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Design and Validation of a Medicinal Plant Diversity Learning Module Based on Research in Las-Lasan Village Klaten for High School Students

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ABSTRACT

This study examines the diversity of medicinal plants in Las-Lasan Village, Klaten, and develops a research-based learning module for high school students. This research is part of a research and development project encompassing the following stages: preliminary study, planning, initial product development, revision of the initial product, limited field testing, and revision of the second product. The learning module design is based on existing learning modules used in high schools and integrated with the research findings on medicinal plant diversity. The learning module was validated by learning module experts and experts in plant diversity. Data analysis of expert validation results was conducted using quantitative descriptive analysis. The study concludes that the medicinal plant diversity learning module based on research in Las-Lasan Village, Klaten is highly feasible for use in high school biology learning. By integrating empirical data, the module enhances students' understanding of ecology and biodiversity, promotes independent learning, and supports contextual, critical, and applicable education.

KEYWORDS

Medicinal plants,
Biology,
Learning module,

1. Introduction

Medicinal plants have played a central role in human civilization, functioning not only as primary sources of traditional medicine but also as vital components of modern pharmaceuticals (Tungmunnithum et al, 2018; Jamshidi-Kia et al, 2018). The World Health Organization (WHO) estimates that around 80% of the global population relies on plant-based traditional remedies for primary healthcare. This reliance demonstrates the ecological, cultural, and economic importance of medicinal plants across societies. However, global biodiversity is increasingly threatened by deforestation, habitat loss, climate change, and unsustainable exploitation, putting medicinal plants at serious risk. Preserving and documenting local plant resources has therefore become an urgent priority, not only for health and economic purposes but also for sustainable education and conservation strategies (Majeed, 2017; Wijesekera, 2017).

Indonesia, recognized as one of the world's mega-biodiversity countries, harbors an extraordinary richness of medicinal plants distributed across diverse ecological regions. Many species are integral to cultural traditions and community healthcare practices, with knowledge often passed down orally from generation to generation (Sanka et al, 2023). Unfortunately, modernization and the declining use of traditional medicine have reduced awareness of medicinal plant diversity, particularly among younger generations. In schools, especially at the senior high school level, the biology curriculum rarely integrates local biodiversity in a meaningful way (Suhartati et al, 2024). As a result, students often

experience a disconnect between what they learn in class and their immediate environment, raising concerns about the continuity of ethnobotanical knowledge and the potential loss of valuable natural resources (Rinto et al, 2023).

Previous research in science and biology education indicates that integrating local biodiversity into learning materials makes education more contextual and meaningful (Adinugraha, 2022; Anwari, 2016). Conventional teaching that relies heavily on textbooks and generalized content often limits student engagement and their ability to connect scientific concepts with real-world issues. In contrast, research-based learning materials have been shown to enhance student motivation, scientific literacy, argumentation skills, and ecological awareness (Burrow, 2018; Haviz, 2018). Similarly, socio-scientific issue (SSI)–based approaches and ethnobiological knowledge have proven effective in fostering critical thinking, reasoning, and environmental stewardship (Paristri, 2018; Jia et al, 2025). Despite this evidence, a substantial gap remains: most ethnobotanical studies in Indonesia focus on documenting species diversity, pharmacological potential, or ecological indices, yet their findings often remain confined to scientific publications and are rarely translated into structured, validated educational resources for schools.

This gap represents a missed opportunity in biology education. Existing teaching materials often remain abstract, disconnected from students' local contexts, and insufficiently validated in terms of scientific accuracy and pedagogical feasibility. Consequently, students seldom engage with authentic data from their own communities, limiting the development of ecological literacy, inquiry skills, and independent learning.

Addressing these challenges requires innovative efforts to bridge biodiversity research and classroom practice. One promising pathway is the development of research-based instructional modules derived directly from empirical studies in local contexts. Such modules can enrich the curriculum with authentic data, strengthen the connection between students and their environment, and foster both cognitive and affective learning outcomes (Haka et al, 2020; Syahfitri & Muntahanah, 2023; Yulis et al, 2021).

Based on this rationale, the present study was designed with three objectives: (1) to identify and analyze the diversity of medicinal plants in Las-Lasan Village, Klaten Regency, using systematic ecological methods; (2) to develop a high school biology learning module grounded in these empirical findings; and (3) to validate the module in terms of content accuracy, pedagogical relevance, and classroom feasibility. By achieving these objectives, the study seeks to provide an empirically grounded, pedagogically sound model of research-based learning that enhances biology education while promoting biodiversity conservation and cultural continuity.

2. Method

The type of research refers to the stages of research and development (R&D) based on Borg and Gall, which have been adapted into seven stages (Nugroho, et al 2017; Haka et al, 2020; Latifa, 2021), namely investigation and data collection, design, initial prototype creation, initial product testing, improvements to the initial product, limited-scale trial testing, and further improvements. The modification was made because certain original stages, such as dissemination and implementation, are considered optional and demand more time and resources. In contrast, the present study primarily emphasizes product development and feasibility testing on a limited scale. This adjustment allows the procedure to maintain the fundamental principles of research and development while making it more

contextually relevant and efficient for implementation at the secondary school level. The research and development process for the learning module was conducted from January 2025 to March 2025. The development procedure for the Medicinal Plant Diversity module can be illustrated as shown in Figure 1.

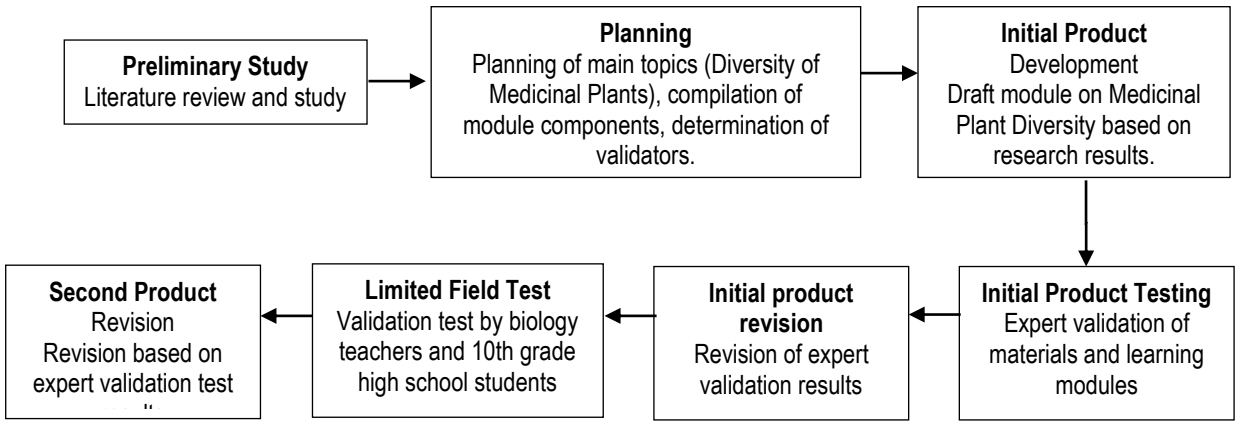

Figure 1. Procedure for Developing Research-Based Learning Modules

This study employed a Research and Development (R&D) model to design and validate a medicinal plant diversity learning module based on research in Las-Lasan Village, Klaten. The process was carried out through several stages. The research began with a preliminary study, which included problem identification, literature review, and data collection to ensure the module addressed actual educational needs. The planning stage followed, focusing on determining the topic, structuring the module components (introduction, objectives, core material, activities, evaluation, and references), and selecting four expert validators and two biology teachers. An initial product draft was then developed, containing content, practice activities, and evaluation instruments aligned with educational standards. This draft underwent a small-scale trial with five subject-matter experts and six module-development experts to obtain feedback. Based on their input, the module was revised to improve accuracy, clarity, and instructional design. The revised version was tested in a limited field trial with biology teachers to assess practicality and effectiveness in classroom learning. A final second revision was then conducted, producing a validated and high-quality module ready for implementation in high school biology instruction.

Data for this study were collected through three main techniques. The first was observation, which was conducted to examine the diversity of medicinal plants in Las-Lasan Village, Bulan. This technique allowed the researchers to directly document the presence, distribution, and ecological characteristics of the species found in the field. The second technique was documentation, in which various medicinal plants were photographed and recorded as supporting data. These records were then identified and verified using the Google Lens application to ensure accuracy in species classification. The third technique involved the use of a questionnaire as an assessment instrument. This was employed during the validation process of the developed module, in which subject-matter experts, module-development experts, and practicing biology teachers evaluated the accuracy, feasibility, and pedagogical quality of the product (Haka et al, 2020; Bachtiar et al, 2022).

The data collected in this study were analyzed using both qualitative and quantitative methods. For the qualitative analysis, data obtained from observations and documentation of medicinal plants were examined descriptively to provide a comprehensive picture of species diversity in Las-Lasan Village. In addition, feedback from subject-matter experts and module-development experts was analyzed qualitatively to identify necessary improvements in the draft module and to ensure the accuracy and relevance of the content. For the quantitative analysis, data from the evaluation

conducted by material experts, module experts, and biology teachers were processed to determine the degree of feasibility of the developed module. The scores obtained from various evaluated aspects were calculated and interpreted using the formula proposed by Nugroho and Subiyantoro (2017). This calculation provided a percentage score that represented the overall validity and feasibility of the medicinal plant diversity module for use in high school biology learning (Haka et al, 2020).

$$N = \frac{K}{Nk} x\ 100\%$$

Explanation:

N : Percentage of each aspect assessed

K : Total score obtained

Nk : Highest score that can be achieved

Meanwhile, the module eligibility standards are presented in Table 1.

Table 1. Module Eligibility Standards

Score Range	*Qualification*	*Criteria*
81≤N<100	Very Good	Very Feasible
62 ≤N< 81	Good	Feasible
43 ≤N< 62	Enough	Not Feasible
24 ≤N< 43	Less	Not Feasible

If the validation results show a percentage of ≥ 81%, then the learning module on medicinal plant diversity based on research is deemed highly suitable for use in learning.

3. Results and Discussion

3.1 Identify and Analyze The Diversity of Medicinal Plants in Las-Lasan Village

The study of medicinal plant diversity was conducted by examining the diversity of medicinal plants through systematic ecological methods. The ecological indices used in vegetation analysis included calculations of the Importance Value Index (IVI), diversity index, species richness index, species evenness index, and dominance index. The research results were used as content in the module. The research results on the diversity of medicinal plants can be found in Table 2.

Table 2. Results of Medicinal Plant Diversity Identification.

Plant Name	*Number*	*IVI*	*Rank*	*H'*	*R_1*	*E*	*C*
Phyllanthus urinaria	29	2.25	3	2.25	3.11	0.23	0.001
Piper betle	5	1.18	12				0.000
Kaempferia galanga	12	1.47	7				0.000
Zingiber officinale	29	1.88	4				0.003
Cimbopogon Nardus L. Rendle	28	1.85	5				0.001
Curcuma domestica Val	12	1.47	11				0.000
Alpinia galanga	6	6.17	1				0.002
Curcuma zanthorrhiza	12	1.51	10				0.000
Boesenbergia rotunda	18	2.61	2				0.000
Moringa oleifera	1	1.03	15				0.000
Aloe vera	10	1.36	8				0.000
Merremia mammosa	2	1.1	14				0.000
Mimosa pudica L	2	1.1	14				0.000
Colocasia esculenta	7	1.29	9				0.000
Morinda citrifolia	1	1.03	15				0.000
Apium graveolens	16	1.59	6				0.000
Psidium guajava L	1	1.4	13				0.001
Murraya paniculata	1	1.4	13				0.000
Annona muricata	1	1.4	13				0.000
Carica papaya L	8	1.29	9				0.003

Description: Importance Value Index (IVI), Rank (Diversity Ranking), H' (Species Diversity), R1 (Species Richness Index), E (Species Evenness Index), C (Dominance Index).

Research findings on medicinal plant diversity (Table 2) not only provide information on the types of plants that have the potential to be used in everyday life, but also have strategic value as a learning resource in the context of biology education. Empirical data obtained, such as the Importance Value Index (IVI), diversity index, species richness index, species evenness index, and dominance index, can be directly integrated into the development of learning modules.

3.2 Develop a learning module for high school biology based on these research findings

The development of the research-based medicinal plant learning module begins with a planning stage, which includes defining the topics to be addressed, designing the module components, and selecting expert reviewers. The central theme of this module is biodiversity in medicinal plant diversity, designed for 10th-grade high school students at the E Phase level. At this stage, students are expected to respond to global issues and actively engage in seeking solutions to real-world problems.

The competencies targeted in this module include observing, questioning, predicting, designing and conducting investigations, processing and analyzing data, evaluating and reflecting, as well as presenting outcomes in the form of simple projects or visual simulations using digital technology. To support these competencies, the module incorporates specific success indicators: (10.1) evaluating various levels of biodiversity and their roles in ecosystems, along with associated threats and conservation strategies, presented in tabular form; (10.2) conducting observational studies on biodiversity levels by comparing data from different regions in Indonesia using valid sources; and (10.3) identifying plant species in a research area through vegetation surveys, collecting and analyzing vegetation data, and calculating ecological indices such as the Importance Value Index (IVI), diversity index, species richness index, evenness index, and dominance index. Based on these analyses, students are expected to accurately interpret ecosystem conditions. The module is structured comprehensively, consisting of an introductory section (containing background information and instructions for use), a core section (with lesson materials, identification results of medicinal plants, student worksheets, and evaluation activities), and a closing section (containing conclusions and research implications). The module concludes with a bibliography.

The development of the research-based medicinal plant learning module involves designing and drafting modules that facilitate the preparation of teaching materials. The drafting process follows established guidelines to ensure that the modules are structured systematically and adhere to sound pedagogical principles. The following section presents the draft of the learning module that has been developed (Figure 2-5).

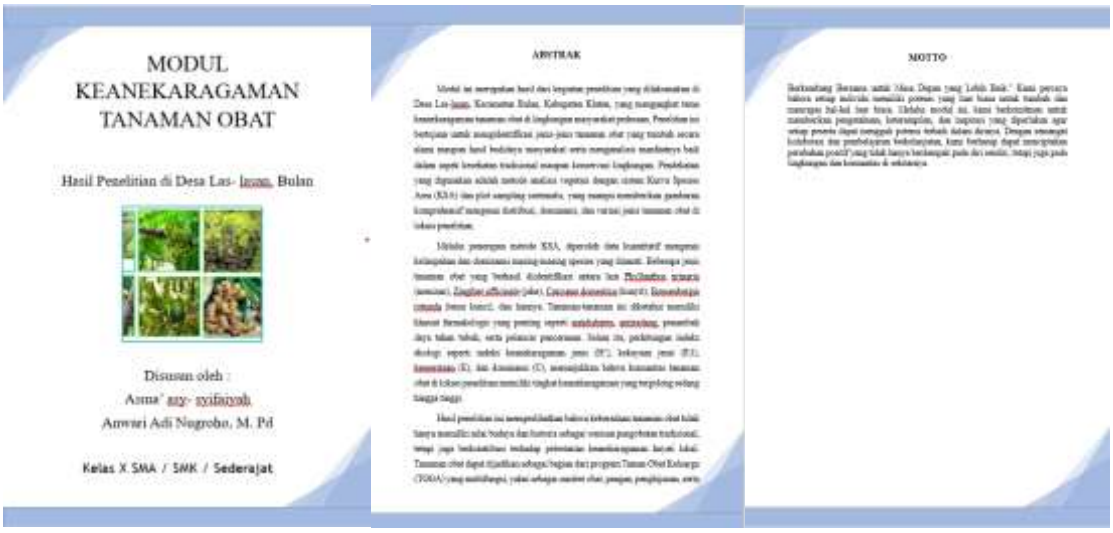

Figure 2. Cover, Abstract and Motto

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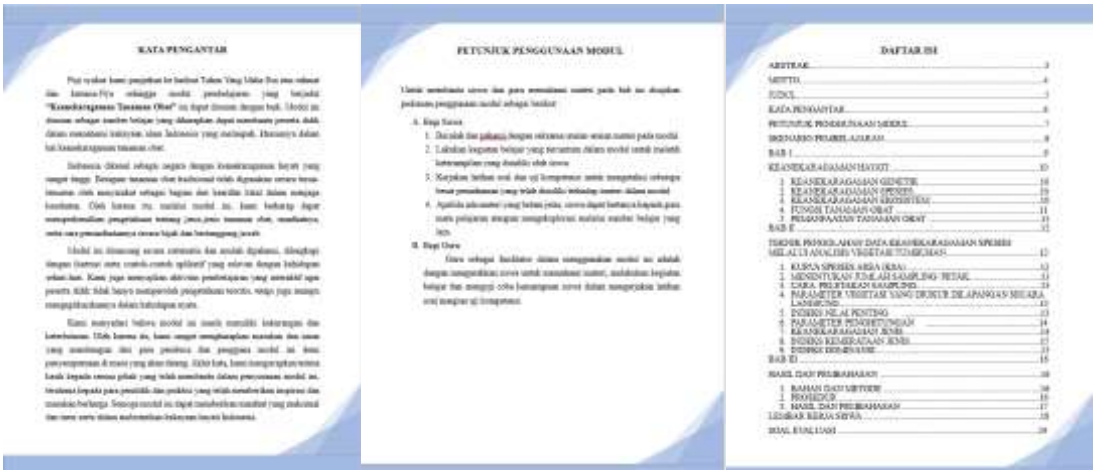

Figure 3. Foreword, Module usage instructions and Table of contents

Figure 4. Contents

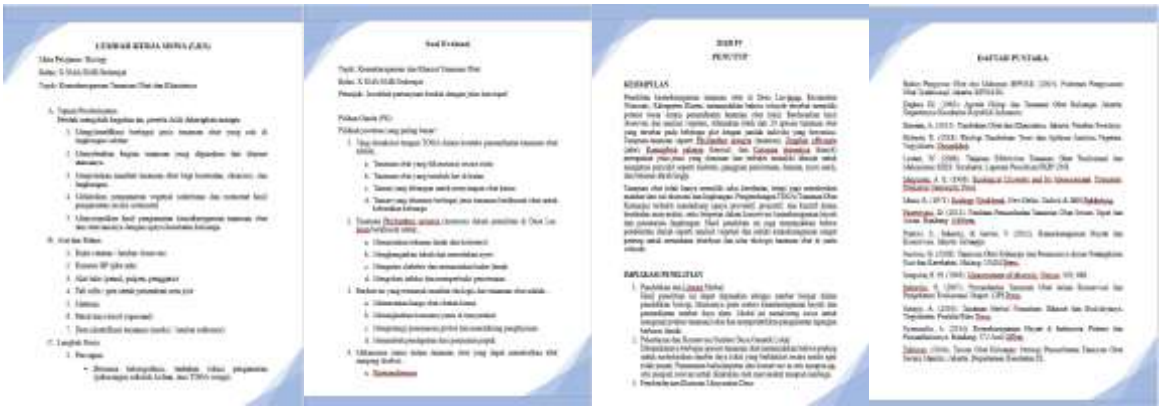

Figure 5. Student worksheets, Evaluation, Conclusion, and References

The draft of the research-based medicinal plant learning module was validated to obtain both qualitative descriptive evaluations and quantitative analyses. The validation process was conducted at Universitas Veteran Bangun Nusantara by distributing assessment instruments to expert validators. These validators consisted of subject matter experts and module development experts. This procedure aligns with (Nugroho et al, 2017; Haka et al, 2020), who emphasized that the initial product testing stage involves validation of the draft module by expert reviewers. Specifically, validation by subject

matter experts focused on learning aspects and the accuracy and relevance of the content. The results of the content validity evaluation are presented in Table 3.

Table 3. Expert assessment results on content validity

Validators	*Score (%)*	*Criteria*
1.	96,86	Very feasible
2.	88, 21	Very feasible
3.	96,86	Very feasible
4.	80,21	feasible
5.	84.81	Very feasible

The subsequent draft of the learning module was validated by module development experts. The evaluation covered several aspects, including the overall organization of the presentation, clarity and usefulness of the content, student engagement, visual design, structure of the learning module, variation in the delivery of information, and compliance with ethical standards and copyright regulations. The results of the expert validation are presented in Table 4.

Table 4. Expert assessment results on learning module validity

Validators	*Score (%)*	*Criteria*
1	98,82	Very feasible
2	90,41	Very feasible
3	98,21	Very feasible
4	88,44	Very feasible
5	82,91	Very feasible

The results of the expert assessment on the validity of the learning module show that all validators rated the module within the very feasible category, with scores ranging from 82.91% to 98.82%. The highest validity score was given by validator 1 (98.82%), while the lowest was given by Validator 5 (82.91%). Despite this variation, all scores fall within a high feasibility range, indicating that the module has met the required criteria in terms of content, presentation, and pedagogical structure. These results suggest that the medicinal plant diversity learning module is generally well-designed, scientifically accurate, and pedagogically appropriate for classroom use. Minor revisions may still be necessary to address specific suggestions from individual experts; however, the overall evaluation confirms that the module is valid and feasible for implementation in biology learning.

The research-based learning module on medicinal plant diversity was evaluated by expert validators, who provided constructive feedback and suggestions. Based on these inputs, the initial draft was revised to improve the overall module design. This validation stage is consistent with Sulistyaningrum, Karyanto et al, (2015) and Bachtiar et al (2022), who emphasized that expert review serves as an essential process for generating recommendations and improvements prior to conducting limited-scale testing. The suggestions from the expert validators formed the basis for refining the learning module, as summarized in Table 5.

Table 5. Input and revisions from expert validators

No	*Suggestions*	*Revisions*	*Conclusion*
Content Expert			
1	Please complement the material with illustrations at the biodiversity level.	Add relevant illustrations.	Overall, the material is already good.
2	In the results and discussion section, use local names instead of common names.	Replace common names with local names.	Overall, already good.
3	The results and discussion section should be revised to ensure consistency with the learning outcome indicators.	Revise results and discussion.	Overall, already good.

No	Suggestions	Revisions	Conclusion
Content Expert			
4	It is recommended to add more references from the last five years. The objectives should focus more on Higher Order Thinking Skills (HOTS).	Include references from the last five years.	Suitable for testing.
Learning Module Expert			
1	Some Latin names are inaccurate (e.g., taro, aloe vera) in relation to genetic diversity.	Correct the Latin names.	Overall, already good.
2	Please include teaching strategies in the learning scenario.	Add teaching strategies.	Overall, the module is already good.
3	Some scientific names are not italicized in accordance with binomial nomenclature. The writing of formulas and units also requires attention, as errors may change the meaning (e.g., square meters written as m2 should be written as m^2).	Revise italicization of scientific names and correct notation of formulas and units.	The module can be used as a supplementary medium.
4	The content of the module should focus more on the core material so that students can better understand it. Line spacing should also be adjusted to make the text easier to read. Comparative illustrations beyond research results could also be added.	Add illustrations and adjust spacing.	Suitable for use.
	Please correct the scientific names in the abstract.	Revise scientific names in the abstract.	Suitable for use.
	The factors influencing ecosystem diversity in Chapter 1, first page, are inconsistent in terminology.	Correct inconsistencies.	Suitable for use.
	It is recommended to add more attractive illustrations related to biodiversity.	Add illustrations.	Suitable for use.

The validated learning modules were subsequently tested through a limited field trial to obtain both qualitative and quantitative evaluations of the main product, namely the medicinal plant diversity module. The trial was conducted by distributing assessment instruments to practitioners, specifically two biology teachers, who evaluated the revised module (Bachtiar et al, 2022). Their assessments focused on several aspects, including the overall organization of the presentation, clarity and usefulness of the content, student engagement, visual design, structure of the textbook/module, variation in the delivery of information, and compliance with ethical standards and copyright regulations. The results of the validity assessment by the biology teachers are presented in Table 6.

Table 6. Results of the Validity Test of Material and Modules by Biology Teachers

Practitioner	Validation Test	Score (%)	Criteria
Teacher 1	Material	84.81	Very Feasible
	Module	85.62	Very Feasible
Teacher 2	Module	82.91	Very Feasible

The validation results from practitioners (biology teachers) indicate that the medicinal plant diversity learning module meets the criteria for feasibility. Teacher 1 assessed both the material and the module, with scores of 84.81% and 85.62%, respectively, while Teacher 2 evaluated the module with a score of 82.91%. All assessments fall into the very feasible category. On average, the practitioners' evaluations reached 84.45%, confirming that the module is considered suitable for classroom implementation. Although the scores are slightly lower than those given by expert validators, they remain within a high feasibility range. This indicates that the module is not only scientifically valid but also practical and applicable in actual teaching contexts. Minor revisions may still be beneficial to further improve clarity, usability, and alignment with classroom practices; however, the overall feasibility of the module has been strongly supported by practitioner feedback.

Following the validation test conducted by biology teachers, several constructive suggestions and inputs were obtained. These recommendations provided valuable insights for improving the content, presentation, and practical usability of the medicinal plant diversity module. The feedback served as the basis for the revision process to ensure that the module not only meets scientific and pedagogical standards but is also more effective and engaging for classroom implementation (Cruz & Rivera, 2022). A summary of the teachers' suggestions is presented in Table 7.

Table 7. Suggestions and improvements from biology teachers

No	*Suggestions*	*Revisions*	*Category*
1	The content of the module should be more focused on the core material so that students can better understand it. The line spacing should also be adjusted to make the text easier to read. In addition, comparative illustrations beyond the research results could be included to support the core material.	Include additional illustrations and adjust spacing.	Feasible
2	Some scientific names are not italicized according to the rules of binomial nomenclature. The notation of formulas and units also requires attention, as inaccuracies may lead to differences in meaning (e.g., square meters written as m2 should be written as m²).	Correct the Latin names and revise the notation of formulas and units.	Feasible

The validation results showed that the diversity of medicinal plants module obtained an average score of 91.08% from biology teachers, placing it in the very feasible category. This percentage aligns with Nugroho et al. (2017), who stated that scores ranging from 81–100% are considered very feasible and are therefore highly appropriate for use in the learning process. Thus, the developed module meets the required standards of feasibility as a biology learning medium.

The validation process involved multiple evaluators, including four subject matter experts, four module experts, and two biology teachers. As presented in Tables 3 and 4, both the learning and content/material aspects were rated as very feasible, while assessments from biology teachers (Table 6) also fell into the same category. Collectively, these results indicate that the module is not only valid in terms of content but also pedagogically appropriate and relevant for classroom use. This finding supports Amrina and Arifin (2020) and Bachtiar et al (2022), who emphasized that a high-quality module must fulfill validity criteria, including clear usage instructions, an appropriate format, systematic presentation, and relevant learning materials aligned with the curriculum.

In addition to content validity, the feasibility of the module ensures its role in supporting independent, communicative, and systematic learning. According to the Ministry of Education and Culture (2008), a good module should be self-instructional (can be studied independently), self-contained (covering complete learning material), and user-friendly (easy to understand). The developed module meets these criteria through its comprehensive structure, which includes an abstract, introduction, usage instructions, learning materials, plant identification results, student worksheets, and evaluation questions. This structure is intentionally designed to facilitate student autonomy and strengthen conceptual understanding (Sudarman & Ardian, 2021; Tarigan et al, 2021; Syafii & Yasin, 2013).

Furthermore, this research highlights the potential of research-based modules to create more contextual and meaningful learning. The integration of empirical data such as the Importance Value Index (IVI), diversity index, species richness, evenness, and dominance encourages students to connect ecological concepts with real-world conditions. These findings are consistent with Hadianto (2020); Rambitan & Maasawet, (2025); Rahmi et al. (2025); Tanjung et al. (2023), who reported that learning based modules significantly enhance students literacy skills and learning outcome. The inclusion of empirical case studies not only provides authentic learning experiences but also develops analytical and scientific skills through observation, data interpretation, and issue-based discussions.

Despite being categorized as highly feasible, the validation process also revealed the need for further revisions, particularly in refining sentence clarity to improve readability for students. This aligns with Gustinasari et al. (2017); Ita (2024); Rahmi et al. (2025), who argued that biology learning modules must be grounded in relevant facts, principles, and theories while being presented in a communicative and accessible manner suitable for learners.

The development process in this study followed a modified Borg and Gall R&D model across seven stages, ranging from preliminary studies to product development, validation, and revision.

However, to complete all stages of the Borg and Gall model, large-scale operational trials are required in schools with diverse curricula to further assess the effectiveness of the module under different learning conditions. The outcomes of these trials will provide the basis for final revisions, ensuring a more refined and adaptable product (Rahmi et al. 2025; Mellisa, 2025; Cruz & Rivera, 2022).

The implications of this study extend across several dimensions. From an educational standpoint, the findings indicate that empirical research can be effectively transformed into contextual and applicable learning resources, thereby bridging the gap between scientific inquiry and classroom practice (Wulandari et al., 2022; Mashur et al., 2018; Hadianto et al., 2018; Abdullah, 2021). From a conservation perspective, the developed module enriches students' ecological understanding of local medicinal plant diversity, while simultaneously fostering environmental awareness and a sense of responsibility toward biodiversity preservation (Hariyadi et al., 2024; Ginanjar et al., 2024). From a skills-development perspective, the module promotes inquiry-based learning that nurtures independent study habits, enhances critical thinking, and contributes to the cultivation of scientific literacy (Syahfitri & Muntahanah, 2024; Marlina et al., 2025).

Looking ahead, the development of similar research-based modules could be expanded by including larger samples, diversifying content from other biodiversity research, and integrating digital technology to create more interactive learning experiences. Future studies could also examine the long-term impacts of research-based modules on students' critical thinking and ecological literacy. Overall, this study confirms that research-based instructional materials can enhance the quality of biology education while simultaneously contributing to biodiversity conservation and cultural preservation.

4. Conclusion

This study demonstrates that the medicinal plant diversity module, developed from research conducted in Las-lasan Village, Bulan, is highly feasible for use as a biology teaching resource at the senior high school level. The module not only presents material theoretically but also integrates empirical data, thereby enhancing students' understanding of ecology and biodiversity while fostering independent learning. Its success provides evidence that research-based teaching materials can improve the quality of education by offering learning that is more contextual, critical, and applicable.

Furthermore, the use of this research-based module contributes significantly to the effectiveness of biology learning, encouraging students to be more active and independent in understanding the subject matter. By grounding the content in local empirical research, the module offers a more concrete and contextual learning experience that supports the development of critical thinking skills and deeper ecological understanding. This study also enriches the quality of teaching resources by providing valid and evidence-based materials that can serve as alternative instructional tools for educators. Looking ahead, the module has strong potential for further development, particularly through the integration of digital technology, making it more adaptive to modern educational needs and supportive of sustainable education goals.

References

Abdullah, Z. (2021). Development of a biology learning module integrated with Islamic values to improve environmental care character. *Hikmatuna: Journal for Integrative Islamic Studies, 7*(1), 17–30. https://doi.org/10.28918/hikmatuna.v7i1.2890

Adinugraha, F. (2022, June). An approach to local wisdom and cultural in biology learning. In *ICES 2021: Proceedings of the 3rd International Conference of Education and Science, ICES 2021, November 17–18, 2021, Jakarta, Indonesia* (p. 281). European Alliance for Innovation. https://doi.org/10.4108/eai.17-11-2021.2318660

Anwari, Nahdi, M. S., & Sulistyowati, E. (2016, February). Biological science learning model based on Turgo's local wisdom on managing biodiversity. In *AIP Conference Proceedings* (Vol. 1708, No. 1, p. 030001). AIP Publishing. https://doi.org/10.1063/1.4941146

Bachtiar, I., Handayani, B. S., Japa, L., & Bahri, S. (2022). Learning module development on the Nyale worm biology for high school students and teachers. *Jurnal Penelitian Pendidikan IPA, 8*(2), 1000–1004. https://doi.org/10.29303/jppipa.v8i2.1322

Burrow, A. K. (2018). Teaching introductory ecology with problem-based learning. *The Bulletin of the Ecological Society of America, 99*(1), 137–150. https://doi.org/10.1002/bes2.1364

Cruz, L. I. C., & Rivera, K. C. (2022). Development and validation of project-based module for selected topics in biology. *International Journal of Educational Research & Social Sciences, 3*(3), 1124–1137. https://doi.org/10.51601/ijersc.v3i3.374

Ginanjar, G., Rahayu, M., & Ayuningtyas, V. (2024). The effect of using ecology modules on communication skills, cognitive, and student attitudes through problem-based learning. *Jurnal Pijar Mipa, 19*(1), 13–19. https://doi.org/10.29303/jpm.v19i1.5853

Hadianto, A. (2020, March). Meta analysis the use of e-modules based on research based learning models. In *Journal of Physics: Conference Series* (Vol. 1481, No. 1, p. 012067). IOP Publishing. https://doi.org/10.1088/1742-6596/1481/1/012067

Hadianto, H., Mudakir, I., & Aisyah, I. (2018). Effectiveness of the module with scientific approach to the study of biology in senior high school. *International Journal of Advanced Engineering Research and Science, 5*(7), 126–129. https://doi.org/10.22161/ijaers.5.7.18

Haka, N. B., Anggoro, B. S., Hamid, A., Novitasari, A., Handoko, A., & Puspita, L. (2020, February). The development of biology module based on local wisdom of West Lampung: Study of ecosystem material. In *Journal of Physics: Conference Series* (Vol. 1467, No. 1, p. 012013). IOP Publishing. https://doi.org/10.1088/1742-6596/1467/1/012013

Hariyadi, S., Prihatin, J., & Mabsutsah, N. (2024). STEM-based ecology module development for differentiated learning in agroecosystem of junior high schools. *Research and Development in Education (RaDEn), 4*(2), 1002–1016. https://doi.org/10.22219/raden.v4i2.36314

Haviz, M. (2018). Development of research-based learning model in biology education: What is relevance, consistency and practicality? *Journal of Education and Learning (EduLearn), 12*(1), 143–149. https://doi.org/10.11591/edulearn.v12i1.6555

Ita, I. (2024). Validity and practicality of WASAKA-based ethno-edu module in biology learning. *Journal of Banua Science Education, 4*(2). https://doi.org/10.20527/jbse.v4i2.277

Jamshidi-Kia, F., Lorigooini, Z., & Amini-Khoei, H. (2018). Medicinal plants: Past history and future perspective. *Journal of Herbmed Pharmacology, 7*(1), 1–7. https://doi.org/10.15171/jhp.2018.01

Jia, S., & Ren, S. (2025). The significance of science content knowledge for socioscientific reasoning competency: Evidence from SSI instruction on environmental topics based on the SIMBL model. *Science & Education*, 1–23. https://doi.org/10.1007/s11191-025-00645-0

Latifa, U. N. (2021). Pengembangan modul biologi berbasis penelitian fitoplankton di Waduk Mulur Sukoharjo. *Journal of Biology Learning, 3*(1), 1. https://doi.org/10.32585/jbl.v3i1.1239

Majeed, M. (2017). Evidence-based medicinal plant products for the health care of world population. *Annals of Phytomedicine, 6*(1), 1–4. https://doi.org/10.21276/ap.2017.6.1.1

Marlina, M., Syafi'i, W., & Suwondo, S. (2025). Validity and practicality of ecosystem e-modules integrated with local wisdom to improve students' SCA and critical thinking skills. *JPBI (Jurnal Pendidikan Biologi Indonesia), 11*(2), 728–741. https://doi.org/10.22219/jpbi.v11i2.40353

Mashur, M. A., Amin, M., Lestari, U., Ulum, D., & Jombang, U. B. (2018). Guided inquiry learning module with multimedia assisted on cell metabolism for XII grade of senior high school. *Jurnal Pendidikan Sains, 6*(39), 72–79.

Mellisa, M., Saputri, D., & Rahmadani, I. (2025). Eligibility of e-module biology material cell-assisted flipping book. *Jurnal Bioeduin, 15*(1), 10–22. https://doi.org/10.15575/bioeduin.v15i1.43643

Nugroho, A. A., & Subiyantoro, S. (2017). Pengembangan modul sistematika tumbuhan tinggi berbasis guided discovery untuk mengembangkan kemampuan berpikir kritis mahasiswa pendidikan biologi. *Bio Pedagogi, 6*(2), 19–24. https://doi.org/10.20961/bio-pedagogi.v6i2.20696

Nugroho, A. A., Hanik, N. R., & Harsono, S. (2017). Pengembangan modul biologi molekuler berbasis learning cycle 7E untuk mahasiswa pendidikan biologi. *JEMS: Jurnal Edukasi Matematika dan Sains, 5*(1), 1–7. https://doi.org/10.25273/jems.v5i1.1780

Paristri, Y., & Suyanto, S. (2018). Implementation of socio-scientific issues based instruction to im-

prove critical thinking skills in biology learning. *5th ICRIEMS Proceedings*, 65–72.

Rahmi, L., Waltriandi, Y., & Sari, A. P. (2025). Development of research-based modules in hydroponic learning. *Journal of Biology Education Research (JBER), 6*(1), 20–27. https://doi.org/10.55215/jber.v6i1.24

Rambitan, V. M., & Maasawet, E. T. (2025). Development of biology teaching modules on biodiversity material based on regional potential to improve literacy skills of Grade X students of SMA Negeri 1 Tenggarong. *Jurnal Penelitian Pendidikan IPA, 11*(3), 769–776. https://doi.org/10.29303/jppipa.v11i3.10363

Rinto, R., Iswari, R. S., Mindyarto, B. N., & Saptono, S. (2023). Bridging the generational gap: Exploring youth understanding on ethnobotanical knowledge and its integration in higher education curricula. *Ethnobotany Research and Applications, 26*, 1–16. https://doi.org/10.32859/era.26.48.1-16

Sanka, I., Kusuma, A. B., Martha, F., Hendrawan, A., Pramanda, I. T., Wicaksono, A., ... & Widyaningrum, A. R. (2023). Synthetic biology in Indonesia: Potential and projection in a country with mega biodiversity. *Biotechnology Notes, 4*, 41–48. https://doi.org/10.1016/j.biotno.2023.02.002

Sudarman, S., & Ardian, A. (2021). The development of interactive module to support student centered learning. *Akademika, 10*(1), 77–92. https://doi.org/10.34005/akademika.v10i01.1344

Suhartati, S., Genisa, M. U., Saputri, W., Wardhani, S., & Astriani, M. (2024). Permasalahan pembelajaran biologi di SMA N 1 Tempilang melalui studi analisis. *Biodik, 10*(1), 8–14. https://doi.org/10.22437/biodik.v10i1.31357

Syafii, W., & Yasin, R. M. (2013). Problem solving skills and learning achievements through problem-based module in teaching and learning biology in high school. *Asian Social Science, 9*(12), 220. https://doi.org/10.5539/ass.v9n12p220

Syahfitri, J., & Muntahanah, M. (2023). Needs analysis of the biology interactive module based on Bengkulu local wisdom. *International Journal of STEM Education for Sustainability, 3*(1), 139–155. https://doi.org/10.53889/ijses.v3i1.142

Syahfitri, J., & Muntahanah, M. (2024). The effectiveness of local wisdom-based interactive digital module on students' critical thinking disposition. *International Journal of Evaluation and Research in Education (IJERE), 13*(4), 2170. https://doi.org/10.11591/ijere.v13i4.28256

Tanjung, F. P. P. S., Anas, N., & Hutasuhut, M. A. (2023). Development of biology learning module based on local potential types of fish in Sibolga waters. *Islamic Journal of Integrated Science Education (IJISE), 2*(3), 125–138. https://doi.org/10.30762/ijise.v2i3.1618

Tarigan, W. P. L., Sipahutar, H., & Harahap, F. (2021). The effect of interactive digital learning module on student's learning activity and autonomy. *Bioedukasi: Jurnal Pendidikan Biologi, 14*(2), 196. https://doi.org/10.20961/bioedukasi-uns.v14i2.49366

Tungmunnithum, D., Thongboonyou, A., Pholboon, A., & Yangsabai, A. (2018). Flavonoids and other phenolic compounds from medicinal plants for pharmaceutical and medical aspects: An overview. *Medicines, 5*(3), 93. https://doi.org/10.3390/medicines5030093

Wijesekera, R. O. B. (2017). Plant-derived medicines and their role in global health. In *The medicinal plant industry* (pp. 1–18). Routledge. https://doi.org/10.1201/9780203736395-1

Wulandari, D. S., Prayitno, B. A., & Marid, M. (2022). Developing the guided inquiry-based module on the circulatory system to improve student's critical thinking skills. *Journal of Biological Education Indonesia (Jurnal Pendidikan Biologi Indonesia), 8*(1), 77–85. https://doi.org/10.22219/jpbi.v8i1.16512

Yulis, P. A. R., & Isda, M. N. (2021, March). Preliminary studies of the development of local wisdom-based biotechnology module for biology students. In *Journal of Physics: Conference Series* (Vol. 1842, No. 1, p. 012068). IOP Publishing. https://doi.org/10.1088/1742-6596/1842/1/012068