify learning challenges, student characteristics, and limitations of available teaching materials. Next, the design stage involved developing an initial draft of the module, including key components such as learning outcomes, objectives, materials, scientific literacy-based activities, and evaluation.

During the development stage, the initial product was validated by subject matter experts, linguists, and media experts to assess aspects of content, language, presentation, and graphics. The validation results served as the basis for revising the module to meet established quality criteria. After being declared valid, the module underwent a limited trial with 10th-grade students at MAS Darul Ihsan Aceh Besar to assess readability and practicality. The readability test was conducted by asking students for feedback on the clarity of the content, ease of understanding, and the module's appeal. The practicality test was conducted through a questionnaire completed by biology teachers regarding the module's ease of use in the learning process. The final stage was dissemination, which involved limited implementation of the module in the target classes as a form of field testing.

The study population was all 10th-grade students at MAS Darul Ihsan Aceh Besar, while the sample was determined using purposive random sampling involving two classes, each with 30 students. The research instruments included an interview questionnaire, an expert validation sheet, a readability questionnaire, and a practicality questionnaire. The data obtained were analyzed descriptively and quantitatively to determine the module's validity, readability, and practicality. Eligibility criteria were determined based on the average scores from the validators and respondents, which were then interpreted into categories of very appropriate, appropriate, fairly appropriate, or not appropriate. Thus, this methodology

is designed to produce teaching modules that are valid, practical, and relevant to the needs of biology learning based on scientific literacy.

Results and Discussion

This research resulted in a scientific literacy-based teaching module on biodiversity designed for 10th-grade students at MAS Darul Ihsan Aceh Besar. The module was developed through a Research and Development process using the 4D model (Define, Design, Develop, and Disseminate). The definition phase revealed that biology learning in schools is still limited to textbooks, underutilizes the potential of the surrounding environment, and does not optimally develop students' scientific literacy skills. Based on these needs, the researchers designed a module containing learning outcomes, concept maps, material descriptions, scientific literacy-based activities, practice questions, and evaluations linked to real-world phenomena.

During the development phase, the module was validated by three groups of experts: material experts, language experts, and media experts. The validation results showed an average score of 89% for content, 87% for language, and 90% for presentation and graphics, all of which fall into the "very appropriate" category. This demonstrates that the module's material aligns with the curriculum, is scientifically accurate, easy to understand, and has an attractive and systematic presentation. After minor revisions based on validator feedback, the module was piloted with students.

The readability test involving 10th-grade students showed an average score of 86%, categorized as "very feasible." Students assessed the module as easy to understand, with a coherent flow of material, and activities that encouraged critical thinking, connecting concepts to their surroundings, and engaging in group discussions. Some students suggested a greater variety of practice questions, but overall, they found the module's contextual nature helpful.

Furthermore, the practicality test, conducted through a biology teacher questionnaire, yielded an average score of 88%, categorized as "very practical." Teachers assessed the module as facilitating the learning process because it included instructions, concept maps, and clear evaluations. The module was also deemed relevant to local environmental issues, particularly those related to biodiversity in Aceh, making it a suitable alternative teaching material to support the implementation of the Independent Curriculum.

Overall, the results of this study indicate that the developed scientific literacy-based teaching module is highly feasible and practical for use in biology learning. The module not only helps improve understanding of the concept of biodiversity, but also contributes to

training students' scientific thinking skills, ecological awareness, and scientific literacy in the 21st century.

Table 1. Student Ability

Student Initials	Pretest Score	Posttest Score	Category
NS	79	93	Very Good
NR	67	79	Good
PAZ	84	99	Very Good
QS	75	88	Very Good
RN	85	100	Very Good
SS	75	88	Very Good
SN	80	94	Very Good
SS	80	94	Very Good
SH	84	99	Very Good
SAP	72	85	Very Good
SZF	67	79	Good
SW	84	99	Very Good
TN	83	99	Very Good
YN	82	96	Very Good
ZM	81	95	Very Good
ZH	83	98	Very Good
ZN	80	94	Very Good
ZH	82	96	Very Good
ZM	71	83	Very Good
ZZ	77	91	Very Good

Table 2. Results of Expert Validation, Readability Test, and Practicality Test of the Teaching Module

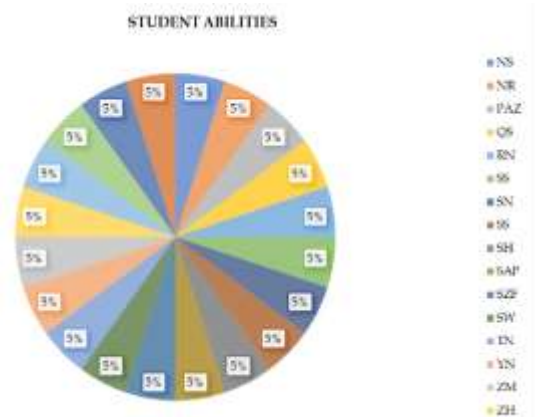| Aspects	Score (%)	Category
Content Expert Validation	89	Very Worthy
Linguist Validation	87	Very Worthy
Presentation and Graphics Expert Validation	90	Very Worthy
Student Readability Test	86	Very Worthy
Teacher Practicality Test	88	Very Worthy

Figure 1. Science literacy ability of class X students of MAS Darul Ihsan Aceh Besar

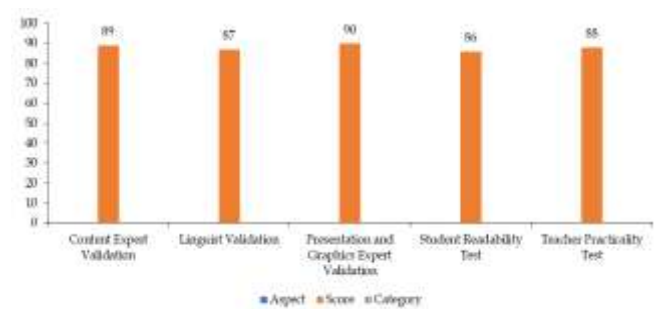**Figure 2.** Student learning outcomes data (pretest and posttest) class X MAS Darul Ihsan Aceh Besar

Figure 3. Student learning outcomes data (Pretest and Posttest) of class X MAS Darul Ihsan Aceh Besar

The bar chart above displays the results of expert validation, readability testing, and practicality testing for the science literacy-based teaching module. This chart allows journal readers to immediately visualize the comparison of scores for each aspect.

Discussion

The results of the study indicate that the scientific literacy-based teaching module on biodiversity was deemed highly appropriate in terms of validity, readability, and practicality. Expert validation showed that the content aspect received a high score, categorized as very appropriate. This demonstrates that the material was designed in accordance with learning outcomes, was conceptually accurate in biology, and relevant to the demands of scientific literacy. This finding aligns with the views of Rahayu (2014) and Sadler et al. (2020), who emphasized that well-structured learning tools facilitate students' understanding of scientific concepts while fostering critical thinking skills and connecting science to real life. Furthermore, validation of the language, presentation, and graphics aspects also received a very appropriate rating, indicating that the module was easy to understand and visually appealing. This supports the opinion of Dale et al. (Abidin, 2020; Deng et al., 2018) that learning texts must be tailored to students' cognitive development to ensure readability and increase learning motivation.

The results of the student readability test showed an average score of 86%, categorized as very

appropriate, indicating that the module was easy to understand and supported independent learning. Scientific literacy-based activities such as observing, asking questions, reasoning, experimenting, and communicating have been shown to encourage active student engagement. This finding is consistent with research by Putri et al. (2023), which showed that scientific literacy-based teaching materials can improve students' critical thinking skills and scientific awareness. With a contextual approach, students not only master theory but also connect biological concepts to real-world phenomena in their environment, including biodiversity and conservation issues. This is important considering that one of the weaknesses of biology learning in Indonesia is the dominance of memorization and students' low ability to connect concepts to empirical reality (Yulianti & Suparmi, 2023; Ivaningtias et al., 2024; Situmorang, 2016; Parisu et al., 2025; Syafa'madani & Puspitawati, 2025).

In terms of practicality, teachers gave an average score of 88%, which is considered very practical. The module is considered to facilitate teachers' learning because it is equipped with instructions, concept maps, and systematic evaluation. Furthermore, the module also helps create contextual learning, in line with the spirit of the Independent Curriculum, which emphasizes literacy, numeracy, and differentiation. These findings support the research of Dalaila et al. (2022), Wijaya et al. (2021), Saija et al. (2022), Mabrura et al. (2022), Argiyanti et al. (2024), and Shahida et al. (2021) stated that scientific literacy-based modules are an alternative learning medium that is practical, engaging, and relevant to students' needs. These modules also facilitate teachers in developing varied learning by utilizing local potential, particularly Aceh's rich biodiversity, as study material.

The success of these modules is also influenced by the integration of local issues in the material development. For example, Aceh's biodiversity, including the Leuser forest ecosystem and endemic fauna, is presented as a case study, thus enhancing meaningful learning. This aligns with the theory of contextual teaching and learning (Johnson, 2017), which emphasizes the importance of connecting learning materials with real-life experiences so that students can internalize knowledge more deeply. Thus, the modules function not only as sources of information but also as ecological educational tools that foster awareness of environmental conservation.

Overall, this research demonstrates that the scientific literacy-based learning modules developed are not only theoretically valid but also practical and effective for use in biology learning. The module's strength lies in its ability to integrate biodiversity material with real-life contexts, thereby enhancing

students' scientific literacy skills and ecological awareness. Thus, the results of this study strengthen previous findings (Wijaya & Safitri, 2021; Yulianti & Suparmi, 2023) that innovation in contextual teaching materials based on scientific literacy can be a strategic solution in improving the quality of biology learning in secondary schools and addressing the challenge of low scientific literacy of Indonesian students as reflected in the PISA results (OECD, 2023).

Conclusion

This research successfully developed a scientific literacy-based teaching module on biodiversity for 10th-grade students at MAS Darul Ihsan Aceh Besar using the 4D development model. Validation results indicated that the module was highly feasible in terms of content, language, presentation, and graphics, with an average score above 85%. The student readability test also categorized it as highly feasible, meaning the module was easy to understand, engaging, and supported independent learning. Meanwhile, the practicality test involving teachers resulted in a highly practical category, as the module was proven to assist teachers in developing contextual, systematic, and relevant learning in accordance with the Independent Curriculum. The main advantage of this module lies in its integration of biodiversity material with local contexts and real-world phenomena, thereby enhancing students' scientific literacy skills, critical thinking, and ecological awareness. Therefore, this teaching module is deemed valid, practical, and effective as an alternative teaching material in biology lessons in secondary schools.

Conflicts of Interest
All author declares that there is no conflict of interest.

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