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Development of Local Potential-Based Exploration Modules for Learning About Terrestrial Insect Diversity in High Schools

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ABSTRACT

This study aimed to analyze terrestrial insect diversity and develop a local potential-based exploration module for high school biology learning aligned with the Merdeka Curriculum. The research employed a Research and Development (R&D) design adapted from the Borg and Gall model, consisting of biodiversity data collection, module design, expert validation, and limited field testing. Field observations conducted at the Integrated Agricultural Laboratory of Jagan, Sukoharjo recorded 641 terrestrial insect individuals with a moderate level of species diversity and a relatively stable ecological structure. These empirical data were transformed into structured learning materials incorporating exploration activities, guided inquiry, and reflective tasks. The developed module was validated by subject-matter experts, instructional design experts, biology teachers, and Grade X students. The validation results indicated a very high level of feasibility, with expert scores exceeding 87% and positive responses from both teachers and students in terms of clarity, relevance, readability, and usability. These findings suggest that integrating authentic local biodiversity data into instructional modules enhances the quality and meaningfulness of biology learning. The module also demonstrates strong potential for adaptation in other regions through contextualization based on local biodiversity resources.

Pengembangan Modul Eksplorasi Berbasis Potensi Lokal untuk Pembelajaran Keanekaragaman Serangga Darat di Sekolah Menengah Atas

ABSTRAK: *Penelitian ini bertujuan untuk menganalisis keanekaragaman serangga darat serta mengembangkan modul eksplorasi berbasis potensi lokal untuk pembelajaran biologi SMA yang selaras dengan Kurikulum Merdeka. Penelitian menggunakan desain Research and Development yang diadaptasi dari model Borg dan Gall, meliputi pengumpulan data biodiversitas, perancangan modul, validasi ahli, dan uji coba terbatas. Hasil observasi lapangan di Laboratorium Pertanian Terpadu Jagan, Sukoharjo mencatat 641 individu serangga darat dengan tingkat keanekaragaman sedang dan struktur ekologi yang relatif stabil. Data empiris tersebut kemudian diintegrasikan ke dalam bahan ajar yang memuat aktivitas eksplorasi, penyelidikan terbimbing, dan refleksi. Modul yang dikembangkan divalidasi oleh ahli materi, ahli desain pembelajaran, guru biologi, dan siswa kelas X. Hasil validasi menunjukkan tingkat kelayakan yang sangat tinggi, dengan skor ahli di atas 87% serta respons positif dari guru dan siswa terkait kejelasan, relevansi, keterbacaan, dan kegunaan. Temuan menunjukkan integrasi data keanekaragaman hayati lokal dalam modul pembelajaran mampu meningkatkan kualitas dan kebermaknaan serta dimanfaatkan di berbagai daerah berbasis potensi lokal.*

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INTRODUCTION

Terrestrial insects play a crucial role in maintaining ecosystem stability through their functions as pollinators, decomposers, and key components of food webs. Their ecological contributions are fundamental to sustaining biodiversity, supporting agricultural productivity, and maintaining environmental balance (Angon et al., 2023; Rehman et al., 2022). However, recent global trends indicate a significant decline in insect populations, driven by habitat loss, climate change, and anthropogenic disturbances (Wagner, 2020; Wilson & Fox, 2021). This decline not only threatens ecological resilience but also reduces the availability of biological resources essential for environmental education. In this context, strengthening biodiversity literacy has become increasingly important, particularly within formal education systems. High school biology education represents a strategic platform for fostering ecological awareness and scientific understanding among students (Honra, 2025; Sembiring & Yusuf, 2025). Therefore, integrating authentic biodiversity knowledge into educational practices is essential to address both ecological and pedagogical challenges.

Despite the recognized importance of biodiversity education, classroom practices often remain detached from real ecological contexts. Biology instruction at the secondary school level frequently emphasizes theoretical knowledge and textbook-based learning, limiting students' opportunities to engage directly with living organisms (Park et al., 2020; Situmorang et al., 2024). As a result, students tend to perceive biodiversity as abstract information rather than as dynamic ecological phenomena. This gap between theory and real-world experience can lead to superficial understanding and reduced interest in environmental topics (Chawla, 2020; Grennfelt et al., 2020). Furthermore, limited exposure to local biodiversity restricts the development of essential scientific skills such as observation, classification, and data interpretation (Echeverria et al., 2021; Ekström, 2021). These conditions highlight a persistent issue in biology education, where learning remains conceptually isolated from students' immediate environments. Consequently, there is a need to reorient instructional approaches toward more contextual and experiential learning.

The urgency of improving biodiversity education is further emphasized within the framework of the Merdeka Curriculum in Indonesia, which promotes deep learning, student autonomy, and contextual learning experiences. In practice, however, the implementation of these principles remains inconsistent, particularly in biology classrooms (Hastangka et al., 2025; Hunaepi & Suharta, 2024). Preliminary observations indicate that teaching practices are still predominantly teacher-centered, with limited opportunities for student exploration and inquiry-based activities. Instructional materials are often generalized and fail to incorporate local ecological data, reducing their relevance to students' lived experiences (Duggan et al., 2020; Hunaepi & Suharta, 2024). This disconnect undermines the effectiveness of learning and weakens students' environmental awareness. Moreover, the absence of locally contextualized learning resources prevents students from recognizing the ecological significance of their surrounding environments. Therefore, developing instructional materials that integrate local biodiversity is both an educational necessity and a curriculum demand.

One promising approach to addressing these challenges is the use of local potential-based learning, which emphasizes the integration of locally available resources into instructional design. By utilizing local biodiversity as a learning context, students can connect abstract biological concepts with observable phenomena in their environment (Hamzah & Nurahasana, 2023; Wiegelmann & Zabel, 2021). This approach aligns with place-based education principles, which have been shown to enhance student engagement, conceptual understanding, and environmental responsibility (Hernandez, 2023; Yemini et al., 2025). In addition, incorporating authentic ecological data into learning materials can

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foster higher order thinking skills and scientific reasoning (Kwangmuang et al., 2021; Li et al., 2024). Learning modules, in particular, offer a structured format for implementing such approaches by guiding students through exploration, inquiry, and reflection. Consequently, local potential-based modules represent a pedagogically sound strategy for improving biodiversity learning in high school settings. This rationale underscores the importance of developing context-specific instructional materials grounded in empirical data.

Previous studies have demonstrated the effectiveness of inquiry-based and field-based learning approaches in enhancing students' understanding of biodiversity. Research indicates that direct engagement with natural environments enables students to construct knowledge through observation, data collection, and scientific investigation (Bae & Lai, 2020; Schilhab, 2021). Additionally, modules incorporating local contexts have been reported to improve science literacy, motivation, and conceptual comprehension (Uslan et al., 2024). Several studies also highlight the role of research-based learning materials in promoting conservation awareness and critical thinking skills (Philokyprou, 2025; Restović & Bulic, 2024). Furthermore, the integration of citizen science and project-based learning has been shown to strengthen students' connection to nature and biodiversity knowledge (Forti, 2023; Niemiller et al., 2021). These findings collectively suggest that contextual and experiential approaches are highly beneficial in biology education. However, the implementation of such approaches remains limited in many educational contexts.

Although existing studies provide valuable insights, several limitations remain evident. Many instructional modules are designed in a generalized manner and do not explicitly incorporate specific local ecosystems, reducing their contextual relevance (Duggan et al., 2020; Setiyanika et al., 2023). In addition, research focusing specifically on terrestrial insects as primary learning objects is still relatively scarce, despite their ecological importance and diversity (Slade & Ong, 2023; Stoler & Relyea, 2020). Most studies also emphasize either inquiry-based learning or local potential integration separately, rather than combining both approaches in a single instructional framework. Moreover, limited attention has been given to the systematic integration of empirical biodiversity data into structured learning modules. These gaps indicate the need for more comprehensive and context-specific instructional designs that bridge theoretical knowledge with real ecological conditions. Addressing these limitations is essential for advancing the quality and relevance of biology education.

Based on the identified gaps, there is a clear need to develop a learning module that integrates local biodiversity data, particularly terrestrial insect diversity, into structured exploration-based activities. Such a module should not only provide scientific content but also facilitate inquiry, data analysis, and reflective learning. By utilizing real ecological data from local environments, students can develop deeper conceptual understanding and stronger connections to biodiversity issues. In addition, integrating empirical research findings into instructional materials can enhance the authenticity and credibility of the learning process. This approach also aligns with design-based research principles, which emphasize the development of practical and adaptable educational solutions (Fowler & Leonard, 2024; Tinoca et al., 2022). Therefore, a context-specific exploration module based on local potential offers a meaningful contribution to both theory and practice in biology education. This perspective forms the foundation for the present study.

Accordingly, this study aims to: (1) characterize terrestrial insect diversity at the Integrated Agricultural Laboratory of Jagan, Sukoharjo as core content for learning; (2) develop a local potential-based exploration module for high school biology; and (3) evaluate the feasibility of the developed module through expert, practitioner, and student validation.

Theoretically, this study contributes to the development of contextual learning frameworks

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that integrate local biodiversity into biology education. Practically, it provides a structured and adaptable instructional module that can be implemented in high school classrooms and replicated in other regions. By combining empirical ecological data with inquiry-based learning design, this study offers an innovative approach to enhancing biodiversity literacy. Furthermore, the findings are expected to support the implementation of the Merdeka Curriculum by promoting meaningful, student-centered learning experiences. Ultimately, this research seeks to bridge the gap between ecological knowledge and classroom instruction through context-based educational innovation.

METHOD

This study employed a Research and Development (R&D) design aimed at developing and evaluating a local potential-based exploration module on terrestrial insect diversity for high school biology. The R&D approach was selected because it enables the systematic development of educational products while simultaneously assessing their feasibility and practicality in real learning contexts. The study adapted the Borg and Gall development model, which was modified into seven operational stages to suit the scope and feasibility of this research. This design is appropriate as it integrates empirical data collection, product development, validation, and iterative revision, thereby ensuring that the resulting module meets both scientific and pedagogical standards.

The research was conducted at the Integrated Agricultural Laboratory of Jagan, Sukoharjo, Indonesia, which served as both the source of empirical biodiversity data and the contextual basis for module development. The implementation phase involving users took place in a public senior high school in Sukoharjo. The study was carried out over a six-month period, from March to August 2025, encompassing field data collection, module design, validation, and revision stages. The selected location is characterized by diverse terrestrial insect populations, making it a suitable site for contextual biodiversity-based learning development.

The population of this study consisted of three groups: subject-matter experts, instructional design experts, and end users (teachers and students). The sample included six subject-matter experts and six instructional design experts, all of whom held at least a master's degree in biology education or a related field and had experience in curriculum or instructional material development. Additionally, two biology teachers with a minimum of five years of teaching experience were involved as practitioner validators. The user testing involved 25 Grade X high school students, selected using purposive sampling based on their prior exposure to biodiversity topics. This sampling approach was employed to ensure that participants possessed sufficient background knowledge to evaluate the usability and relevance of the module.

Data were collected using multiple research instruments designed to capture both qualitative and quantitative information. The primary instruments included validation questionnaires, observation sheets, and documentation forms. The validation questionnaires were developed based on established instructional design and content evaluation criteria, encompassing aspects such as content accuracy, instructional clarity, relevance to curriculum, visual presentation, and usability. Each item was measured using a Likert-scale format ranging from 1 (very inappropriate) to 5 (very appropriate). In addition, open-ended sections were included to gather qualitative feedback and suggestions from validators. The instrument indicators were adapted from previous module development studies and aligned with the principles of contextual and inquiry-based learning.

The validity and reliability of the instruments were ensured through a multi-step process. Content validity was established through expert judgment, involving senior

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academics in biology education who reviewed the relevance and clarity of each item. Revisions were made based on their feedback prior to implementation. Construct validity was examined by aligning instrument indicators with theoretical frameworks of instructional design and biodiversity learning. To ensure reliability, a pilot test was conducted with a small group of respondents, and internal consistency was analyzed using Cronbach's alpha, with a threshold value of ≥ 0.70 indicating acceptable reliability. This process ensured that the instruments were both valid and reliable for measuring module feasibility.

The data collection procedure was conducted in several sequential stages. First, a field study was carried out to collect empirical data on terrestrial insect diversity, including species composition, abundance, and ecological indices. Second, a literature review was conducted to identify relevant theories and curriculum requirements. Third, the initial module prototype was developed by integrating empirical findings into structured learning materials. Fourth, the module underwent expert validation, during which subject-matter and design experts evaluated its quality. Fifth, revisions were made based on expert feedback. Sixth, practitioner and user testing were conducted to assess the module's practicality and usability in real classroom contexts. Finally, a final revision was implemented to produce the operational version of the module.

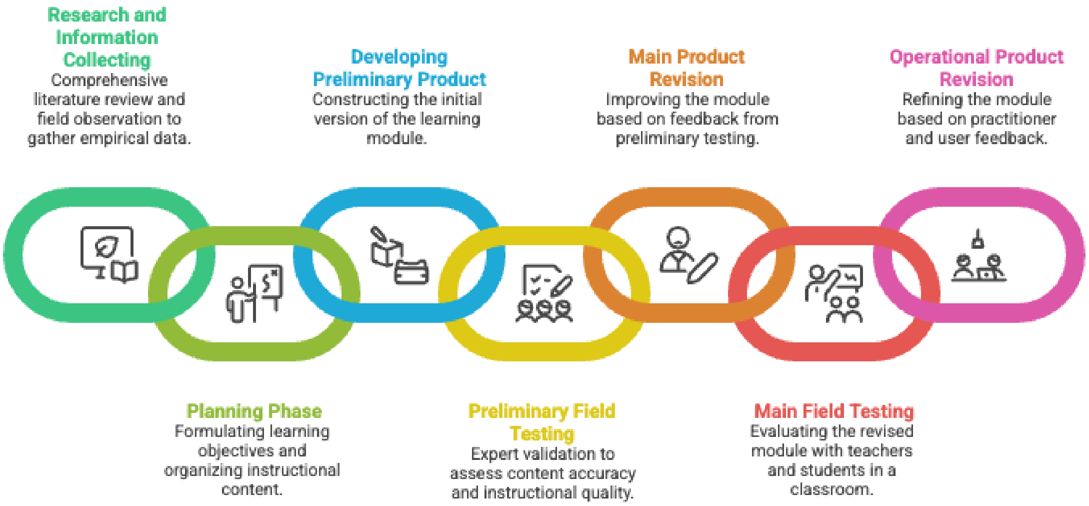

Figure 1. Research Procedure

Quantitative data obtained from validation questionnaires were analyzed using descriptive percentage analysis. The feasibility score for each aspect was calculated using the formula:

$$N = \frac{\Sigma_X}{N_{max}} \times 100\%$$

where N represents the percentage score, Σ_X is the total score obtained, and N_{max} is the maximum possible score. The results were then interpreted based on predefined feasibility criteria: 0–20% (very infeasible), 21–40% (infeasible), 41–60% (moderately feasible), 61–80% (feasible), and 81–100% (very feasible). Qualitative data from open-ended responses were analyzed using thematic analysis, involving data reduction, categorization, and interpretation to identify patterns and inform module revision. The integration of quantitative and qualitative analyses allowed for a comprehensive evaluation of the module's quality.

This study adhered to established research ethics principles. All participants were

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informed about the purpose of the study and provided voluntary consent prior to participation. Confidentiality and anonymity were strictly maintained by ensuring that no personal identifiers were disclosed in the data reporting. Participants were also given the right to withdraw from the study at any stage without any consequences. Furthermore, the study ensured academic integrity by properly citing all sources and avoiding data manipulation. Ethical considerations were particularly emphasized during student involvement to ensure a safe and respectful research environment.

RESULTS AND DISCUSSION

Results

The initial stage of this study involved field observation and biodiversity data collection conducted at the Integrated Agricultural Laboratory of Jagan, Sukoharjo. The results indicated that a total of 641 terrestrial insect individuals were recorded, representing a range of taxonomic groups. Several taxa, including mosquitoes, grasshoppers, crickets, and ants, exhibited relatively high abundance, suggesting their adaptability to the local environmental conditions. In contrast, other taxa were present in lower numbers, indicating variability in species distribution within the habitat. The calculated ecological indices showed a moderate level of species diversity and richness, with relatively even distribution and no dominant species. These findings demonstrate that the study area supports a stable and heterogeneous terrestrial insect community.

Based on the empirical findings, the study proceeded to the development of a local potential-based exploration module. The biodiversity data obtained from the field were systematically transformed into instructional content aligned with the learning outcomes of Phase E in the Merdeka Curriculum. The module was designed to incorporate activities such as insect identification, ecological data analysis, and guided inquiry tasks. The learning indicators included analyzing levels of insect diversity, conducting observations, comparing biodiversity data, and drawing conclusions based on ecological analysis. The module structure consisted of an introduction, core materials, presentation of local potential, student worksheets, observation activities, evaluation instruments, and references.

Figure 2. Cover

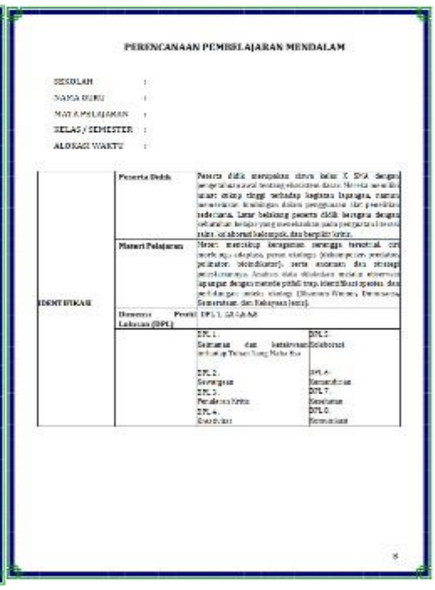
PETUNJUK PENGGUNAAN MODUL

Pedoman Penggunaan Modul
Untuk membantu siswa dan guru memahami materi pada bab ini disajik pedoman penggunaan modul sebagai berikut

A. Bagi Siswa
1. Bacalah dan pahami dengan seksama uraian-uraian materi pada modul.
2. Lakukan kegiatan belajar yang tercantum dalam modul untuk melatih keterampilan yang dimiliki oleh siswa.
3. Kerjakan latihan soal dan uji kompetensi untuk mengetahui seberapa besar pemahaman yang telah dimiliki terhadap materi dalam modul.
4. Apabila ada materi yang belum jelas, siswa dapat bertanya kepada guru mata pelajaran ataupun mengeksplorasi melalui sumber belajar yang lain.

B. Bagi Guru
1. Guru sebagai fasilitator dalam menggunakan modul ini adalah dengan mengarahkan siswa untuk memahami materi, melakukan kegiatan belajar dan mengujicoba kemampuan siswa dalam mengerjakan latihan soal maupun uji kompetensi

Figure 3. Instructions for use



PERENCANAAN PEMBELAJARAN MENDALAM

SEKOLAH :
NAMA GURU :
MATA PELAJARAN :
KELAS / SEMESTER :
ALOKASI WAKTU :

IDENTIFIKASI	Peserta Didik	[illegible]	
	Materi Pelajaran	[illegible]	
	Dimensi Profil Lulusan (DPL)	[illegible]	
		DPL 1. Keimanan dan ketakwaan terhadap Tuhan Yang Maha Esa	DPL 5. Kolaborasi
		DPL 2. Kewargaan	DPL 6. Kemandirian
		DPL 3. Penalaran Kritis	DPL 7. Kesehatan
		DPL 4. Kreativitas	DPL 8. Komunikasi

Figure 4. Lesson Plan

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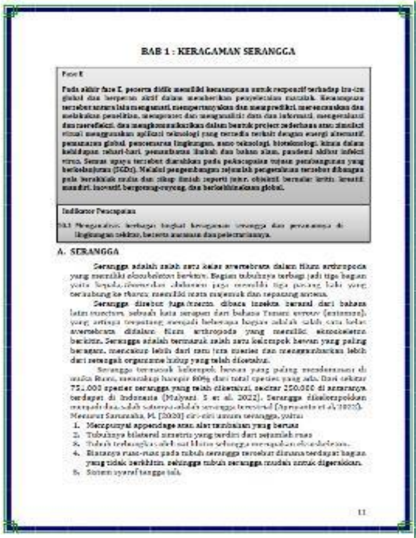
BAB 1 : KERAGAMAN SERANGGA

Figure 5. Material


LEMBAR KERJA SISWA (LKS)

Figure 6. Worksheet Based on Local Potential

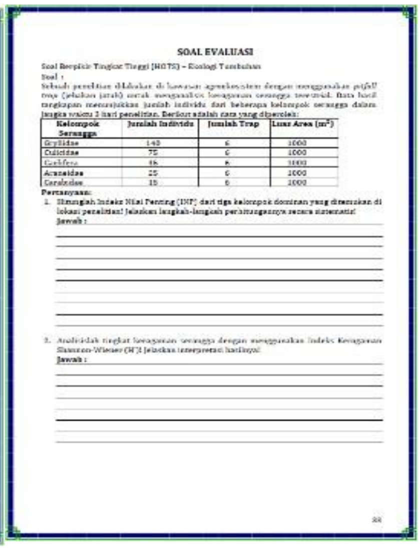
SOAL EVALUASI

Figure 7. Evaluation

The module components presented in Figures 2–7 illustrate a systematic and comprehensive instructional design. The module includes usage instructions, lesson plans, local potential-based materials, student worksheets, and evaluation sections. Each component was developed to integrate empirical biodiversity data with structured learning activities, ensuring that students can engage in exploration, analysis, and reflection. The organization of the module supports independent learning and facilitates the implementation of contextual and inquiry-based learning approaches.

The feasibility of the module content was evaluated through validation by six subject-matter experts. The results showed that all validators rated the module within the "very feasible" category. The percentage scores ranged from 87.50% to 96.67%, with an average score of 93.47%. These results indicate that the content of the module is scientifically accurate, relevant to learning objectives, and appropriate for high school biology instruction.

Table 2. Results of Material Validity Evaluation

Validator	Percentage Score (%)	Criteria
1	94.17	Very Feasible
2	96.67	Very Feasible
3	95.00	Very Feasible
4	90.83	Very Feasible
5	87.50	Very Feasible
6	96.67	Very Feasible
Average	93.47	Very Feasible

In addition to content validation, the module was evaluated by instructional design experts to assess its structure, presentation, and usability. The results showed that all validators provided scores above 87%, with an average score of 92.61%, categorized as very feasible. This indicates that the module has a well-organized structure, clear presentation, and appropriate instructional design for facilitating student learning.

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Table 3. Results of Learning Module Validity Evaluation

Validator	Percentage Score (%)	Criteria
1	93.18	Very Feasible
2	96.59	Very Feasible
3	94.32	Very Feasible
4	93.18	Very Feasible
5	87.50	Very Feasible
6	90.91	Very Feasible
Average	92.61	Very Feasible

The validation process also generated feedback and suggestions for improving the module. The main recommendations included adding Latin names for insect species, correcting typographical errors, improving image resolution, and enhancing instructional clarity. These suggestions were systematically incorporated into the revised version of the module.

Table 4. Suggestions and Improvements from Subject-Matter Experts and Module Experts

Suggestions	Improvements
Subject Matter Experts	
It is recommended that all individual names be accompanied by their Latin names.	List the Latin names of each insect on pages 23-27.
Some typographical errors and inaccuracies need to be corrected.	Correct typos and inaccuracies. For example, “di bawah” on page 18 should be “di bawah,” ‘jagan’ on page 29 should be “Jagan,” etc.
Images should be of good resolution so that they are not unclear, broken, or blurred.	Improve images with good resolution so that they appear clear. Refer to pages 23-27.
It would be good to add illustrations of insects to the material, then check again whether the evaluation measures all learning objectives.	Add illustrations of insects to the material referring to pages 6-7 and 30-36.
Modules Experts	
Clearer instructions for use are needed.	Correct the module usage instructions on page 7.
Implementation for learning does not yet exist.	Add implementation for learning to the module on page 36.
It is recommended that all individual names be accompanied by their Latin names.	List the Latin names of each insect on pages 23-27.

Following expert validation, the module was evaluated by practitioners, namely two biology teachers. The results showed that the module achieved an average feasibility score of 87.50%, which falls within the “very feasible” category. The teachers indicated that the module is suitable for classroom use, with clear learning objectives, relevant content, and a well-structured format.

Table 5. Results of Validity Testing by Practitioners

Practitioners	Percentage Score (%)		Criteria
	Module	Content	
1	89.77	93.30	Very Feasible
2	85.23	81.67	Very Feasible

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Practitioners	Percentage Score (%)		Criteria
	Module	Content	
Average	87.50	87.50	Very Feasible

49 3

The module was further evaluated through user testing involving 25 Grade X high school students. The results showed that all students rated the module as "very feasible," with scores exceeding 87% and an average score of 94.96%. These results indicate that the module is easy to understand, engaging, and supportive of student learning activities.

Table 6. Results of Validity Testing by Students

Students	Percentage Score (%)	Criteria
1	87.66	Very Feasible
2	96.06	Very Feasible
3	89.32	Very Feasible
4	92.01	Very Feasible
5	97.35	Very Feasible
6	92.69	Very Feasible
7	90.72	Very Feasible
8	89.02	Very Feasible
9	96.52	Very Feasible
10	94.51	Very Feasible
11	97.35	Very Feasible
12	92.88	Very Feasible
13	93.83	Very Feasible
14	98.03	Very Feasible
15	100.00	Very Feasible
16	94.55	Very Feasible
17	94.81	Very Feasible
18	92.96	Very Feasible
19	98.34	Very Feasible
20	96.21	Very Feasible
21	96.37	Very Feasible
22	97.05	Very Feasible
23	96.06	Very Feasible
24	98.60	Very Feasible
25	98.18	Very Feasible
Average	94.96	Very Feasible

Feedback from teachers and students was also collected to improve the final version of the module. The suggestions included improving visual quality, adding more engaging illustrations, updating references, and including assessment components for observation activities. These inputs were used to refine the module before finalization.

Table 7. Suggestions and Improvements from Teachers and Students

Suggestions	Improvements
Teachers	
Only corrections to the typing, there are some words with incorrect letters (typos) and do not yet comply with the rules of writing.	Correcting misspelled words (typos) and correcting them according to writing rules. For example, pitfall trap becomes pitfall trap, Density becomes Density.
Improve low-resolution or blurred images.	Improve the image resolution so that all images

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Suggestions	Improvements
	on pages 23–27 appear clear.
Add the latest scientific references on insect diversity.	Add the latest scientific references regarding insect diversity to Chapter I.
Include a section for assessing student observation results.	Include a section for assessing student observation results.
Students	
More interesting illustrations are needed. The image quality needs to be improved to make it clearer.	Adding more interesting illustrations and improving image quality for greater clarity.

3 Overall, the results indicate that the developed module meets the criteria of feasibility in terms of content, instructional design, and usability. The consistent high scores across expert, practitioner, and user evaluations demonstrate that the module is appropriate for implementation in high school biology learning.

Discussion

29 The findings of this study reveal that the terrestrial insect community in the Integrated Agricultural Laboratory of Jagan, Sukoharjo exhibits a moderate level of species diversity with a relatively stable ecological structure. This condition suggests a balanced ecosystem in which no single species dominates excessively, allowing for functional ecological interactions such as pollination, decomposition, and trophic regulation. From an ecological perspective, moderate diversity often reflects environments that are neither highly disturbed nor entirely pristine, but rather dynamically stable (Wagner, 2020; Wilson & Fox, 2021). This finding aligns with ecological resilience theory, which posits that ecosystems with moderate diversity can maintain stability through functional redundancy and species complementarity. Previous studies by Slade & Ong (2023) and Stoler & Relyea (2020) similarly report that terrestrial insect communities in semi-managed habitats tend to exhibit moderate diversity due to a balance between natural and anthropogenic influences. However, compared to highly conserved ecosystems, the diversity level observed here may be lower, potentially due to agricultural activities and habitat modification. This suggests that local environmental conditions play a critical role in shaping biodiversity patterns. Consequently, the ecological data generated in this study provide not only descriptive insights but also a meaningful basis for contextualized learning.

Building on these ecological findings, the transformation of empirical biodiversity data into structured learning materials represents a significant pedagogical contribution. The integration of real-world data into instructional modules reflects the principles of constructivist learning theory, where knowledge is actively constructed through interaction with authentic contexts (Hernandez, 2023; Kwangmuang et al., 2021). The use of local insect diversity as learning content allows students to connect abstract biological concepts with observable phenomena, thereby enhancing conceptual understanding. This finding supports previous research indicating that contextualized learning materials improve cognitive engagement and knowledge retention (Hamzah & Nurahasana, 2023; H. Li et al., 2024). Compared to traditional textbook-based approaches, which often present decontextualized information, this module offers a more meaningful learning experience. However, the effectiveness of such integration depends on the accuracy and relevance of the empirical data used. In this study, the use of systematically collected biodiversity data strengthens the scientific validity of the module. Therefore, the integration of empirical ecological data into
30 instructional design can be seen as an effective strategy for bridging the gap between theory and practice.

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Another important finding is the high feasibility of the developed module based on expert validation, with scores consistently exceeding 87%. This indicates that the module meets key criteria of instructional quality, including content accuracy, clarity, and alignment with curriculum standards. From the perspective of instructional design theory, particularly the ADDIE framework and design-based research principles, high feasibility reflects the effectiveness of iterative development and validation processes (Fowler & Leonard, 2024; Tinoca et al., 2022). The involvement of both subject-matter experts and instructional design experts ensures that the module is not only scientifically sound but also pedagogically appropriate. Similar findings have been reported by Uslan et al. (2024), who demonstrated that expert-validated modules tend to exhibit higher usability and instructional effectiveness. However, it is important to note that validation scores alone do not guarantee actual learning outcomes. The absence of experimental testing in this study limits the ability to assess the module's impact on student achievement. Nevertheless, the high validation results provide strong initial evidence of the module's quality and potential applicability.

The positive responses from biology teachers further reinforce the practical relevance of the developed module in real classroom settings. Teachers rated the module as highly feasible, indicating that it aligns well with instructional needs and classroom realities. This finding can be interpreted through the lens of curriculum implementation theory, which emphasizes the importance of teacher acceptance and usability in determining the success of educational innovations (Hastangka et al., 2025; Hunaepi & Suharta, 2024). The module's clear structure, contextual content, and alignment with the Merdeka Curriculum likely contributed to its positive reception. Previous studies by Duggan et al. (2020) and Situmorang et al. (2024) highlight that instructional materials lacking contextual relevance often face resistance from educators. In contrast, the present module demonstrates how local potential-based resources can enhance teacher engagement and instructional effectiveness. However, variations in teacher readiness and pedagogical competence may influence the implementation of such modules in different contexts. Thus, while the findings are promising, broader implementation studies are needed to confirm their generalizability.

In addition to teacher validation, the very high level of student acceptance indicates that the module is engaging, accessible, and supportive of learning processes. Students reported that the module was easy to understand and facilitated active participation, which suggests that it effectively promotes inquiry-based learning. This aligns with experiential learning theory, which posits that direct engagement with real-world phenomena enhances learning outcomes (Bae & Lai, 2020; Schilhab, 2021). The inclusion of activities such as observation, data analysis, and reflection enable students to develop higher-order thinking skills. Similar findings have been reported by Forti (2023) and Niemiller et al. (2021), who emphasize the role of inquiry-based and citizen science approaches in fostering scientific literacy. However, student perceptions may also be influenced by novelty effects, where new learning materials generate temporary enthusiasm. Therefore, long-term studies are needed to evaluate whether the observed engagement translates into sustained learning gains. Despite this limitation, the high student validation scores provide evidence of the module's usability and pedagogical value.

A critical aspect of this study is the integration of local potential-based learning with inquiry-based instructional design, which addresses a significant gap in previous research. While earlier studies often focus on either contextual learning or inquiry-based approaches separately, this study combines both within a single framework. This integration reflects the principles of place-based education, which emphasize the use of local environments as a foundation for learning (Wiegelmann & Zabel, 2021; Yemini et al., 2025). The findings suggest that such integration not only enhances conceptual understanding but also fosters

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environmental awareness and responsibility. Compared to studies by Philokyprou (2025) and Restović & Bulic (2024), which primarily examine research-based learning materials, this study extends the theoretical framework by incorporating empirical biodiversity data into module design. This represents a novel contribution to the field of biology education. However, the effectiveness of this integrated approach may vary depending on the availability of local biodiversity resources. Therefore, adaptation to different ecological contexts requires careful consideration.

Furthermore, the study highlights the importance of contextual factors in shaping both ecological findings and educational outcomes. The specific characteristics of the research site, including its agricultural setting and biodiversity composition, influence the type of data generated and its applicability to learning. This suggests that local potential-based modules are inherently context-dependent and may not be directly transferable without modification. This finding is consistent with the work of Echeverria et al. (2021) and Ekström (2021), who emphasize the role of local context in environmental education. At the same time, this context-dependency can be seen as a strength, as it allows for the development of highly relevant and meaningful learning experiences. However, it also raises questions about scalability and standardization. Alternative explanations for the observed effectiveness may include factors such as teacher facilitation and student motivation, which were not explicitly controlled in this study. Therefore, future research should explore these variables in more detail.

Finally, this study contributes both theoretically and practically to the field of biology education by demonstrating how empirical ecological data can be systematically integrated into instructional design. Theoretically, it extends existing frameworks of contextual and inquiry-based learning by incorporating local biodiversity as a central component. Practically, it provides a validated and adaptable module that can be implemented in high school settings. This contribution addresses a critical gap identified in previous studies, particularly the lack of context-specific instructional materials (Duggan et al., 2020; Setiyanika et al., 2023). Moreover, the study positions itself within the broader global discourse on sustainability education and biodiversity literacy. By linking ecological research with classroom practice, it offers a model for interdisciplinary integration. Nevertheless, the absence of experimental validation remains a limitation that should be addressed in future studies. Overall, the findings underscore the potential of local potential-based modules to transform biology learning into a more meaningful, contextual, and scientifically grounded process.

CONCLUSION AND SUGGESTIONS

This study successfully characterized the diversity of terrestrial insects at the Integrated Agricultural Laboratory of Jagan, Sukoharjo, and utilized the empirical findings as the core content for developing a local potential based exploration module for high school biology learning. The results of biodiversity analysis indicated a moderate level of species diversity and a relatively stable ecological structure, providing a meaningful and contextually relevant foundation for instructional material development. The developed module integrates authentic local biodiversity data with structured exploration activities, guided inquiry tasks, and reflective learning components aligned with the Phase E learning outcomes of the Merdeka Curriculum.

The feasibility evaluation results demonstrate that the module possesses a very high level of validity and practicality. Validation by subject matter experts and instructional design experts confirmed that the module meets scientific accuracy, instructional quality, and design standards. Furthermore, practitioner validation indicated that the module is

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pedagogically appropriate and applicable in real classroom contexts, while user validation showed that the module is highly readable, engaging, and effective in supporting student learning. These findings suggest that integrating local biodiversity data into instructional materials enhances the relevance, meaningfulness, and effectiveness of biology learning at the secondary school level.

Despite these positive outcomes, this study has several limitations. The research was limited to the development and feasibility evaluation stages and did not include experimental testing to measure the effectiveness of the module in improving learning outcomes, higher order thinking skills, or long-term retention. In addition, the implementation was conducted within a single ecological and institutional context, which may limit the generalizability of the findings without further adaptation.

Therefore, future research is recommended to conduct experimental or quasi-experimental studies to examine the effectiveness of the module compared to conventional learning materials. Longitudinal studies are also needed to evaluate its impact on students' biodiversity literacy, environmental awareness, and scientific reasoning over time. Furthermore, replication of this module development framework in different ecological regions is encouraged to test its adaptability and scalability. From a practical perspective, educators are encouraged to integrate local potential into biology learning as a strategy to promote contextual, inquiry-based, and meaningful learning experiences.

LIMITATIONS

This study has several limitations that should be acknowledged. First, the research was limited to the development and feasibility validation stages of the module and did not include experimental implementation to measure its direct effectiveness on students' learning outcomes, critical thinking skills, or long-term biodiversity literacy. The evaluation focused primarily on expert judgment, teacher responses, and student perceptions regarding the usability and appropriateness of the module. Consequently, although the module demonstrated a very high level of feasibility, the extent to which it significantly improves cognitive achievement and environmental awareness remains empirically untested. In addition, the sample size for field implementation was relatively limited and involved students from a single senior high school, which may restrict the broader generalizability of the findings.

Another limitation relates to the contextual nature of the module development process. The instructional materials were specifically designed based on terrestrial insect diversity data collected from the Integrated Agricultural Laboratory of Jagan, Sukoharjo, meaning that the ecological content and examples may not fully represent biodiversity conditions in other regions. Differences in local ecosystems, school resources, teacher readiness, and student characteristics could influence the applicability and effectiveness of the module in different educational settings. Furthermore, the study relied mainly on descriptive quantitative analysis and qualitative feedback without incorporating more advanced statistical approaches or comparative experimental designs. Therefore, future studies are recommended to conduct wider-scale implementation, experimental testing, and cross-regional adaptation to strengthen the validity, scalability, and educational impact of the developed module.

AUTHOR CONTRIBUTIONS

AAN contributed to the conceptualization of the study, research design, field data collection, module development, data analysis, and manuscript drafting. **VA** and **AA** contributed to instructional design validation, data interpretation, literature review,

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manuscript revision, and final editing. All authors reviewed and approved the final version of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest regarding the publication of this study. The research was conducted independently without any commercial or financial relationships that could be interpreted as potential conflicts of interest.

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