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Dayak Ethnobotanical Knowledge in Biodiversity Learning: Development and Evaluation of Ethnobotany-Based Teaching Materials

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Abstract: Biodiversity learning in senior high schools is often abstract and weakly connected to students local socio-ecological realities. Local ethnobotanical knowledge can provide a contextual basis for more meaningful biodiversity learning. This study aimed to develop and evaluate Dayak ethnobotany-based biodiversity teaching materials for Grade X students. The study used a Research and Development design with the ADDIE model. The participants were 23 tenth-grade students from one intact class and two biology teachers at SMA Negeri 1 Uut Murung, Central Kalimantan, Indonesia. The student sample represented a limited field trial to examine the feasibility and initial effectiveness of the product in a real classroom context. Data were collected using expert validation sheets, teacher and student response questionnaires, and learning outcome tests with a one-group pretest-posttest design. Product validity using Gregory's formula obtained a score of 1.00, indicating very high validity. Practicality scores reached 95,5% from teachers and 91,5% from students. Learning outcomes increased from 47.25 to 89.86, with an N-Gain score of 0.83, categorized as high. The greatest improvement occurred in students cognitive understanding of biodiversity, especially its relationship with the local environment and local wisdom-based in conservation. Thus, the teaching materials are valid, practical, and effective for contextual biodiversity learning.

Keywords: ADDIE model; Biodiversity teaching materials; Contextual learning; Dayak ethnobotany; Local wisdom

Introduction

Biodiversity learning at the senior high school level often emphasizes the delivery of abstract concepts that are insufficiently connected to students' ecological realities. This condition creates a gap between conceptual understanding and real-life experiences, making it difficult for students to construct meaningful and contextual knowledge of biodiversity. Previous studies on contextual learning and culturally responsive science learning emphasize that connecting scientific concepts with students' real-world and cultural experiences can enhance conceptual understanding, learning engagement, and cultural awareness (Kamila et al., 2024; Rahmawati et al., 2020). However, in many educational contexts, biodiversity instruction still relies heavily on textbook-based explanations that are detached from students' immediate environments.

This issue become more critical in remote regions such as Uut Murung District in Central Kalimantan, where students live in close interaction with biodiverse environments but have limited access to contextual biology teaching materials. Although the region possesses rich biodiversity and ecological resources, these local potentials have not been optimally utilized as learning resources in school biology education, a condition that is consistent with the need for science teaching materials integrated with local potential

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(Kamila et al., 2024). Indonesia itself is recognized as one of the world's megabiodiversity countries, hosting extraordinary species richness and ecological diversity that can serve as valuable contextual learning resources (Díaz et al., 2020). According to the Ministry of Environment and Forestry the Republic of Indonesia (KLHK, 2022), Indonesia's biodiversity requires conservation efforts that involve education and local community participation. Nevertheless, the integration of local ecological knowledge into formal science education remains limited. Central Kalimantan, particularly the tropical rainforest ecosystem of Uut Murung District, represents a living environment characterized by high species diversity and long-standing interactions between local communities and their natural surroundings. These interactions have shaped the development of indigenous knowledge systems of the Dayak community, especially in the utilization of plants for various purposes such as food sources, traditional medicine, ritual practices, and construction materials (Hadi et al., 2023; Az-Zahrah et al., 2021).

These indigenous knowledge systems are currently facing significant challenges. Environmental pressures such as deforestation and forest degradation threaten the sustainability of biodiversity and the cultural knowledge associated with it (Margono et al., 2014). In addition, social transformation and modernization have gradually altered the transmission patterns of traditional knowledge, causing younger generations to become increasingly detached from local cultural practices. Ethnobotanical knowledge that was once embedded in everyday life is now at risk of fragmentation or even disappearance if it is not properly documented and integrated into formal educational contexts (Amir & Soendjoto, 2018; Abas et al., 2022; Malapane et al., 2022). Therefore, integrating indigenous knowledge into science education represents a strategic effort to preserve cultural heritage while simultaneously enhancing the relevance of learning.

From a scientific perspective, ethnobotany provides a bridge between local knowledge and biodiversity concepts. It contains ecological, cultural, and conservation values that are closely related to students' daily lives. Through ethnobotanical examples, students can better understand the relationship between humans, plants, and environment (Lira et al., 2023). Integrating ethnobotany into biodiversity learning therefore allows students to understand biodiversity not only as a biological classification system but also as a complex system involving ecological functions, economic value, and socio-cultural significance (Ridwan et al., 2023). This perspective aligns with the principles of contextual learning and place-based education, which position the local environment as a primary learning resource and emphasize the importance of connecting scientific concepts with students' lived experiences. Several studies have demonstrated that contextual, culturally responsive, ethnoscience-oriented and place-based learning approaches can enhance science learning by connecting concepts with students' cultural and environmental experiences (Syamsiah et al., 2021; Arifin et al., 2024; Fitri et al., 2024; Rahmawati et al., 2020). In addition, learning approaches that incorporate local wisdom have been shown to facilitate the internalization of cultural values and strengthen students' understanding of environmental issues (Maharani & Muhtar, 2022).

Despite these potentials, the learning context at SMA Negeri 1 Uut Murung indicates that biology teaching materials are still dominated by general national textbooks that do not adequately accommodate local ecological potential as a learning resource. Based on preliminary observations and interviews with biology teachers at SMA Negeri 1 Uut Murung, students were familiar with several local plants in daily life but still had difficulty relating them to scientific concepts of biodiversity. Teachers also reported that the available teaching materials rarely presented examples of Dayak ethnobotanical knowledge from the students' surrounding environment. As a result, the connection between biodiversity concepts and students' real environments remains weak, and learning tends to be predominantly textual rather than experiential and contextual.

Previous studies have shown that systematically developed local wisdom-based teaching materials can improve the relevance and effectiveness of biology learning (Ramdiah et al., 2020; Sriyati et al., 2021; Suryanti et al., 2020). However, such teaching materials remain limited, particularly those integrating ethnobotanical knowledge from indigenous communities in remote educational contexts. Although ethnobotany has been widely studied in terms of its cultural and ecological significance, most studies focus primarily on documenting traditional knowledge rather than translating it into structured instructional materials for formal education. Similarly, research on contextual science learning has demonstrated its effectiveness in improving students' conceptual understanding, yet relatively few studies have integrated local wisdom knowledge into biodiversity teaching materials within a systematic instructional design framework. Consequently, the potential of ethnobotanical knowledge as a pedagogical resource in formal biology education remains under explored, particularly in remote high school contexts where indigenous knowledge systems are still actively practiced.

In response to these issues, this study focuses on developing Dayak ethnobotany-based biodiversity teaching materials and evaluating their feasibility and effectiveness in supporting contextual biology learning. This study emphasizes the transformation of Dayak ethnobotanical knowledge from local ecological practices into structured teaching materials for senior high school biodiversity learning. Unlike previous ethnobotanical studies that mainly documented plant uses and local ecological knowledge, this study further evaluates the validity, practicality, and effectiveness of the developed materials in classroom learning, as commonly emphasized in instructional development research (Arifin et al., 2024; Musdalifah et al., 2024). By integrating contextual learning principles with indigenous knowledge systems, this study bridges scientific concepts with students' socio-ecological realities. The findings are expected to contribute to culturally contextualized biodiversity education, particularly in a remote school context where indigenous knowledge is still closely connected to students' daily lives.

Method

Research Design

This study employed a Research and Development using the ADDIE instructional design model proposed by Branch (2009). The ADDIE model consists of five stages: analysis, design, development, implementation, and evaluation.The research flow is presented in figure 1.

The analysis stage included needs analysis, curriculum analylisis, material characteristic analysis, and learning resource potential analysis. The design stage involved preparing the structure, content, learning activities, assessment instruments, and visual layout of the teaching materials. The development stage included product development, and expert validation. The implementation stage was conducted through a limited field trial involving 23 Grade X students and two biology teachers at SMA Negeri 1 Uut Murung. The evaluation consisted of formative and summative evaluation to determine the feasibility, practicality, and effectiveness of the developed teaching materials..

Although this design has limitations in controlling external variables and establishing causal inference, it is widely used in the preliminary stage of effectiveness testing in educational development research conducted in authentic classroom contexts. Each stage was conducted systematically to ensure that the developed teaching materials were aligned with students' needs, curriculum reruirements, local ethnobotanical potential, and classroom implementation conditions.

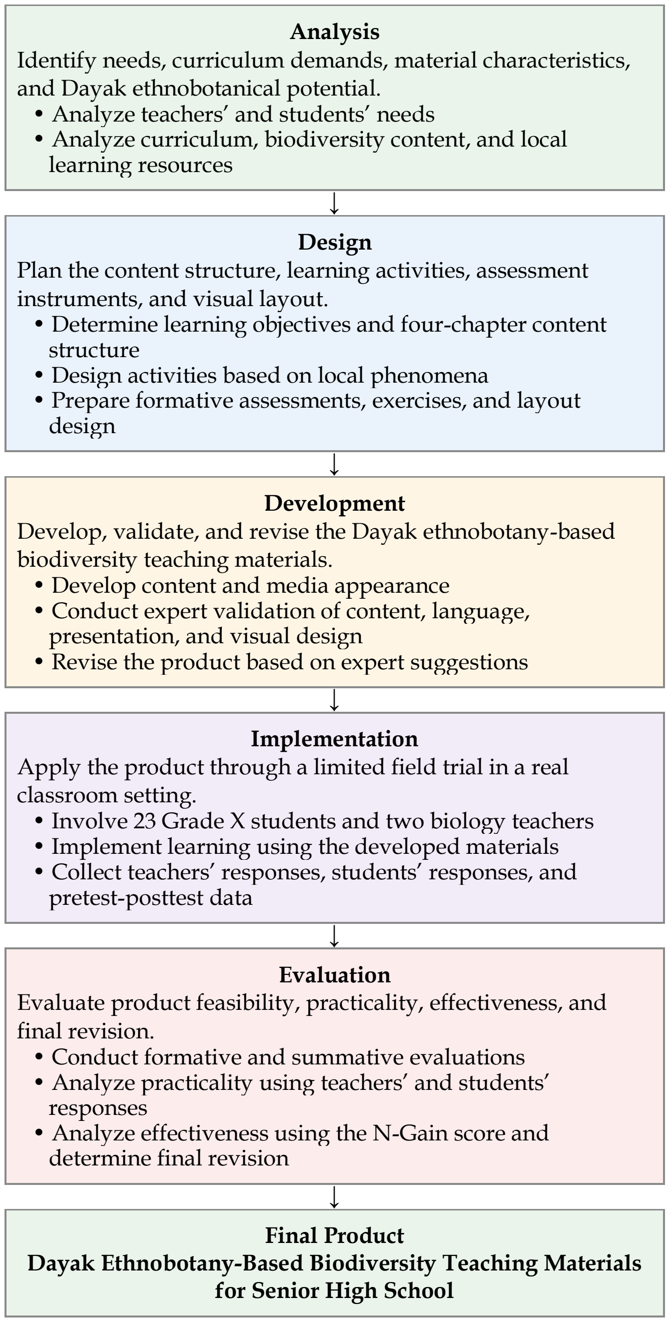

Figure 1. Development procedure of ethnobotany-based biodiversity teaching materials using the ADDIE instructional design model

Instrument

The instruments used in this study were designed to evaluate the validity, practicality, and effectiveness of the developed biodiversity teaching materials. Four types of instruments were employed, namely expert validation sheets, teacher response, student response questionnaires, and learning outcome tests.

Table 1. Indicators of Research Instruments

Aspect	Indicators
Teaching material validation	Instructions, material presentation, material completeness, visual design, appeareance and language clarity
Practicality (teachers' response)	Content coverage and accuracy, insight enrichment, physical appearance and writing criteria
Practicality (students' response)	Content coverage, presentation, language clarity, and graphic design
Effectiveness	Conceptual understanding, level, benefits of biodiversity, and biodiversity conservation

Data Analysis Techniques

Data were analyzed quantitatively and supported by descriptive qualitative analysis to comprehensively describe the quality of the developed teaching materials.

Validity of Teaching Materials

The validity of the research instruments was evaluated through expert validation sheets involving two experts in biology education. The experts validation used a four-point relevance scale, ranging from 1= irrelevant to 4 = highly relevant. Before applying Gregory's formula, scores of 1-2 were classified as weak relevance, while scores of 3-4 were classified as strong relevance. The recognized scores were then entered into a 2 x 2 agreement matrix to determine the content validity index, as recommended in content validity analysis procedures (Gregory, 2007; Retnawati; 2016). The content validity of the teaching materials was analyzed using Gregory's formula:

$$V = \frac{D}{A+B+C+D} \quad (1)$$

Where V is the content validity index, A indicates that both validators rated the item as weakly relevant, B indicates that the first validator rated the item as strongly relevant while the second validator rated it as weakly relevant, C indicates that the first validator rated the item as weakly relevant while the second validator rated it as strongly relevant, and D indicates that both validators rated the item as strongly relevant.

Practicality of Teaching Materials

The practicality of the teaching materials was measured through teacher and student response questionnaires. The data were analyzed using the average percentage score, calculated using the following formula:

$$\%R = \frac{\text{Score obtained}}{\text{Maximum score}} \text{ X } 100\% \quad (2)$$

where %R represents the practicality percentage, the obtained score refers to the total score from the response questionnaire, and the maximum score refers to the highest possible score.

The practicality scores were interpreted using categorical intervals ranging from very practical to not practical. This interpretation is consistent with previous educational product development studies that classified practicality based on teacher and student response questionnaires (Ambarwati & Wilujeng, 2023; Salsabilla et al., 2024).

Effectiveness of Teaching Materials

The effectiveness of the teaching materials was measured using the Normalized Gain (N-Gain), calculated based on the comparison between pretest and posttest scores:

$$g = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maksimum Score} - \text{Pretest Score}} \quad (3)$$

Where g is the N-Gain score, posttest score is the score obtained after using the teaching materials, pretest score is the score obtained before using the teaching materials, and maximum possible score. The results were classified into three categories: High ($g > 0.7$); Medium ($0.3 < g \leq 0.7$); Low ($g \leq 0.3$), following Hake's normalized gain classification (Hake, 1998).

Result and Discussion

Needs Analysis and Design of Teaching Materials

The analysis stage in the ADDIE model aims to identify learning needs, curriculum alignment, material characteristics, and relevant local potential as the foundation for developing teaching materials. The results of observations indicate that biodiversity learning at SMA Negeri 1 Uut Murung is predominantly based on general national textbooks that do not sufficiently connect biological concepts with students' surrounding environmental context. As a result, biodiversity learning tends to be abstract and less meaningful for students.

This condition indicates a gap between scientific concepts and students' real-life experiences, which may hinder the development of conceptual understanding. Similar findings have been reported in contextual learning research, which emphasizes that the integration of real-world experiences into science learning can enhance students' conceptual understanding and learning engagement (Podschuweit & Bernholt, 2018; Riza et al., 2024). Furthermore, the limited exploration of local phenomena may reduce students' cognitive engagement during the learning process.

The analysis of content characteristics indicates that biodiversity is inherently both conceptual and contextual, encompassing genetic diversity, species diversity, and ecosystem diversity. These characteristics require instructional strategies that not only explain theoretical concepts but also relate them to authentic ecological contexts. In this regard, the integration of ethnobotany becomes highly relevant, as it provides real-life examples that facilitate students' understanding of biodiversity concepts.

Table 2. Characteristics of Biodiversity Content and Implications for Teaching Material Development

Content Area	Core Concept and Learning Demand	Implications for Teaching Materials
Biodiversity Concept	Variation of living organisms; understanding	Conceptual definitions accompanied by examples of local species
Levels of Biodiversity	Genetic, species, and ecosystem variation; classifying and analyzing	Case studies of local flora and ecosystems
Benefits of Biodiversity	Economic, ecological, and social values; evaluating	Examples of Dayak ethnobotanical utilization
Biodiversity Conservation	Conservation and sustainability; applying problem-solving	Environment-based conservation projects

The results indicate that biodiversity content strongly supports the application of contextual learning approaches. The integration of ethnobotany provides concrete examples of species diversity and plant utilization within local communities, enabling students to connect scientific knowledge with everyday experiences. Such contextual learning environments have been shown to facilitate deeper conceptual understanding and promote active knowledge construction (Chi & Wylie, 2014; Podschuweit & Bernholt, 2018; Riza et al., 2024).

In addition, the ethnobotanical potential analysis identified 16 local plant species with educational value. These species were categorized based on their functions as medicinal plants, food sources, ritual materials, and construction materials. This classification demonstrates that biodiversity holds not only ecological value but also socio-cultural significance within local communities. These findings are supported by previous ethnobotanical studies indicating that plant utilization practices among Dayak communities reflect adaptive ecological relationships and resource management (Az-Zahrah et al., 2021; Amir & Soendjoto, 2018; Supiandi et al., 2023). Thus, the analysis stage confirms that ethnobotany-based contextual teaching materials are necessary to bridge the gap between abstract scientific concepts and students' local environmental realities.

The design stage aims to transform the results of the analysis into a systematic instructional framework that includes the structure of teaching materials, content structure, presentation strategies, learning activities, and intended learning outcomes. This stage also involves the preparation of evaluation instruments based on aspects of content feasibility, language clarity, presentation quality, and alignment with the selected learning approach (Martatiyana et al., 2023).

The developed teaching materials were designed in the form of a supplementary book that positions ethnobotany as the primary conceptual framework rather than merely an additional illustration. This design integrates scientific biodiversity concepts with students' socio-ecological contexts. The instructional design is grounded in the principles of contextual learning and place-based education, which emphasize the use of the local environment as the primary source of learning (Lave & Wenger, 1991; Sobel, 2004). From a cognitive perspective, the design also aligns with the ICAP framework (Interactive–Constructive–Active–Passive), which emphasizes that deeper learning occurs when students actively construct knowledge through meaningful interaction (Chi & Wylie, 2014). Through exploration, analysis, and reflection activities based on local environmental phenomena, the teaching materials are designed to promote deeper conceptual understanding.

Furthermore, the integration of Teaching at the Right Level (TaRL) and Culturally Responsive Teaching (CRT) strengthens the relevance of learning by adaptingmaterial complexity and incorporating students' cultural backgrounds into the learning process (Gay, 2010). Consequently, the design of the teaching materials is not only oriented toward conceptual mastery but also toward the development of ecological awareness and cultural identity.

The teaching materials are organized into four chapters that cover the concepts of biodiversity, Dayak ethnobotany in Central Kalimantan, biodiversity conservation and local wisdom, and contextual case study and exercises. Each chapter presents contextual introductions, conceptual explanations, local phenomenon-based activities, summaries, and formative assessments. This organization is designed to encourage students to engage in higher-order thinking processes through discussion, reflection, and contextual problem-solving.

Validation of Teaching Materials

A detailed description of the developed materials is presented in figure 2 – 5, while the validation results presented in Table 4 indicate that the developed teaching materials achieved very high validity with a content validity index of CV = 1.00. This result suggests that the materials meet the criteria of content accuracy, presentation quality, visual design, and language appropriateness.

The developed teaching materials were designed to present biodiversity through the integration of visual identity, conceptual explanations, observation-based activities, and Dayak ethnobotanical content. Figure 2 shows the cover, which introduces the local and ecological orientation of the material through natural visual elements. Figure 3 presents biodiversity concepts through local examples and reflective questions, while Figure 4 provides activities that guide students to observe, identify, and classify biodiversity in their surrounding environment. Figure 5 illustrates the integration of Dayak ethnobotanical knowledge through gulinggang or ketapang cina (Cassia alata L.), including its scientific name, local name, ecological characteristics, medicinal uses, and traditional utilization. This structure was intended to make biodiversity learning more concrete by connecting scientific concepts with local plants and students' everyday environmental experiences. This is consistent with Nurdiana et al. (2024), who showed that ethnobotanical studies of local plant use can be developed as relevant biology learning resources, particularly for biodiversity-related materials.

The use of local examples and observation-based activities is pedagogically important because contextual learning resources allow students to construct scientific meaning from ecological and cultural situations that are familiar to them. In this regard, Suciyati et al. (2021) emphasized that the integration of ethnoscience in biology learning can strengthen the contextuality and meaningfulness of learning by connecting biological concepts with local knowledge and students' lived experiences. Similarly, Zulharman et al. (2023) demonstrated that ethnobotany-based materials can support science learning because they present biological concepts through plant utilization practices that are culturally and ecologically relevant to learners. These findings support the idea that biodiversity teaching materials should not only present taxonomic or conceptual information, but also provide opportunities for students to relate biological concepts to the plants, practices, and environmental phenomena found in their own communities.

Figure 2. Cover

Figure 3. Examples of biodiversity content

Figure 4. Examples of student activity

Figure 5. Examples of Dayak ethnobotanical content

Furthermore, the inclusion of observation-based activities reflects the principle that science learning becomes more effective when students are actively involved in investigating real objects and environmental phenomena. Experiential learning enables students to develop understanding through direct experience, reflection, and conceptual interpretation rather than through textual explanation alone. Susiloningsih et al. (2023) reported that experiential learning in science supports the achievement of learning objectives by engaging students in active and reflective learning processes. In line with this, Anwar et al. (2024) showed that environmental issue-based learning can improve students' environmental literacy and data interpretation competence, indicating that learning activities connected to real environmental contexts can strengthen both conceptual and analytical skills. Therefore, the figures demonstrate that the developed materials are not merely visually attractive, but are pedagogically structured to support contextual, active, and culturally relevant biodiversity learning.

Table 3. Results of Expert Validation

Aspect	CV	Category
Instructions	1.00	Very High
Content Presentation	1.00	Very High
Content Completeness	1.00	Very High
Visual Design	1.00	Very High
Language	1.00	Very High
Total	1.00	Very High

Expert validation plays an essential role in ensuring the academic and pedagogical quality of instructional materials. The developed materials can be evaluated not only for scientific accuracy but also for their instructional relevance, readability, visual clarity, and suitability for students' learning characteristics. Previous studies have shown that the validation process is important in the development of teaching materials because systematic expert feedback helps improve content organization, language clarity, presentation, and alignment between learning objectives, materials, and assessment components (Ivaningtias et al., 2024). In this study, feedback from expert validators contributed to improvements in linguistic clarity, consistency of terminology, visual presentation, and the contextual relevance of Dayak ethnobotanical examples.

The high validity of the developed materials is also supported by their integration of local knowledge with scientific biodiversity concepts. Previous studies reported that learning resources developed from Dayak ethnobotanical knowledge achieved high levels of validity and feasibility because they systematically connected local biological knowledge with biology and biodiversity learning (Saputri et al., 2024; Sunarya et al., 2024). In addition, local wisdom-based biodiversity teaching materials have also been shown to be valid and feasible for supporting contextual biology learning (Ivaningtias et al., 2024; Apriansyah et al., 2024). Similarly, Ramdiah et al. (2020) showed that local wisdom-based biology teaching materials can achieve strong validity when they are developed based on students' needs, curriculum requirements, and local environmental contexts. These findings strengthen the present result, indicating that Dayak ethnobotanical knowledge can be transformed into valid instructional materials when it is organized scientifically and pedagogically.

The validation result confirms that ethnobotany-based teaching materials are not only culturally relevant but also academically feasible for formal biology learning. The inclusion of local plant utilization, conservation practices, and socio-ecological contexts helped make the biodiversity content more meaningful and contextual. Thus, the validation process ensured that the developed materials were appropriate for supporting contextual biodiversity learning before being implemented in the classroom.

Practicality of Teaching Materials

The practicality test results (Tables 5 and 6) indicate that the developed teaching materials received highly positive responses from both teachers and students. The average scores of teachers' responses were 95.5%, while students' responses reached 91.5%, both categorized as very positive. These results show that the teaching materials were easy to use, clearly organized, visually appropriate, and relevant to the learning context at SMA Negeri 1 Uut Murung.

Table 4. Teacher Responses to the Teaching Materials

Indicator	Percentage (%)	Category
Content coverage	97	Very Positive
Content accuracy	92	Very Positive
Content currency	100	Very Positive
Insight enrichment	100	Very Positive
Physical appearance	93	Very Positive
Writing criteria	91	Very Positive
Overall Score	95.50%	Very Positive

Table 5. Student Responses to the Teaching Materials

Indicator	Percentage (%)	Category
Content coverage	93	Very Positive
Presentation	90	Very Positive
Language clarity	89	Very Positive
Graphic design	94	Very Positive
Overall Score	91.50%	Very Positive

Teachers reported that the materials helped them explain biodiversity concepts through contextual examples derived from local Dayak ethnobotanical knowledge. Students also indicated that examples of local plant utilization made the learning content more relatable and easier to understand. These findings suggest that the practicality of the materials was supported not only by layout, language clarity, and ease of use, but also by their cultural and ecological relevance. This is consistent with culturally responsive and contextual learning perspectives, which emphasize that learning becomes more meaningful when instructional materials reflect students' cultural backgrounds, lived experiences, and surrounding environment (Gay, 2010; Suciyati et al., 2021; Rahmawati et al., 2020).

The high practicality scores are also in line with previous studies showing that ethnoscience, local wisdom, and local context-based teaching materials can increase the relevance of science learning and help students connect classroom concepts with daily life. Local-based teaching materials have been reported to support students' scientific reasoning, argumentation, and problem-solving skills because they provide learning contexts that are closer to students' real experiences (Kundariati et al., 2022). Similarly, biology modules developed from local wisdom, such as fish anatomy learning resources based on Ngebel Lake, were considered meaningful because they connected biological concepts with local environmental and cultural contexts (Primiani et al., 2020). In biodiversity learning, local plant biodiversity modules were also developed as an effort to contextualize biodiversity concepts while supporting the conservation of local wisdom (Mumpuni et al., 2020). These findings indicate that learning resources developed from local contexts tend to be easier for students to understand because they provide familiar examples, reduce the abstractness of scientific concepts, and strengthen the relationship between biology learning and students' daily socio-ecological realities (Ramdiah et al., 2020; Hasanah et al., 2018; Sari et al., 2023; Zulharman & Noeryoko, 2023; Kundariati et al., 2022; Primiani et al., 2020; Mumpuni et al., 2020).

Effectiveness of Teaching Materials

The effectiveness test results presented in Table 7 indicate a substantial improvement in students learning outcomes. The mean pretest score was 47.25, while the mean posttest score increased to 89.86. The difference between the two scores was 42.61, and the mean N-Gain score was 0.83, categorized as high. These results demonstrate that the developed teaching materials effectively enhanced students' conceptual understanding of biodiversity.

Table 6. Results of Learning Effectiveness Test

Parameter	Value	Category
Mean pretest score	47.25	Low
Mean posttest score	89.86	High
Difference (Δ)	42.61	-
Mean N-gain	0.83	High
N-gain (%)	82.96%	High

However, the improvement in learning outcomes should not be interpreted solely as an increase in scores. Instead, it reflects a deeper learning process in which students connected scientific concepts with their local environmental contexts. The integration of ethnobotany enabled students to construct knowledge through authentic examples, thereby strengthening cognitive engagement. These findings are consistent with previous studies demonstrating that local wisdom- and ethnoscience-based learning can support meaningful science learning by connecting scientific concepts with students' cultural contexts and improving higher-order thinking and learning outcomes (Maulani et al., 2024; Christiana & Rohaeti, 2024; Ramdiah et al., 2020; Zukmadini et al., 2020; Hasanah et al., 2018).

The improvement in students learning outcomes indicates that contextual materials based on local knowledge can help students connect scientific concepts with familiar socio-ecological experiences. Previous studies have also shown that ethnoscience and local wisdom-based learning resources can support contextual science learning, improve students' engagement, and strengthen higher-order thinking skills (Sari et al., 2023; Zulharman & Noeryoko, 2023; Maulani et al., 2024; Fuadi et al., 2024). Students learned biodiversity not only as a scientific classification system but also as a socio-ecological phenomenon closely related to their daily lives. This approach is aligned with situated learning and place-based education, which emphasize that knowledge construction becomes more meaningful when learning activities are linked to authentic environmental experiences (Lave & Wenger, 1991; Sobel, 2004).

In addition, ethnobotanical knowledge contributes to strengthening students' ecological awareness and understanding of conservation practices because it reflects the adaptive relationships between communities and their natural environments. Previous studies have also shown that indigenous and local knowledge systems play an important role in supporting sustainable biodiversity conservation and environmental management (Ridwan et al., 2023; Az-Zahrah et al., 2021; Sinthumule, 2023). Thus, ethnobotany functions not merely as contextual enrichment but also as a conceptual bridge that integrates scientific, ecological, and cultural dimensions in biology education.

This study contributes to contextualized biology education by demonstrating how Dayak ethnobotanical knowledge can be transformed into structured biodiversity teaching materials and empirically tested in a remote high school context. Unlike ethnobotanical studies that mainly document indigenous plant knowledge, this study organized local ecological knowledge into instructional components and evaluated its validity, practicality, and effectiveness in formal biology learning. From a practical perspective, the developed materials offer an alternative resource for biodiversity learning in schools located in biodiversity-rich environments.

Conclusion

This study developed Dayak ethnobotany-based biodiversity teaching materials for senior high school biology learning. The materials demonstrated strong feasibility, with a content validity index of CV = 1.00, a teacher response score of 95.5%, a student response score of 91.5%, and an N-Gain score of 0.83, categorized as high. These findings show that Dayak ethnobotanical knowledge can be effectively transformed into contextual teaching materials that help students connect biodiversity concepts with local environmental conditions and local wisdom-based conservation practices. Future studies should involve broader samples, different school settings, and additional learning outcomes, such as environmental awareness, critical thinking, and students' long-term conceptual retention

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Author Contributions

Conceptualization, F.M. and H.; methodology, F.M., H., and Hrt..; formal analysis, F.M.; investigation, F.M.; resources, F.M.; data curation, F.M.; writing-original draft preparation, F.M.; writing-review and editing, H. And Hrt.; validation, H. And F.; visualization, F.M.; supervision, H., Hrt., and S.; project administration, F.M.; theoretical framework and biology learning review, S. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. The research was conducted without any commercial or financial relationships that could be interpreted as a potential conflict of interest.

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