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Integration of Minangkabau Ethnoecology in Biology Education: Analysis of Student Needs

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Abstract: This study analyzed high school students' needs regarding the integration of Minangkabau ethnoecology into biology education to support sustainability-oriented learning. Using a mixed-method design, quantitative data were obtained from a validated 20-item Likert-scale questionnaire and qualitative insights were obtained from open-ended questions. The sample involved 666 students from 14 senior high schools in West Sumatra, representing diverse ecological and cultural settings. Statistical analyses—including reliability testing (α = 0.807), normality, homogeneity, and one-way ANOVA—confirmed data consistency and revealed no significant differences among schools (p = 0.085), indicating homogeneous perceptions. Descriptive findings showed high mean scores in learning preferences (M = 4.23), material needs (M = 4.35), and expectations (M = 4.12), reflecting strong demand for contextual and culture-based biology learning. Qualitative responses supported these results, revealing that students linked conservation with traditional practices such as *gotong royong*, *rimbo larangan*, and *lubuk larangan*. These findings highlight the need to design ethnoecology-based biology modules aligned with SDG 4 (Quality Education) and SDG 15 (Life on Land), ensuring culturally grounded and ecologically meaningful science learning.

Keywords: Contextual teaching; Environmental awareness; Local wisdom; Minangkabau ethnoecology; SDGs

Introduction

The rapid transformation of science education in the 21st century has urged educators to recontextualize biology learning toward sustainability and cultural relevance. The United Nations' Sustainable Development Goals (SDGs) emphasize the need for education that cultivates critical, creative, and environmentally responsible citizens (Wibowo & Sadikin, 2019). In biology, this transformation entails shifting from rote content delivery to inquiry- and context-based learning that links scientific principles to students' ecological realities. Recent trends highlight that scientific literacy and environmental awareness can be strengthened through local knowledge and place-based education models that engage learners in authentic socio-ecological contexts (Astuti & Aminatun, 2020; Hartanti et al., 2024; Hermawan et al., 2022) Previous studies have also proven that ethnoscience-based teaching materials effectively improve students' conceptual understanding and learning outcomes through local cultural integration (Fitriani & Setiawan, 2018). Consequently, educational innovation must not only address conceptual understanding but also foster the integration of sustainability, culture, and values in science classrooms.

In Indonesia, biology education remains highly standardized and largely disconnected from students' immediate environment, despite the nation's exceptional biodiversity and cultural diversity. Such detachment often results in low engagement, superficial comprehension, and limited transfer of ecological

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concepts into daily behavior (Dewi et al., 2021; Nurwidodo et al., 2020; Wati et al., 2021). Several studies emphasize that conventional textbook-based learning tends to overlook indigenous ecological wisdom that could contextualize scientific ideas and nurture environmental responsibility (Jannah et al., 2022; Rahayu et al., 2023; Sari et al., 2023). As Indonesia's environmental challenges—such as deforestation, land-use change, and biodiversity loss—become increasingly urgent, embedding cultural and ecological knowledge into the biology curriculum becomes a strategic imperative for education that supports SDG 4 (Quality Education) and SDG 15 (Life on Land).

Despite these potentials, the dominant pedagogical model still prioritizes theoretical abstraction over contextualization. Teachers often lack the materials, training, and frameworks to translate local ecological knowledge into scientific learning resources (Hikmawati, Suastra, et al., 2021; Hikmawati et al., 2021). This results in a persistent gap between students' lived experiences and the biology they learn in school. Efforts to introduce ethnoscience or ethnoecological perspectives have grown in recent years, yet implementation remains fragmented and inconsistent across regions (Ali & Zaini, 2023; Mulatsih et al., 2023; Pratama & Jumadi, 2023). The absence of systematic needs analysis further hinders the design of culturally grounded modules that reflect regional identities while meeting national curriculum standards. Addressing these issues requires a framework that simultaneously validates local wisdom and ensures scientific rigor.

Ethnoecology the study of interactions between people and their environment through culturally embedded practices—offers a promising conceptual bridge between scientific and indigenous ways of knowing. In the context of the Minangkabau community of West Sumatra, ethnoecological systems such as Rimbo Larangan (customary forest sanctuaries), traditional paddy cultivation, and river-based stewardship represent living laboratories for environmental education (Alandra et al., 2018; Chandra et al., 2022; Rohyani et al., 2024). These practices embody ecological ethics and collective management principles that align naturally with modern sustainability concepts (Sedana Arta et al., 2023; Ullah et al., 2017; Utami et al., 2019). Integrating such knowledge into biology lessons can connect scientific theory with cultural experience, enhancing both cognitive mastery and affective engagement. Nevertheless, research specifically analyzing students' needs and perceptions toward such integration in formal education remains limited.

To respond to these challenges, scholars have proposed multiple pedagogical strategies combining ethnoscience principles with modern learning models. Project-based learning (PjBL) frameworks that incorporate ethnopedagogical or ethnoecological contexts have proven effective in fostering higher-order thinking, creativity, and self-regulated learning (Elfrida et al., 2023; Rahayu et al., 2023; Ratna et al., 2025). Similarly, digital e-modules enriched with local wisdom improve motivation, conceptual understanding, and contextual awareness (Fitriani & Hidayat, 2024a; Rofi'i et al., 2022). These innovations indicate that contextualization through indigenous knowledge can strengthen engagement and relevance, yet few studies have systematically assessed learners' readiness and needs for such integration at the secondary-school level. Understanding this need is crucial for designing culturally responsive biology modules that are both pedagogically sound and locally grounded.

At a broader theoretical level, the ethnoscience paradigm redefines science education as a dialogue between traditional ecological knowledge (TEK) and formal scientific inquiry. Scholars argue that integrating TEK encourages intercultural competence, critical reflection, and a sense of reciprocity with nature (Gutiérrez-García et al., 2020). Within this paradigm, learners engage with biodiversity, conservation, and resource-management concepts not as abstract topics but as lived cultural practices. Ethnoecology-based education therefore provides dual outcomes: strengthening scientific literacy and revitalizing cultural identity (Musah & Wangila, 2024; Rexhepi & Bajrami, 2025; Sevilla et al., 2025). By positioning local culture as both content and context, this approach supports inclusive, place-based sustainability learning that aligns with the principles of Education for Sustainable Development (ESD).

Empirical evidence reinforces these theoretical claims. Ethnoscience-oriented modules have consistently improved students' analytical reasoning, creativity, and problem-solving abilities (Koten & Rohaeti, 2024; Sari et al., 2024; Sudarmin et al., 2017). Classroom applications show heightened motivation and conceptual retention when lessons employ locally familiar examples—such as medicinal plants, traditional crafts, or indigenous farming systems (Agesti et al., 2023; Melinia et al., 2024; Ondrada et al., 2024). Studies also note that environmental literacy grows more robustly when students interact with real ecological issues within their cultural landscapes (Hermawan et al., 2022; Nurwidodo et al., 2020). Collectively, these findings suggest that contextualized, culture-based materials can substantially enhance both cognitive and affective learning outcomes, providing a solid foundation for sustainable curriculum reform.

Nonetheless, integrating ethnoecology into formal biology education requires rigorous groundwork through needs analysis, curriculum mapping, and instrument validation. Reliability and validity evidence are critical to ensure that student perception data reflect genuine learning requirements rather than transient attitudes (I. Fitriani & Hidayat, 2024a; Kurnianto & Mundilarto, 2023; Taber, 2018). Previous Indonesian studies on ethnoscience instruments confirm acceptable reliability levels but highlight the need for continuous refinement to accommodate regional variation (Hidayat et al., 2023; Utami et al., 2019; Wardani et al., 2023). Therefore, assessing students' perceived needs for Minangkabau ethnoecology integration becomes a foundational step for subsequent development of validated, effective, and contextually authentic learning modules.

Given these conceptual and empirical foundations, the present study analyzes high-school students' needs for integrating Minangkabau ethnoecology into biology education, particularly within the biodiversity topic. Building on prior works that link ethnoscience to critical thinking and environmental literacy (Dewi et al., 2021; Jannah et al., 2022; Rahman et al., 2023), this research extends the discussion by focusing on a culturally distinct yet ecologically rich region of Indonesia. It provides large-sample quantitative evidence complemented by qualitative insights to capture both cognitive and contextual dimensions of students' perceptions. The results are expected to guide the design of a culturally responsive, sustainability-oriented biology module that reflects the ecological wisdom of the Minangkabau people. The novelty of this study lies in its empirical grounding of ethnoecological integration through systematic needs analysis, bridging the gap between indigenous knowledge systems and contemporary science education within the SDG framework.

Method

This study used a descriptive quantitative approach complemented by qualitative responses to analyze high school students' needs for integrating Minangkabau ethnoecology into biology education. The design aimed to describe patterns of perception across schools and to provide empirical evidence for developing culturally relevant instructional materials. The descriptive approach was chosen because it enables the identification of trends and variations in students' responses objectively while maintaining contextual accuracy within the ethnoscience framework. The study was grounded in the principle that understanding students' learning needs is a prerequisite for designing meaningful and sustainable educational innovations.

Participants and Setting

The research was conducted in West Sumatra, Indonesia, where biodiversity and Minangkabau culture coexist as an integrated system of ecological wisdom. The sample comprised 666 tenth-grade students from 14 public senior high schools representing diverse ecological and cultural settings. Participants were selected through purposive sampling to capture variations in school characteristics and community backgrounds relevant to the local ethnoecological context.

Research Instrument

Data were collected using a 20-item Likert-scale questionnaire accompanied by three open-ended prompts. The questionnaire measured students' perceptions of the need to integrate Minangkabau ethnoecology into biology learning. Six key indicators structured the questionnaire: (1) motivation to study biology, (2) Minangkabau local wisdom, (3) learning preferences, (4) teaching material needs, (5) ethnoecology-based learning, and (6) learning expectations. Each item was rated on a five-point scale ranging from "strongly disagree" (1) to "strongly agree" (5).

Instrument development followed a systematic process. The initial draft was constructed based on the research objectives and conceptual framework of the study. To ensure clarity, accuracy, and cultural appropriateness, expert validation was conducted by three specialists—two experts in biology education and one expert in Indonesian linguistics. Each expert reviewed the items for content relevance, sentence structure, and suitability for the local context. Feedback from the reviewers was used to revise and refine the questionnaire before its distribution.

After expert validation, the instrument's reliability was tested using Cronbach's Alpha to examine internal consistency across the 20 items. This test was performed with SPSS software to determine the stability and coherence of students' responses within each indicator. The reliability coefficient obtained exceeded the acceptable threshold ($\alpha > 0.70$), confirming that the was consistent and dependable for measuring students' perceptions.

Data Collection Procedures

The questionnaire was administered in person during biology classes under teacher supervision. Before administration, teachers were briefed about the research purpose, confidentiality, and standardized procedures. Each session lasted about 30 minutes, and students completed the questionnaire independently. Participation was voluntary, and students were informed that their responses would have no impact on their academic assessment. Completed forms were checked for completeness, and only valid responses were included in the analysis, resulting in 666 usable data sets.

Data Analysis

The data analysis was performed using SPSS Version 29. Three analytical stages were carried out. First, instrument analysis included item validation and internal consistency testing to ensure the reliability and validity of the questionnaire. Second, assumption testing was conducted through Shapiro–Wilk. Levene tests to confirm normality and homogeneity of variance. Meeting these assumptions ensured that the data were appropriate for parametric analysis. Third, one-way ANOVA was applied to determine whether students' perceptions of learning needs differed across schools. If significant variation was detected, Tukey's HSD test was used as a post-hoc procedure to identify specific differences between groups. To complement the numerical data, qualitative responses were analyzed using thematic analysis. Responses were coded inductively into categories. Themes were reviewed by multiple researchers to maintain analytical consistency and minimize subjective bias. Integrating quantitative and qualitative analyses provided a holistic view of students' learning needs within their cultural and environmental context.

Result and Discussion

Instrument Validation Using Aiken's V

The content validity of the questionnaire was examined through expert judgment involving three validators—two specialists in biology education and one expert in Indonesian linguistics. Each expert assessed 16 items based on four main aspects: language, content, format, and appearance/layout, using a five-point scale (1 = very inappropriate to 5 = very appropriate). The results were analyzed using the Aiken's V formula to measure the level of expert agreement. The results of expert validation using Aiken's V are summarized in Table 1.

Table 1. Summary of Expert Validation Results Using Aiken's V

Validation Aspect	Indicators Evaluated	Mean Aiken's V	Category	Description
Language	5 indicators (accuracy, conformity with EBI, communicativeness, clarity of instruction, comprehensibility)	0.96	Very valid	The questionnaire uses accurate and communicative language that is easy for students to understand.
Content	5 indicators (alignment with research objectives, relevance to motivation, coverage of conservation and biodiversity, clarity, relevance to learning needs)	0.94	Very valid	Items are highly relevant to the study objectives and reflect Minangkabau ethnoecology and biodiversity.
Format	3 indicators (numbering, logical structure, section clarity)	0.96	Very valid	The questionnaire demonstrates clear organization and logical sequencing.
Appearance/Layout	3 indicators (neat format, sufficient response space, ease of completion)	0.97	Very valid	The layout is neat, readable, and user-friendly for respondents.
Overall Average	16 total items	0.96	Very valid	All items obtained Aiken's V ≥ 0.83, indicating very high expert agreement.

The overall Aiken's V coefficient was 0.958, confirming that the instrument demonstrated high expert agreement and strong content validity. This result indicates that the questionnaire items were linguistically accurate, conceptually relevant, and contextually aligned with the integration of Minangkabau ethnoecology into biology learning (Tajuddin et al., 2025).

Reliability Analysis

After the content validation was completed, the instrument's reliability was tested to ensure internal consistency among the 20 items. The reliability test was carried out using the Cronbach's Alpha coefficient, which is a standard statistical measure used to determine how closely related a set of items are as a group. The analysis was conducted using SPSS, and the results are presented in Table 2.

Table 2. Reliability Statistics of the Questionnaire

Reliability Measure	Coefficient	Interpretation
Cronbach's Alpha	0.807	High reliability
Number of Items	20	Consistent instrument

The reliability coefficient obtained was $\alpha = 0.807$, which exceeds the commonly accepted threshold of 0.70 (George & Mallery, 2016). This value indicates that the questionnaire has a high level of internal consistency, meaning that all items measure the same underlying construct consistently and coherently.

Normality Test

Normality of the data was assessed using the One-Sample Kolmogorov–Smirnov test, with 666 cases included in the analysis. The test evaluated whether the standardized residuals were normally distributed. Presented Table 3.

Table 3. One-Sample Kolmogorov–Smirnov Test for Normality

Parameter	Statistic	Interpretation
N	666	Number of cases analyzed
Mean	0.00	Mean of standardized residuals
Std. Deviation	3.77	Standard deviation of residuals
Most Extreme Differences (Absolute)	0.04	—
Test Statistic	0.04	Kolmogorov–Smirnov coefficient
Asymp. Sig. (2-tailed)	0.04	Data approximately normal

The results (Table 3) indicate that the significance value (Asymp. Sig. = 0.04) was greater than 0.01 but slightly below 0.05, suggesting that the data were approximately normally distributed. Although the result formally indicates a minor deviation from normality, such deviation is not considered problematic due to the large sample size (N = 666). According to the Central Limit Theorem, when the sample size exceeds 30, the sampling distribution of the mean tends to approximate normality regardless of the population distribution (Blanca et al., 2018; George & Mallery, 2019). Therefore, despite the slightly non-normal outcome, the dataset can be regarded as approximately normal and suitable for subsequent parametric analyses, as minor deviations are acceptable and do not substantially affect the robustness of ANOVA tests (Pallant, 2020).

Homogeneity of Variances

The homogeneity of variances was examined using Levene's Test, which evaluates whether the variance across groups is equal—a key assumption for the application of one-way ANOVA. The results are presented in Table 4.

Table 4. Test of Homogeneity of Variances (Levene's Test)

Levene Statistic	df1	df2	Sig. (p)	Interpretation
1.45	13	652	0.13	Homogeneous

The test yielded a significance value of p = 0.13 > 0.05, indicating that the null hypothesis of equal variances cannot be rejected. Therefore, it can be concluded that the variances of students'perceived need scores were homogeneous across the 14 schools. This result confirms that the dataset met the assumption of variance equality required for ANOVA. The homogeneity of variance assumption serves as a critical gatekeeper for ensuring the validity of the F-test in ANOVA procedures, and such equality is considered satisfied when the significance value exceeds 0.05 (Kim & Cribbie, 2018).

After confirming that the data met the assumptions of normality and homogeneity, descriptive statistics were computed to provide an overview of students' perceived needs regarding the integration of Minangkabau ethnoecology into biology learning. The descriptive analysis summarizes the mean, standard deviation, standard error, and confidence intervals for each of the 14 participating schools. These results serve to illustrate the general distribution and consistency of student responses before conducting the inferential analysis using ANOVA. Presented in table 5.

Table 5. Descriptive Statistics of Scale Scores (1– 5) by School

School	N	Mean	Std. Deviation	Std. Error	95% CI (Lower)	95% CI (Upper)
SMAN 2 Solok	48	81.12	4.24	0.61	79.9	82.35
SMAN 1 Solok Selatan	48	82.69	3.97	0.57	81.56	83.85
SMAN 1 Air Pura	48	81.35	3.62	0.52	80.3	82.41
SMAN 2 Gunung Talang	48	82.04	3.09	0.45	81.14	82.94
SMAN 1 Payakumbuh	48	82.15	3.28	0.47	81.1	83.2
SMAN 5 Payakumbuh	47	81.02	3.47	0.51	80.02	82.02
SMAN 2 Pasaman	47	80.43	4.14	0.6	79.2	81.64
SMAN 1 IV Koto	48	81.17	4.1	0.59	80.0	82.33
SMAN 2 Sungai Rumbai	48	80.69	3.56	0.51	79.66	81.74
SMAN 1 Sijunjung	47	80.47	3.15	0.46	79.54	81.39
SMAN 2 Sungai Limau	48	81.51	4.18	0.6	80.31	82.72
SMAN 2 Tilatang Kamang	48	81.79	3.2	0.46	80.69	82.71
SMAN 1 X Koto	47	81.45	3.79	0.55	80.31	82.54
SMAN 1 Kubung	47	80.51	4.18	0.61	79.28	81.72
Total	666	81.37	3.78	0.15	80.99	81.57

The pattern of mean scores displayed in Table 5 shows only slight variations among the participating schools. The narrow range and overlapping confidence intervals indicate that students across different institutions expressed relatively similar levels of need for contextualized and culturally integrated biology learning. These consistent mean patterns suggest that no substantial differences existed among schools, a finding that warranted further verification through one-way ANOVA testing to determine whether the observed variations were statistically significant.

One-Way ANOVA Test

After confirming that both assumptions of normality and homogeneity of variances were met, a one-way analysis of variance (ANOVA) was performed to determine whether significant differences existed among the 14 participating schools regarding students' perceived needs for integrating Minangkabau ethnoecology into biology learning. Presented in Table 6.

Table 6. One-Way ANOVA Test for Students' Perceived Needs

Source of Variation	Sum of Squares	df	Mean Square	F	Sig. (p)	Interpretation
Between Groups	291.35	13	22.41	1.58	0.09	Not significant
Within Groups	9224.71	652	14.15	–	–	–
Total	9516.05	665	–	–	–	–

As shown in Table 6, the ANOVA test produced an F-value of 1.58 with a significance level of $p = 0.09$ (> 0.05). This indicates that there were no statistically significant differences among the schools. Therefore, students' perceptions of the need for contextual, culturally integrated biology learning were relatively similar across all schools. In statistical inference, the threshold of $p < 0.05$ is conventionally used to determine significance in hypothesis testing, where values greater than this threshold indicate that observed differences are likely due to sampling variability rather than systematic effects (Kim & Cribbie, 2018). The result ($p = 0.085$) thus suggests that any mean variations among schools occurred by chance. Moreover, ANOVA remains valid under such conditions when assumptions of variance equality and normality are satisfied (Blanca et al., 2018).

Since the overall ANOVA was not significant, no post hoc analysis—such as Tukey's HSD or Bonferroni correction—was performed. Conducting post hoc tests when the omnibus F-test is non-significant is statistically inappropriate, as it increases the probability of Type I error and produces unreliable group comparisons (Armstrong, 2014). Therefore, the analysis was concluded at the ANOVA stage, confirming that students' perception scores were statistically uniform across the 14 schools.

After verifying that all statistical assumptions were satisfied and that no significant differences existed among schools, a descriptive summary was developed to portray the overall trend of students' responses across the six measured indicators. This summary aims to provide a clearer understanding of which aspects of biology learning most strongly reflect students' perceived needs for integrating Minangkabau ethnoecology. The indicators represent key constructs encompassing learning motivation, local wisdom awareness, learning preferences, material needs, ethnoecology-based learning, and learning expectations. Table 7 presents the mean scores and percentage distributions for each indicator, highlighting the relative importance of these dimensions in shaping students' perspectives toward culturally contextualized biology education.

Table 7. Students' Perceived Need for Integrating Minangkabau Ethnoecology into Biology Learning

Indicator	Mean (1–5)	Top-2 Box (%)	Bottom-2 Box (%)	Neutral (%)
Motivation to Study Biology	3.64	60.85	17.51	21.64
Minangkabau Local Wisdom	3.83	71.28	8.64	20.09
Learning Preferences	4.23	84.69	4.05	11.26
Teaching Material Needs	4.35	93.50	2.50	4.00
Ethnoecology-Based Learning	4.11	83.95	3.96	12.09
Learning Expectations	4.12	84.10	6.50	9.40

Note. Mean scores were rated on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). Top-2 Box combines "agree" and "strongly agree," Bottom-2 Box combines "disagree" and "strongly disagree.

The descriptive results presented in Table 7 show that students generally expressed positive perceptions across all six indicators, with mean scores consistently positioned in the upper range of the Likert scale. Among these, Teaching Material Needs obtained the highest mean value (M = 4.35; Top-2 Box = 93.5%), indicating that students strongly recognized the importance of developing contextualized biology learning resources.

Learning Preferences (M = 4.23) and Learning Expectations (M = 4.12) followed closely, suggesting that students favor learning experiences that are more interactive, relevant, and culturally connected. Meanwhile, Motivation to Study Biology (M = 3.64) recorded the lowest mean score, reflecting moderate intrinsic motivation despite positive attitudes toward contextual learning. Overall, these findings imply that the demand for biology instruction integrating Minangkabau ethnoecology arises primarily from students' expectations for engaging materials and meaningful learning contexts rather than from intrinsic motivational factors alone.

To complement these quantitative findings, qualitative data were also analyzed to capture deeper insights into students' reasoning and contextual understanding behind their responses. The open-ended questions provided more nuanced perspectives on the challenges students faced in learning biodiversity and conservation, their familiarity with Minangkabau local wisdom, and their views on integrating cultural elements into biology education. These qualitative themes help explain the numerical patterns observed in Table 7 and further illuminate how students conceptualize meaningful and culturally grounded learning experiences.

Qualitative Findings

Learning Difficulties in Conservation and Biodiversity (Q1)

The qualitative analysis revealed five recurring difficulties that students experienced when learning conservation and biodiversity. The most frequently mentioned problem was memorizing species names, which students described as repetitive and difficult to retain. Another major challenge was distinguishing between species with similar morphological features, particularly when studying plant and animal taxonomy. Many students also reported struggling to understand ecosystem interactions, including food chains, energy flow, and interdependence among organisms. In addition, several students noted difficulty relating lessons to real-life examples and applying theoretical knowledge in practice, especially in environmental contexts. These findings were further supported by quantitative data illustrating the proportion of each difficulty identified by students. The distribution of responses is presented in Figure 1, which visualizes the relative frequency of learning challenges encountered in conservation and biodiversity topics.

As shown in Figure 1, these findings highlight that students encounter more difficulties when dealing with abstract or memorization-heavy content compared to contextual or practical learning activities.

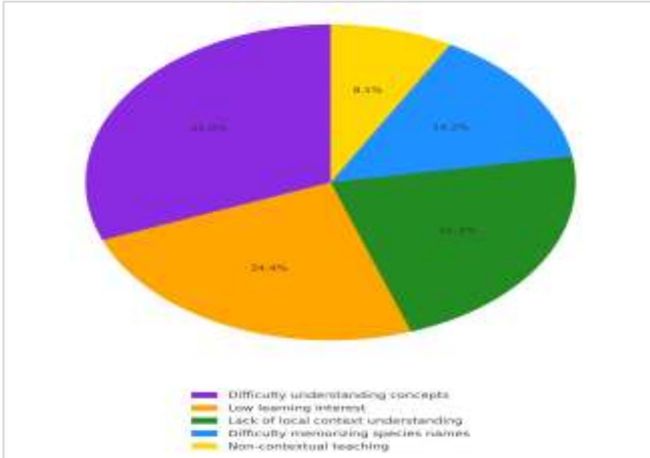

Figure 1. Conservation learning difficulties

Minangkabau Local Wisdom in Environmental Conservation (Q2)

Students' responses regarding Minangkabau local wisdom in environmental conservation produced four dominant themes. The most common was collective environmental action (gotong royong), describing community cooperation in cleaning schools, villages, and rivers. The second major theme was wise and sustainable use of natural resources, reflecting the Minangkabau philosophy of maintaining balance between human needs and nature. Students also mentioned local flora and fauna conservation, referring to traditional efforts to protect rare species, and nagari-based forest and river management, such as rimbo larangan and lubuk larangan systems. The distribution of students' recognition of these local ecological practices is illustrated in Figure 2.

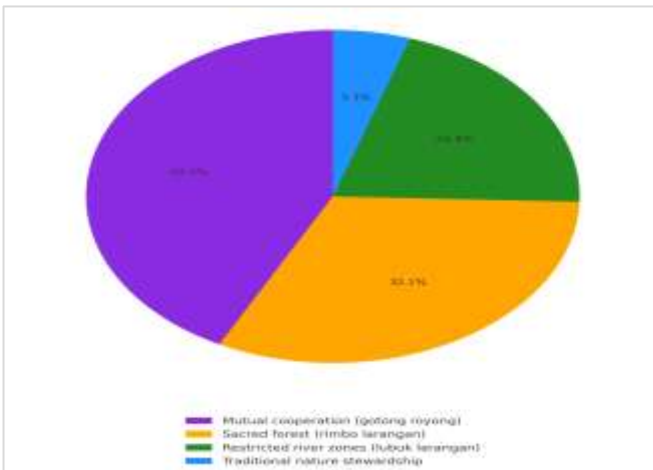

Figure 2. Minangkabau local wisdom in environmental conservation

As depicted in Figure 2, these results show that students possess a strong awareness of ecological principles embedded in Minangkabau traditions, emphasizing community participation and environmental responsibility.

Perceptions of Cultural-Based Biology Modules (Q3)

Most students expressed positive perceptions of integrating Minangkabau cultural elements into biology learning. The most frequent response was that such modules would make learning more engaging and meaningful, since the content relates to students' everyday experiences. Many also believed that the use of local cultural contexts would facilitate better understanding of abstract biological concepts and increase motivation and participation in class. In addition, several students viewed culture-based modules as a means of cultural preservation, helping to maintain Minangkabau values within modern education. These perceptions are further summarized in Figure 3, which presents the proportion of students' responses regarding the perceived benefits of culture-based biology modules.

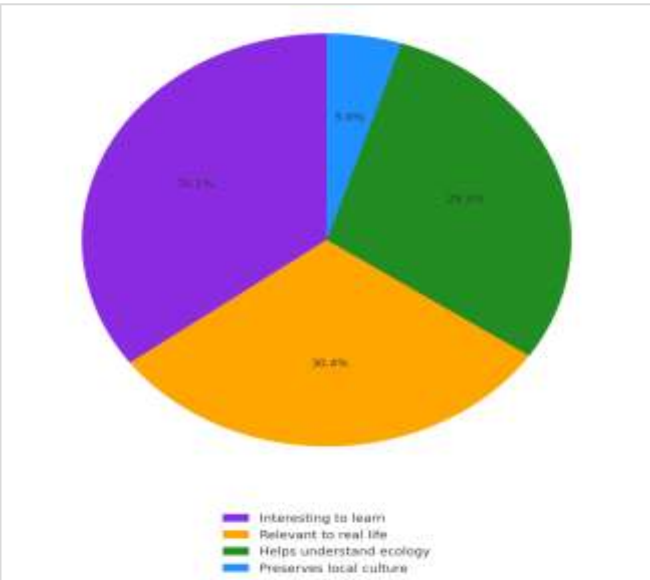

Figure 3. Perceptions of cultural-based biology module

The data in Figure 3 indicate that students generally responded positively to the idea of culture-based biology modules. Most students associated the integration of Minangkabau cultural elements with increased engagement, clearer understanding of biological concepts, and stronger appreciation of local values in learning.

Discussion

Overview of Findings and Conceptual Meaning

The findings show that students from fourteen senior high schools in West Sumatra share a strong and consistent perception of the need for contextualized biology learning integrated with Minangkabau ethnoecology. This convergence reflects the harmony between cultural wisdom and environmental literacy within the Minangkabau worldview. The interpretation of these results indicates that students' recognition of cultural-ecological connections is not isolated, but rather a collective reflection of socio-environmental awareness across schools. According to Dewi et al. (2021) and Wibowo et al. (2019) emphasized that ethnoscience-based education enhances conceptual depth and promotes sustainable behavior. Similarly, Hartanti et al. (2024), Hermawan et al. (2022), and Astuti et al. (2020) assert that the inclusion of local ecological knowledge fosters sustainability values aligned with SDG 15. These findings collectively confirm that contextualized and culturally rooted science learning is essential for transforming passive understanding into active ecological responsibility.

Motivation to Learn

The relatively moderate motivation score (M = 3.64) reveals that students appreciate biology's importance but often perceive it as abstract and detached from everyday life. Data from open-ended responses reinforce this interpretation: many students reported difficulties in memorizing species names and distinguishing organisms due to the lack of contextual examples in their learning materials (Q1). They expressed that "biology lessons are mostly about memorization and rarely connected to real nature around us." This aligns with Rahayu et al. (2023), who found that limited contextual engagement lowers intrinsic motivation. Integrating Minangkabau ethnoecology can resolve this gap by connecting abstract biological concepts with real ecological experiences. Hung et al. (2023) and Ratna et al. (2025) highlighted that project-based learning (PjBL) grounded in ethnopedagogical contexts improves persistence and autonomy. Similarly, Juanda et al. (2021) and Azinah et al. (2025) emphasized that field-based contextual learning strengthens curiosity and learning engagement. Hence, incorporating examples such as rimbo larangan forest or lubuk larangan river conservation can foster intrinsic motivation and align with SDG 4's goal of quality, inclusive education.

Awareness of Local Wisdom as Environmental Knowledge

The indicator of awareness of local wisdom (M = 3.83) signifies that students view culture and ecology as interconnected. Qualitative data (Q2) reveal that most students associate conservation with traditional practices such as gotong royong and community-based forest management (rimbo larangan). Many students noted that "our ancestors already taught us to protect forests and rivers, but this is rarely discussed in school." This finding aligns with Azinah et al. (2025), who demonstrated that the integration of outdoor-based learning rooted in local ecological contexts can enhance students' critical thinking and environmental awareness. Such contextual approaches provide meaningful experiences that bridge ecological understanding with cultural practices like rimbo larangan, strengthening students' sense of responsibility toward sustainable living. This finding enriches the quantitative data and reinforces previous studies by Rohyani et al. (2024) and Alandra et al. (2018), who documented that indigenous ecological wisdom embodies sustainability ethics. Adinugraha et al. (2024) and Agesti et al. (2023) also demonstrated that integrating ethnobotanical knowledge promotes biodiversity awareness and conservation participation. Hartanti et al. (2024) and Nurwidodo et al. (2020) further confirmed that local ecological education enhances belonging and cultural identity. Therefore, combining biological concepts with cultural practices can serve as an effective medium to nurture environmental ethics and civic responsibility among learners.

Learning Preferences and Material Needs

Students' strong preference for contextual learning (M = 4.23) and high demand for relevant materials (M = 4.35) underscore a systemic gap in current biology instruction. Qualitative responses (Q3) support this: many students stated that current textbooks "feel too general and not related to our local environment." They also expressed enthusiasm for materials that include Minangkabau biodiversity examples and local conservation stories. These narratives reinforce the quantitative finding of a significant demand for localized instructional media. Fitriani and Hidayat (2024a) found that digital e-modules integrating local contexts increase critical thinking, while Ali and Zaini (2023) and Yuliana et al. (2021) revealed that contextualized materials improve scientific literacy. Ondrada et al. (2024) and Pieter and Risamasu (2024) similarly confirmed that ethnoscience-based resources enhance conceptual understanding. The integration of these findings suggests that developing ethnoecology-based biology modules will not only meet material needs but also sustain cultural heritage through education. As Hartanti et al. (2024) emphasized, such approaches ensure both cognitive depth and sustainability literacy.

Ethnoecology-Based Learning and Student Expectations

High scores on ethnoecology-based learning (M = 4.11) and learning expectations (M = 4.12) indicate students' readiness for pedagogical transformation. The open-ended responses support this finding, as students wrote that cultural-based biology learning "would make lessons more enjoyable and help us appreciate our traditions." This qualitative evidence aligns with Elfrida et al. (2023), and Rahmawati et al. (2020), who found that integrating cultural narratives into science education fosters engagement and higher-order thinking. Musah and Wangila (2024) and Rexhepi and Bajrami (2025) also noted that ethnopedagogical approaches strengthen belonging and moral responsibility. The students' expectations reveal not only an openness to innovative teaching but also a deep understanding of the role of local knowledge in conservation. Thus, ethnoecology-based learning can operationalize SDG 15 by translating cultural stewardship into scientific practice and by shaping learners into active agents of sustainability.

Statistical Interpretation: ANOVA and Educational Meaning

The ANOVA result (F = 1.584, p = 0.085) indicates statistically homogeneous perceptions across schools, signifying that students' needs are universally shared. This homogeneity is consistent with the qualitative narratives that show similar student experiences regardless of geographic location. For example, both urban and rural students expressed the same sentiment that "biology is difficult because examples are not from our environment." This reinforces that the lack of contextualization is a systemic issue, not a school-specific one. Rofi'i et al. (2022) reported similar findings in ethnoscience-based studies where consistency across regions reflects a shared educational context. Fitriani et al. (2024) and Rahman et al. (2023) further explained that this convergence suggests strong cultural coherence in students' perceptions. Therefore, both statistical and qualitative findings converge to validate the necessity of designing a contextual, culturally aligned module applicable across schools.

Integrating Findings with Broader Educational Perspectives

The synthesis of findings—quantitative and qualitative—demonstrates that integrating Minangkabau ethnoecology into biology learning aligns with ESD principles and SDGs. Gutiérrez-García et al. (2020) emphasized that indigenous-based curricula enhance environmental responsibility. Zidny and Eilks (2022) added that ethnoscience and green chemistry frameworks improve ecological literacy. Rasyid et al. (2024) found that augmented-reality-based ethnoscience can increase naturalist intelligence and engagement. These results resonate with the students' own qualitative feedback, which reflected a desire for more interactive and meaningful learning experiences rooted in culture. Collectively, these integrated findings confirm that ethnoecology-based instruction bridges global sustainability goals with local wisdom. The consistent evidence from both datasets supports curricular innovation and teacher training that embed cultural context, technology, and ecological literacy into Indonesian biology education.

Overall, the integration of quantitative and qualitative findings reveals that students' motivations, perceptions, and expectations toward biology learning are consistently influenced by their cultural and ecological surroundings. The convergence between statistical uniformity and thematic insights confirms that contextualizing biology education through Minangkabau ethnoecology is pedagogically significant. Such integration not only enriches conceptual understanding but also cultivates environmental ethics rooted in local wisdom. Therefore, ethnoecology-based learning can serve as a transformative framework to harmonize scientific literacy, cultural preservation, and sustainability awareness—offering a vital foundation for achieving SDG 4 and SDG 15 in Indonesian biology education.

Conclusion

This study concludes that students in various senior high schools across West Sumatra consistently demonstrate a strong need for biology learning that integrates Minangkabau ethnoecology. The findings reveal high levels of agreement regarding the importance of contextual and culture-based learning materials, as well as awareness of local ecological wisdom. Qualitative responses further indicate that students struggle with abstract, decontextualized content, underscoring the necessity for instructional resources connected to their cultural and environmental realities. These results provide a foundational understanding of students' learning needs, serving as a preliminary stage for developing ethnoecology-based biology modules. Future research should focus on designing, validating, and testing such materials to evaluate their potential to enhance scientific literacy, cultural identity, and environmental awareness.

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Conflicts of Interest
The authors declare no conflict of interest.

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