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Embedding local potential and local wisdom into biology e-modules: Front and analysis

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ABSTRACT

Biology education should be contextualized to students' surroundings by integrating local potential and local wisdom so that learning becomes more meaningful, relevant, and engaging. This study aimed to analyze the need to develop an e-module based on local potential and local wisdom for biology learning in schools in the Toraja region. A descriptive cross-sectional design was employed. Data were collected from two teachers and 35 students selected through purposive and simple random sampling, respectively. The research instruments included questionnaires, interview guides, and document analysis sheets. The analysis of the curriculum, learning process, and teaching materials showed that Toraja has considerable local potential and local wisdom that can be integrated into biology learning. However, the findings also indicated that the available teaching materials are still limited in both quantity and content and have not fully optimized these local values. These findings suggest that learning resources need to be developed more systematically so that they better reflect the students' cultural context and daily experiences. Therefore, the development of an e-module integrating local potential and local wisdom is necessary to support contextual biology learning, enrich students' learning experiences, and improve the relevance and effectiveness of instruction in the Toraja region for school-based biology.



INTRODUCTION

Students require more than the mere rote memorization of conceptual frameworks; they must achieve deep comprehension and demonstrate the ability to synthesize such knowledge with their immediate lived experiences. Consequently, instructional practices must incorporate activities that bridge the gap between theoretical constructs and real-world applications (Wilujeng et al., 2020). Consistent with the necessity for contextualization, Hartanti et al. (2024) assert that biological education should transcend the traditional boundaries of classroom theory, intentionally aligning with the students' ecological and social surroundings. A highly effective strategy to facilitate this alignment involves the comprehensive integration of local potential and indigenous wisdom throughout the entire pedagogical process.

Local potential encompasses the entirety of resources, socio-cultural dimensions, and indigenous knowledge inherent to a specific region, which can be leveraged to elevate societal well-being (Hartanti et al., 2024; Ramdani et al., 2021). Within the pedagogical landscape, the use of local resources significantly enhances the alignment between instructional content and students' immediate environment, thereby fostering active engagement throughout the learning process (Ramdani et al., 2021). Corroborating this view, Annisha (2024) asserts that integrating regional assets into the curriculum is essential for improving educational quality and ensuring that students possess competencies aligned with global advancements. Complementing local potential is the concept of local wisdom, defined as the localized cognitive and behavioral frameworks (intellect and ethics) that communities employ when interacting with their environment or regional phenomena (Khusniati et al., 2017). Local wisdom constitutes indigenous knowledge systems and values that serve as traditional guidelines for governing the social order (Sibarani, 2015). The intrinsic values embedded within local wisdom, such as customs and belief systems, function as potent educational instruments for instilling moral character within community members (Syahfitri & Muntahanah, 2024). Consequently, an educational paradigm that integrates local wisdom encourages learners to maintain an orientation toward the concrete, real-world situations they encounter (Daniah, 2016).

Explicitly, the government requires educational institutions to incorporate local elements into their curricula, reflecting regional distinctiveness and potential by integrating them into specific teaching materials or subjects. Law Number 20 of 2003 concerning the National Education System mandates that Indonesian curricula at every level and type of education must be adapted to the characteristics of the educational unit, regional potential, and the individual potential of students. To realize this objective, the instructional process must integrate activities that bridge the gap between students and real-world contexts (Wilujeng et al., 2020). Under the Kurikulum Merdeka (Independent Curriculum) framework, the government grants institutions the autonomy to embed local elements through three primary alternatives: 1) establishing local content as a standalone subject; 2) integrating local elements across all subject areas; and 3) implementing projects that reinforce student profiles based on Pancasila values (Lidi et al., 2023). A defining characteristic of this curriculum is its emphasis on interpersonal skill development and character building aligned with the Profil Pelajar Pancasila (Pancasila Student Profile). Within this framework, local potential and indigenous wisdom are categorized under the dimension of "Global Diversity." This profile aims to empower students to preserve their noble culture and local identity while maintaining an open-minded disposition when interacting with diverse global cultures (Kemendikbudristek, 2022).

Preliminary observations at a senior high school in North Toraja reveal that educators have yet to integrate local wisdom into the instructional process, particularly within the biology curriculum. This gap exists despite the fact that Torajan society extensively utilizes regional biodiversity, both flora and fauna, to fulfill diverse needs, ranging from food security and ethnomedicine to the requirements of traditional rituals and other localized potentials. Specifically, two primary socio-religious rites, Rambu Tuka' and Rambu Solo', are replete with

indigenous wisdom highly pertinent to biological education. The Torajan people are globally recognized for the Rambu Solo' funeral ceremonies, large-scale events that command the participation of hundreds to thousands of individuals and span several days (Pora' et al., 2023).

Furthermore, the Torajan way of life is governed by the "Tallulolona" philosophy, which synergizes the three vital pillars of existence humans, animals, and plants into a unified environmental collective. This philosophical framework posits that all beings, both human and non-human, possess an equitable right to coexist, a principle manifested in daily practices that prioritize environmental stewardship and profound ecological respect (Sumiaty et al., 2023). Existing scholarship has provided a comprehensive overview of the local potential and indigenous knowledge embedded within Torajan traditions, suggesting that these cultural elements can be successfully transposed into scientific concepts to support the achievement of learning objectives in high school biology for Phases E and F (Sura et al., 2025).

One strategic initiative to facilitate the integration of indigenous wisdom is the development of specialized instructional materials. Modules, in particular, serve as structured written resources designed to promote autonomous learning, empowering students to engage with the content independently and asynchronously without constant teacher supervision (Rakhmatullah et al., 2020). Despite their potential, the incorporation of local wisdom and regional assets from Indonesia's diverse ethnic groups into formal schooling remains suboptimal (Sriyati et al., 2021). Nevertheless, empirical evidence underscores the efficacy of this approach. Maftuha (2025) demonstrates that embedding local wisdom within E-modules significantly enhances the contextual relevance of biology curricula to the students' lived experiences. Consequently, educators are encouraged to synthesize local potential and surrounding cultural values into biology instruction across various Indonesian regions. This shift aligns with the Merdeka Belajar (Emancipated Learning) policy, which prioritizes localization, relevance, and pedagogical flexibility. Supporting this perspective, Sura et al. (2025) assert that regional potential and wisdom can be seamlessly integrated into the Kurikulum Merdeka through an ethnopedagogical approach, reflecting how traditional values serve as a catalyst for educational innovation. Furthermore, the primary advantage of digital modules lies in their accessibility, allowing learners to retrieve and interact with materials regardless of temporal or spatial constraints (Al Rawashdeh et al., 2021).

Drawing upon the aforementioned context, the primary objective of this article is to conduct a comprehensive needs analysis regarding the development of E-modules embedded with local potential and indigenous wisdom for secondary schools in North Toraja. This study specifically addresses the following research question: What are the perceptions of teachers and students concerning the necessity of E-modules that integrate the regional potential and local wisdom of the North Toraja area?

METHODS

This study employs a descriptive cross-sectional design, facilitating an objective and comprehensive evaluation of current conditions. As articulated by Creswell & Guetterman (2019), a descriptive cross-sectional framework is highly appropriate for educational research aimed at elucidating phenomena in their natural contexts without imposing experimental interventions. Data collection was executed through a multifaceted instrumentation suite, including questionnaires, interview protocols, and document analysis rubrics. The participant pool, comprising both educators and students, was established through a dual-stratified sampling approach: first, purposive sampling was implemented to select participants based on predetermined eligibility criteria; second, simple random sampling was applied to a homogeneous population to ensure that every individual possessed an equal probability of selection, thereby enhancing the objectivity and accuracy of parameter estimations (Singh & Shah, 2021). Detailed specifications regarding respondent demographics, sampling techniques, and research objectives are delineated in Table 1.

Table 1*Respondent identification, sample quantity, data collection, and sampling techniques.*

	Respondent /Data sources	Qty	Data collection	Sampling techniques
1.	Biology teachers	2	Interviews	Purposive sampling
2.	Students eleventh-grade	3	Interviews	Simple random sampling
		32	Questionnaires	Simple random sampling
3.	Textbooks used by teachers	2	Document analysis	Purposive sampling

In this study, the multifaceted framework for analyzing developmental requirements encompasses curriculum, instructional, and teaching material analyses. Detailed explications for each dimension are provided as follows:

Curriculum analysis was executed by identifying the specific curricular framework adopted by the sampled educational institution. The primary objective of this analysis was to ascertain the alignment between core competencies, instructional resources, and predefined learning outcomes. As the fundamental pillar of education, the curriculum orchestrates the pedagogical system and delineates the graduate profiles intended for societal integration. Furthermore, the prevailing curriculum provides the strategic direction that governs the entire teaching and learning process (Yaşar & Aslan, 2021). The specific inquiries identified within the curricular dimension are further elaborated in Table 2.

Table 2*Identification of questions for curriculum analysis.*

Data sources	Question topics
Teachers interview	1) Curriculum used 2) Number of learning hours per week 3) Learning outcomes used in Phase E and Phase F

Instructional analysis was conducted to scrutinize the pedagogical strategies currently employed by educators, their practical experiences in integrating indigenous wisdom into their teaching, and their proficiency in embedding Education for Sustainable Development within biology instruction. This dimension specifically seeks to elucidate how traditional knowledge systems and sustainability principles are operationalized in the classroom. The specific inquiries formulated to evaluate these instructional aspects are comprehensively detailed in Table 3.

Table 3*Identification of questions for curriculum analysis.*

Data sources	Question topics
Teachers interviews	1) Biology teaching strategies 2) Experience implementing potential and local wisdom in teaching 3) Knowledge of the potential and local wisdom of Toraja Tribe 4) Perceptions of the potential for integrating the potential and local wisdom of Toraja tribe into learning 5) Relevant topics for integration with the potential and local wisdom of Toraja Tribe
Eleventh-grade student questionnaire	1) Knowledge of potential and local wisdom 2) Experience visiting Toraja traditional ceremonies and various tourist attractions in Toraja

Data sources	Question topics
	3) Knowledge of the Toraja tribe's potential and local wisdom
	4) Teachers' experience in providing information on potential and local wisdom
	5) Desire teaching materials that incorporate the potential and local wisdom of the Toraja tribe's

An analysis of instructional resources was conducted to evaluate the current use of biology teaching materials and to identify the specific challenges and constraints encountered during their implementation. Furthermore, this assessment aimed to capture students' perspectives on the characteristics of learning media that foster engagement and facilitate conceptual clarity. By scrutinizing these factors, the study aims to establish a baseline for developing more effective educational tools. The specific inquiries formulated to explore these instructional dimensions are systematically presented in Table 4.

Table 4

Identification of questions for learning materials analysis.

Data sources	Question topics
Teachers interviews	1) Teaching materials currently used 2) Student learning outcomes using those teaching materials 3) Challenges or obstacles in using those teaching materials
Eleventh-grade student questionnaire	1) Teaching materials or learning resources currently used by teachers 2) Students' experience completing evaluation questions in the textbook 3) Textbook features that are most effective in helping students understand the material 4) Learning materials that can effectively support biology lessons
Textbooks used by teachers	1) Features 2) Book structure and organization 3) Contextual content 4) Local wisdom or local potential content 5) Integration of material visualization and supporting media with the internet 6) Types of evaluation questions

RESULTS AND DISCUSSION

The perspectives of both educators and students regarding the necessity for E-modules enriched with local potential and indigenous wisdom are delineated as follows:

Curriculum Analysis

The curriculum analysis was conducted by scrutinizing the instructional framework implemented at a public senior high school in North Toraja Regency. This evaluative process aimed to determine whether the core competencies, instructional materials, and relevant learning outcomes aligned. Findings from this analysis served as a baseline for designing E-module content, ensuring it is

precisely tailored to student requirements and aligned with the prevailing national curriculum. A comprehensive summary of the curricular analysis results is systematically presented in Table 5.

Table 5

Result of curriculum analysis.

	Aspect	Teacher Responses
1	The implemented curriculum	Kurikulum Merdeka
2	Learning Outcomes framework.	Upon completion of Phase E, students are expected to possess the skills to apply classification principles and biodiversity conservation strategies; describe the roles of viruses, bacteria, and fungi in biological processes; and analyze interactions among ecosystem components and their impact on ecological balance. Furthermore, students demonstrate proficiency in using measurement systems in scientific inquiry, analyzing two-dimensional motion, and evaluating alternative energy sources to address energy scarcity. They are also required to analyze subatomic particles, apply stoichiometric concepts to the quantitative aspects of chemical reactions, and integrate scientific principles to mitigate challenges associated with climate change
3	Instructional hours	3 JP

The curricular analysis was conducted through in-depth interviews with two biology educators at a public secondary school in North Toraja Regency, focusing on seven pivotal curricular dimensions, including the specific curriculum framework, learning outcomes, and the allocation of instructional time. The findings revealed a high degree of consistency between the respondents, both of whom confirmed the implementation of the *Kurikulum Merdeka* (Independent Curriculum) for the 2025–2026 academic year. Furthermore, the learning outcomes being applied were identical, specifically referring to the Phase E Learning Outcomes (LO), which state that by the end of Phase E, students should possess the competencies to apply classification principles and biodiversity conservation strategies; describe the roles of viruses, bacteria, and fungi; analyze ecosystem interactions and their impact on equilibrium; utilize measurement systems in scientific inquiry; analyze two-dimensional motion and alternative energy utilization; examine particulate matter and stoichiometric concepts; and apply scientific principles to mitigate climate change issues (Badan Standar Kurikulum dan Asesmen Pendidikan, 2022). Additionally, tenth-grade biology instruction in the odd semester is allocated three credit hours per week. Consequently, this curricular analysis provides a clear understanding of the instructional guidelines teachers use, establishing a vital foundation for developing teaching materials that are closely aligned with high school learning objectives and outcomes.

Curricular analysis is paramount, as the alignment between instructional content and learning objectives directly influences student engagement and comprehension, particularly in contextual subjects such as high school biology (Ardyati et al., 2025). Effective analysis facilitates the development of standardized and relevant teaching materials, thereby optimizing educational quality and student achievement (Gissel, 2024; Maryam, 2025; Siregar et al., 2021), while simultaneously identifying material discrepancies (Hartati & Rahmawati, 2021). This process is vital in the biological sciences to ensure that textbooks transcend the mere presentation of facts and instead foster scientific literacy, contextual understanding, and critical thinking skills through the

integration of scientific inquiry and real-world applications (Lubis et al., 2024). Ultimately, curricular analysis cultivates a dynamic environment conducive to profound conceptual mastery and the advancement of 21st-century competencies (Ristanto et al., 2023).

Learning Analysis

An instructional analysis was conducted to examine the pedagogical strategies educators employed to teach biodiversity, their practical experience in integrating regional potential and indigenous wisdom into the curriculum, and the initiatives undertaken to cultivate students' critical thinking skills and sustainability awareness. This assessment specifically focuses on the operationalization of contextual learning and its impact on fostering a proactive mindset toward environmental conservation. The findings from the analysis of teacher-led instructional practices are presented in Table 6, while the corresponding data from the students' perspective are presented in Table 7.

Table 6

Result of instructional practices analysis by teachers.

	Aspect	Teacher A	Teacher B
1	Experience in integrating local potential and wisdom into learning	Briefly mentioned during lessons (cited only as an example of biodiversity utilization)	Briefly mentioned during lessons.
2	Student response regarding the integration of local potential and indigenous wisdom into learning	Student responses and learning outcomes were relatively positive	Student responses and learning outcomes were relatively positive.
3	Knowledge of the potential and indigenous wisdom of the Torajan people	Limited knowledge	Moderate knowledge
4	Curricular content relevant for integration with Torajan local potential and indigenous wisdom	According to the teacher, Torajan indigenous wisdom can be integrated into biological lessons on biodiversity	According to the teacher, Torajan indigenous wisdom can be integrated into biology topics such as biodiversity, ecosystems, and the musculoskeletal system

Table 7

Result of instructional practices analysis by students.

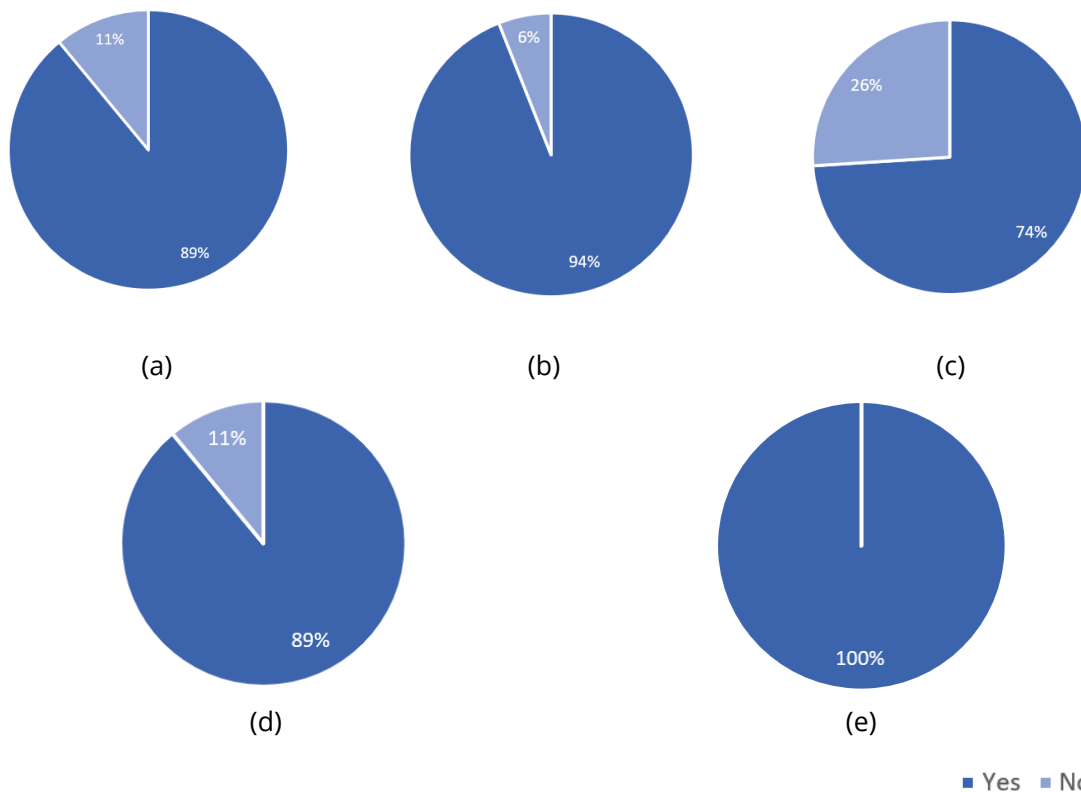
	Aspect	Student A	Student B	Student C
1	Knowledge of indigenous wisdom or local potential	Effective	Satisfactory	Satisfactory
2	The teacher's integration of local potential and indigenous wisdom	Infrequently	Occasionally	Occasionally

	Aspect	Student A	Student B	Student C
3	Instructional methods employed by the teacher	Direct instruction (lecturing), PowerPoint (PPT) presentations, problem-solving exercises, and collaborative group presentations.	Classroom discussions and material delivery via PowerPoint (PPT) presentations	Direct instruction (lecturing), group discussions, and the use of contextual examples from the immediate environment
4	The effectiveness of instructional methods in enhancing biological comprehension	Moderately helpful	Moderately helpful	Moderately helpful

The findings from the eleventh-grade student questionnaires on learning dimensions are illustrated in Figures 1a-1e.

Figure 1

(a) Students' knowledge of potential and local wisdom, (b) Students' experiences visiting traditional Toraja ceremonies and various tourist attractions in Toraja, (c) Students' knowledge of the Toraja tribe's potential and local wisdom, (d) Teachers' experience in providing information on potential and local wisdom, (e) Students' desire for teaching materials that incorporate the potential and local wisdom of the Toraja tribe.



Based on the aforementioned data, it can be inferred that a significant majority of eleventh-grade students possess a foundational understanding of the definitions pertaining to local

potential and indigenous wisdom. Most students have actively engaged with their cultural heritage by attending traditional ceremonies and visiting various landmarks that constitute the socio-cultural assets of the Toraja ethnic group. Regarding their specific knowledge of Torajan indigenous wisdom, the students demonstrated awareness of certain dimensions, particularly the Rambu Tuka' and Rambu Solo' rites, alongside the region's diverse touristic sites. However, educators' dissemination of information about integrating such regional potential into the formal curriculum remains notably deficient. This finding corroborates the qualitative evidence from interviews with both teachers and tenth-grade students, which highlights the pervasive rarity of incorporating local wisdom in biology instruction. Consequently, there is unanimous agreement among students on the need to develop instructional modules that explicitly integrate the Toraja people's local potential and indigenous wisdom.

Biology instruction has historically been dominated by traditional lecture methods, PowerPoint presentations, collaborative discussions, and independent assignments centered on printed textbooks-approaches that, while perceived as moderately beneficial, often lack dynamic engagement. Although interactive digital resources such as video, audio, and multimedia have proven highly effective in bolstering student motivation and conceptual clarity, their widespread implementation is often hindered by infrastructural deficits and limited digital proficiency among educators (Nurjanah et al., 2025). In light of these systemic challenges, the development of more engaging and effective instructional media is imperative, particularly for natural science subjects, which are often delivered through monotonous pedagogical frameworks (Muslimah et al., 2025; Safira & Nahdi, 2024). Empirical evidence suggests that students possess a distinct preference for contextualized learning experiences that bridge theoretical concepts with real-world applications, thereby transforming abstract scientific principles into tangible, relatable knowledge.

A contextual learning approach demonstrates significant efficacy in mitigating the cognitive challenges associated with abstract concepts by positioning students' real-world experiences at the core of the pedagogical process, thereby fostering profound conceptual mastery (Azzahrah et al., 2025). This instructional paradigm enables learners to establish direct connections between classroom theory and their daily lives, encouraging active engagement and the practical application of knowledge, thereby cultivating a more authentic and immersive educational experience (Latuny et al., 2021; Noviarni et al., 2023; Wiradika & Retnawati, 2021). Despite educators' awareness of Torajan regional assets and indigenous wisdom, the empirical integration of these elements-such as the ethnobotanical utility of medicinal plants-remains remarkably infrequent, notwithstanding strong student interest. Synthesizing indigenous values with scientific discourse is essential for enhancing the meaningfulness and relevance of instruction, thereby bolstering scientific literacy and process skills (Festiyed et al., 2022; Sriyati et al., 2021). Nevertheless, a formidable obstacle persists in the difficulty of transposing indigenous knowledge into formalized scientific constructs and designing contextual modules, further exacerbated by limited instructional resources and technological constraints. Consequently, there is an imperative for robust curricular mandates that institutionalize indigenous themes, alongside professional development initiatives for science educators that focus on advanced pedagogical competencies and STEM-integrated approaches, to empower them to orchestrate wisdom-based learning environments (Fauzi et al., 2024; Festiyed et al., 2022).

Teaching Material Analysis

An analysis of instructional resources was conducted to synthesize a comprehensive overview of existing biology teaching materials, the diverse pedagogical constraints encountered in their implementation, and students' perspectives on the specific attributes that make learning media engaging and cognitively accessible. By evaluating these dimensions, the study aims to identify the gaps between current textbook-reliant practices and the learners' preferences for clarity and aesthetic appeal. The empirical findings from this evaluation of instructional materials are presented systematically in Tables 8 and 9.

Table 8*Analysis of instructional materials by the teacher.*

	Aspect	Teacher A	Teacher B
1	Instructional materials or media utilized	Textbooks and Student Worksheets (LKS).	Textbooks, PowerPoint (PPT) presentations, instructional videos, visual illustrations, and PDF-formatted materials.
2	Student learning outcomes	Satisfactory, with students successfully achieving the Minimum Mastery Criterion (KKM).	Enhancing student learning outcomes and intrinsic motivation.
3	Challenges and constraints in utilizing the instructional materials	Student learning motivation.	Unstable internet connectivity and limited instructional time.
4	Materials designed to enhance student learning outcomes and motivation	Digital instructional materials are perceived as more engaging and effective in enhancing student motivation	Field studies (outdoor learning) have the potential to improve students' academic achievement and motivation significantly.

Table 9*Analysis of instructional materials from the student perspective.*

	Aspect	Student A	Student B	Student C
1	Instructional materials or learning resources utilized	Textbooks and presentation slides provided by the teacher	Textbooks, instructional modules, research articles, and educational videos	Textbooks, student worksheets (LKS), and digital modules.
2	Integration of local potential and indigenous wisdom within modules or instructional materials	Highly positive; the integration of local context makes lessons more engaging and easier to comprehend by bridging theory with daily life. It fosters learning enthusiasm by connecting academic content with tangible, familiar surroundings	Highly engaging; it bridges the gap between academic subjects and daily life. The integration of local context enhances learning motivation by providing tangible and relevant examples from students' lived experiences.	Highly positive; it contextualizes theoretical concepts within daily life, making them less abstract. This approach enhances learning motivation by providing tangible and relatable examples that students can easily visualize.

An analysis of existing biology instructional resources, including textbooks, worksheets, slide presentations, and videos, reveals that while learning outcomes remain satisfactory, these

materials fail to adequately stimulate student engagement, consequently presenting educators with challenges such as diminished motivation, temporal constraints, and inconsistent internet connectivity. Educators express a pronounced demand for interactive digital resources, which have been empirically shown to be more effective at bolstering student enthusiasm and active participation than traditional didactic tools (Noor et al., 2022; Syahfitri & Muntahanah, 2024). Digital modules that synthesize multimedia elements, such as simulations, interactive imagery, and video content, are particularly pertinent in biology; they possess the capacity to catalyze learner interest and foster intrinsic motivation for conceptual exploration, thereby mitigating low engagement levels through the creation of a more dynamic and immersive pedagogical environment (Noor et al., 2022; Starr et al., 2020).

Interviews conducted with eleventh-grade students indicate that while educators frequently utilize textbooks and slide presentations, a critical shortage of physical resources, evidenced by a ratio of only 60 textbooks for 12 classes, compels learners to supplement their studies via personal notes or supplementary YouTube content. Based on student feedback on the learning resources teachers use, it is evident that integrating technology into the instructional process is highly feasible at the institution. The robust availability of internet connectivity, coupled with the widespread possession of personal devices and laptops among students, provides a strong foundation for implementing digitally based learning environments. Students articulated that conceptual mastery would be significantly enhanced if the curriculum were anchored in empirical examples and indigenous wisdom derived from their immediate environment. Although educators seldom establish correlations between subject matter and regional potential, students overwhelmingly prefer such integration, believing it makes the instructional process more captivating and contextually relevant. Academically, the synthesis of localized cultural assets into the curriculum has been empirically validated to bolster student engagement, curricular relevance, and intrinsic motivation (Setyorini et al., 2022; Wati et al., 2020). Complementing the teacher interviews, tenth-grade student consultations, and eleventh-grade survey distributions, data for the instructional resource analysis were further enriched by scrutinizing two primary textbooks currently employed in Toraja. The comprehensive findings from the identification and evaluation of these instructional materials are presented systematically in Table 10.

The analysis of biological instructional resources reveals a significant divergence between Textbook A, which is characterized by a concise focus on core topics yet remains suboptimal for autonomous learning due to its non-communicative tone and lack of structural features, and Textbook B, which demonstrates superior pedagogical design. Textbook B offers exhaustive content descriptions and a communicative narrative suitable for independent study, while also incorporating contextual issues, internet integration, and critical thinking frameworks aligned with the Kurikulum Merdeka standards. Nevertheless, both publications conspicuously lack the integration of regional potential and indigenous wisdom. This highlights the necessity for instructional materials designed to be self-instructional, self-contained, and adaptive to enhance students' self-regulated learning.

The implementation of E-modules is highly effective in facilitating the mastery of biological concepts, as these instruments synthesize diverse media, including imagery, video, and animation, to render abstract principles more cognitively accessible (Saputri et al., 2022; Yuliani et al., 2022). The strategic significance of E-modules lies in their user-friendly, autonomous nature, which is instrumental in enhancing learning independence, cognitive outcomes, and critical thinking skills (Hanida et al., 2023). Furthermore, designs rooted in problem-based approaches stimulate sustained exploration, data analysis, and problem-solving, all of which are fundamental to fortifying students' higher-order thinking skills (Anggriani et al., 2024; Nuraeni et al., 2024; Sholihin et al., 2023).

Table 10*Identification and analysis of instructional materials used by teachers.*

	Aspect	Textbooks A	Textbooks B
1	Features	<ol style="list-style-type: none"> 1. Independent Activities 2. Collaborative Activities 3. Practice Exercises 	<ol style="list-style-type: none"> 1. Test Your Knowledge 2. Bio-Concepts 3. Real-World Applications 4. Worked Examples and Solutions 5. Learning Activities 6. Comprehension Check 7. Summary 8. Pre-Project 9. Reflection 10. AKM-Model Assessment Tasks
2	Book structure and organization	<ol style="list-style-type: none"> 1. Chapter Titles 2. Concept Maps 3. Aperception 4. Subject Matter Overview 5. Independent Activities 6. Collaborative Activities 7. Practice Exercises 8. Summary 9. Glossary 10. Reflection 11. Summative Assessment 12. Remedial Work 13. Enrichment 14. End-of-Semester Summative Assessment 	<ol style="list-style-type: none"> 1. Chapter Titles 2. Introduction 3. Subject Matter 4. Learning Activities 5. Worked Examples and Solutions 6. Comprehension Check 7. Test Your Knowledge 8. Summary 9. End-of-Chapter Exercises 10. Reflection
3	Incorporates contextual content	No	No
4	Incorporates indigenous wisdom or local potential	No	No
5	Visualization and internet-integrated instructional media	Yes	Yes
6	Supports autonomous learning	No	Yes

Potential and Local Wisdom of The Toraja Tribe

Based on observations and interviews with traditional leaders and the Toraja Utara Regency Tourism Office, several local potentials and wisdoms that can be integrated into biology learning are presented in Table 11. This table also shows biology topics that can be integrated with the potential and local wisdom of the Toraja people.

Table 11

Integration of Toraja indigenous knowledge and local potentials into biology learning based on learning outcomes.

Learning Outcomes	Phenomena	Biology Material
In Phase E, learners can solve problems based on local, national, or global issues related to understanding the diversity of living things and their roles, viruses and their roles, biological technology innovation, ecosystem components and interactions between components, and environmental change	<i>Ma' Tarampak</i> (Installation of the Roof of the Traditional Tongkonan House - Lower Part)	Biodiversity, Animal
	<i>Massomba Tedong</i> (Prayer of Worship and Praise to the Buffalo)	Biodiversity
	<i>Ma' Bubung</i> (Series of Thanksgiving Worship with the Extended Family)	Biodiversity
	<i>Ma' Pasa' Tedong</i> (Gathering Buffalo for Sacrifice in the Traditional Ceremony)	Biodiversity
	<i>Ma' Pasilaga Tedong</i> (Buffalo Fighting)	Biodiversity
	<i>Mantunu Tedong</i> (Slaughtering of Sacrificial Buffalo)	Biodiversity, Bacteria
	The philosophy of " <i>Tallu Lolona</i> ."	Biodiversity
	It is obligatory to plant Hangjuang (<i>Cordyline fruticosa</i>) and Puring (<i>Codiaeum variegatum</i>) in the yard or courtyard of Torajan traditional houses	Biodiversity
	Toraja woven cloth is used in traditional activities or ceremonies.	Biodiversity
	The Toraja tribe utilizes a variety of medicinal plants in their healing practices.	Biodiversity
In Phase F, learners can describe the bioprocesses that occur in cells and analyze the relationship between the structure of organs in the organ system and their functions and abnormalities or disorders that arise in the organ system. Learners can apply the concepts of inheritance of traits, growth, and development in everyday life and evaluate new ideas about evolution.	Toraja as a Tourist Destination	Biodiversity, Ecosystem
	<i>Ma' Tarampak</i> (Installation of the Roof of the Traditional Tongkonan House - Lower Part)	Nutrients
	<i>Massomba Tedong</i> (Prayer of Worship and Praise to the Buffalo)	Genetic
	<i>Ma' Bubung</i> (Series of Thanksgiving Worship with the Extended Family)	Growth and Development
	<i>Ma' Pasa' Tedong</i> (Gathering of Buffaloes as Sacrificial Offerings in the Traditional Ceremony)	Genetic
	<i>Ma' Pasilaga Tedong</i> (Buffalo Fighting)	Musculoskeletal System, Nutrients
	<i>Mantunu Tedong</i> (Slaughtering of Sacrificial Buffalo)	Digestive System, Respiratory System, Circulatory System
	<i>Ma' Badong</i> (Singing Lamentations in Death)	Respiratory System
	<i>Ma' Kaburu'</i> (Burial of the Deceased)	Respiratory System, Musculoskeletal System

Based on Table 11, several aspects of local potential and wisdom can be integrated into biology teaching materials, such as biodiversity and its benefits in Phase E of the Merdeka Curriculum. Other topics, such as the digestive, locomotor, and respiratory systems, as well as

growth, development, and genetics in Phase F of the same curriculum, can also incorporate activities rooted in local wisdom. Adapting the local potential and wisdom of the Toraja people into teaching and learning activities enables innovations that are responsive to classroom needs, making the learning process more contextual, relevant to students, and responsive to issues they face in their surrounding environment. Local wisdom-based learning is one of the strategies teachers can employ to present contextual learning experiences enriched with real-life applications, while simultaneously preserving the noble values of local wisdom that must be recognized by younger generations. Instructional approaches that utilize learning media grounded in local wisdom have been shown to enhance affective learning outcomes, particularly by fostering a love for local culture in students' immediate environment (Sriyati et al., 2021). Therefore, it is essential to integrate local wisdom and potential into teaching practices. The implementation of learning that draws upon local potential and wisdom has been positively received by students, as evidenced by their enthusiasm and active participation in the learning process.

CONCLUSION

The needs analysis confirms a critical disparity between the abundance of Torajan indigenous wisdom and the availability of relevant biology instructional materials. Although the Kurikulum Merdeka mandates contextual learning, a reliance on conventional resources has prevented the optimal integration of local ecological potential and cultural values. This condition constrains students' learning autonomy and their attainment of meaningful conceptual understanding. Consequently, the development of e-modules grounded in regional potential and indigenous wisdom emerges as a strategic pedagogical imperative. This innovation is essential for providing adaptive self-regulated learning resources while simultaneously transforming biology education into a more contextual, interactive, and efficacious trajectory.

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