Jurnal Pembelajaran Dan Biologi Nukleus p-ISSN: 2442-9481
Vol 12 (3): 1039- 1059, September 2026 e-ISSN: 2685-7332

Development of a Biodiversity Learning E-Module Based on Traditional Plants Used in Gorontalo Wedding Ceremonies (*Modutu*)

Deisy Fitriana Maunu, Novri Youla Kandowangko(*), Jusna Ahmad, Weny J.A. Musa, Ani M. Hasan, Masra Latjompoh

Biology Education Program, Graduate School, Gorontalo State University
Jl. Jend. Sudirman No.6, Dulalowo Timur, Tengah city, Gorontalo, 96128 Indonesia

***Corresponding Author:** novrikandowangko@ung.ac.id

Submitted June 02 Th 2026, and Accepted September 14 Th 2026

Abstract

Background: *Biodiversity education often remains theoretical, with limited integration of biological concepts and students' local knowledge. Traditional plants used in Gorontalo wedding traditions (Modutu) remain underrepresented in digital learning resources that specifically integrate plant diversity and its philosophical significance as a context for biology education. This study aims to develop an e-module featuring traditional Gorontalo wedding plants (Modutu) within the biodiversity curriculum and to assess its validity, practicality, and effectiveness.* **Methodology:** *This Research and Development (R&D) study employed the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The pilot study involved 87 tenth-grade students from SMAN 1 Telaga (n= 28) and SMAN 1 Boliyohuto (n= 59). Data were collected through expert validation sheets, classroom observations, teacher and student questionnaires, and pretest-posttest assessments. Data were analyzed descriptively using percentages and N-Gain.* **Findings:** *The e-module achieved content and media validity scores of 88% and 85%, respectively, categorized as highly valid. Practicality was reflected in lesson implementation rates of 96% and 99%, teacher responses of 95%, and student responses of 87%. Effectiveness was demonstrated by high N-Gain scores of 0.8148 (81.48%) and 0.7100 (71.00%) in limited and broad trials, respectively. The e-module integrates five traditional Modutu plants with biodiversity concepts, contextualizing biology learning through Gorontalo's local wisdom. The developed e-module meets the criteria of being valid, practical, and effective for use as a learning medium for biodiversity.* **Contribution:** *This study contributes to biology education by integrating ethnobotanical knowledge and biodiversity concepts to support learning and introduce Gorontalo's local wisdom to students*

Keywords: *E-Module; Local Wisdom; Modutu; Biodiversity; Traditional Gorontalo Plants*

Jurnal Pembelajaran dan Biologi Nukleus (JPBN) by LPPM Universitas Labuhanbatu is under a Creative Commons Attribution-ShareAlike 4.0 International License (CC BY - SA 4.0)
https://doi.org/10.36987/jpbn.v12i3.9583

INTRODUCTION

The plant biodiversity found across various regions of Indonesia constitutes a wealth of biological resources that provide a variety of benefits to communities and specific ethnic groups (Ahmad et al., 2024). Indonesia itself is known for its exceptionally high level of biodiversity, leading it to be frequently referred to as one of the world's biodiversity hotspots or a megabiodiversity country (Rachmawati et al., 2024). Consequently, an understanding of plant biodiversity is a key component of biology education in schools. However, in reality, the material on plant biodiversity in school biology education is often still presented theoretically through textbooks, resulting in a learning process that lacks context and fails to fully connect biological concepts with students' environments and daily lives. This situation aligns with the findings of Alfian et al., (2022), which indicate that biodiversity education remains theoretical and fails to connect the material to students' real-world contexts; consequently, conceptual understanding is suboptimal because students tend to memorize the material without grasping its practical applications. These findings underscore the importance of utilizing the surrounding environment as a learning resource so that biodiversity concepts can be studied through real-world objects and direct experiences. A study by Maulia et al., (2026) also indicates that using the environment as a learning resource can provide direct experiences through the observation of plant morphology and identification, thereby enabling a more concrete and meaningful understanding of biodiversity concepts.

The presentation of biology material, which tends to be abstract, also causes students to experience difficulties in understanding the concepts being studied (Suryani, 2025). Viratama et al., (2025) also state that the abstract nature of the subject matter is one of the main causes of learning difficulties. Some aspects of biology are tangible (visible) because they can be presented as concrete facts, while others are abstract or intangible (invisible), making them difficult to demonstrate through empirical evidence. According to Mardin et al., (2024), the instructional media and learning resources used by teachers remain limited and lack variety. Furthermore, the phenomena presented in instruction have not been fully connected to everyday life, so students have not gained a deep understanding from the ongoing learning process. In line with the views of Dai et al., (2021), if the instructional media used do not align with students' circumstances and interests, their enthusiasm for participating in learning decreases, and their understanding of the material is suboptimal.

Furthermore, in the practice of teaching biology in schools—particularly regarding biodiversity—students often struggle to grasp concepts due to limited instructional media. Without adequate media support, students tend to face obstacles in understanding the material presented by teachers (Sari et al., 2019). Global technological advancements have driven digitalization, which directly impacts the world of education; consequently, the teaching and learning process is now required to integrate digital technology (Cahya et al., 2023). Digital media allow students to access learning materials flexibly, enabling the learning process to take place anytime and anywhere (Widiastari & Puspita, 2024). Bakari et al., (2025) also argue that the use of technology in biology education is a crucial strategy, particularly for biodiversity

topics that require clear visualizations to make the material easier for students to understand.

One type of digital learning medium that can be used in biology education is the e-module. E-modules are electronic learning resources that can be accessed anytime and anywhere, thereby helping to increase students' interest and independence in learning (Mulyasari & Solikhah, 2021). E-modules are designed to meet students' learning needs by presenting material not only in text form but also supplemented with visual aids such as images, animations, and simulations to clarify concepts (Maharani, 2025). The use of e-modules in learning aligns with the demands of 21st-century education, which emphasizes the integration of technology into education. Perdana et al., (2025) state that 21st-century learning is characterized by rapid advancements in science and technology, which drive a paradigm shift in education through curriculum innovation, the use of learning media, and the integration of technology into the learning process.

In addition to the use of technology, biology instruction also needs to integrate local wisdom so that learning materials are more contextual and relevant to students' lives. As noted by Hidayat et al., (2025), the limited availability of contextual teaching materials that utilize local potential is one of the challenges in implementing biology instruction in schools. The integration of local wisdom into the learning process is of high urgency, as cultural values not only serve as markers of identity but can also be used as a source of inspiration and an engaging learning method (Fadhilah et al., 2025). Polii & Ahmadi (2024) also identify local cultural wisdom as a crucial foundation in education, as it enriches learning experiences, strengthens cultural identity, and supports more contextual and meaningful learning. The urgency of integrating local wisdom into digital teaching materials is supported by research by Sriyati et al., (2026), who developed a biology e-module by integrating the potential and local wisdom of the Toraja people into the biodiversity curriculum. The research findings indicate that the use of this e-module significantly improved students' critical thinking skills. These findings indicate that integrating local wisdom into e-modules not only makes biology content more relevant to students' environment and culture but also supports the achievement of learning competencies.

One form of local wisdom related to the use of plants can be found in the traditional Gorontalo wedding custom known as *Modutu*. Modutu is part of the traditional wedding procession of the Gorontalo people, marked by the presentation of a dowry—agreed upon during the *tolobalango* (betrothal) stage—by the groom's family to the bride's family, accompanied by various traditional items or other customary possessions (Jibu & Kustiawan, 2021). The Modutu ceremony not only involves the presentation of the dowry but is also accompanied by various traditional plants as complementary offerings to the assets presented by the groom's family. In line with the view of Hinta et al., (2021), the presence of these plants is not merely a material complement; rather, each type of plant carries philosophical significance that represents values, hopes, and prayers for married life among the Gorontalo people.

The plants included as complements to the dowry in the traditional "Modutu" ceremony include Bali oranges, sugarcane, coconuts, pineapples, and jackfruit. The use of these five plants is not only related to the completeness of the traditional dowry but also serves a symbolic function, representing the values and hopes for married life

among the Gorontalo people. Bali oranges are interpreted as a symbol of perfection; sugarcane symbolizes sweetness and happiness in married life; coconuts are associated with the beginning of life and the commitment to building a household; pineapples symbolize respect for parents or elders; while jackfruit serves as a reminder to always follow religious guidance and rules in married life. This demonstrates that the traditional plants used in Gorontalo wedding ceremonies—particularly in the *Modutu* traditional ceremony—have great potential to serve as a contextual learning resource in biology education.

The use of indigenous plants in the *Modutu* procession has the potential to serve as a contextual learning resource for teaching biodiversity, as it connects biological concepts with the environment and the local wisdom of the Gorontalo community. However, this potential has not yet been incorporated into digital teaching materials that specifically integrate the diversity of indigenous plants and their philosophical meanings within the *Modutu* ceremony. Therefore, there is a need to develop teaching materials capable of systematically harnessing this local potential in accordance with the demands of technology-based learning. This study aims to develop an e-module based on the local wisdom of Gorontalo's traditional wedding plants (*Modutu*) for the topic of biodiversity, as well as to determine the validity, practicality, and effectiveness of the developed product. This development is expected to produce learning media suitable for supporting the biology learning process, particularly regarding plant biodiversity.

METHOD

Research Design

This study employed the *Research and Development* (R&D) method using the ADDIE development model, which comprises five stages: *Analysis, Design, Development, Implementation, and Evaluation*. The research was conducted at two of Senior high schools in Gorontalo Province: SMA Negeri 1 Telaga Senior high schools and SMA Negeri 1 Boliyohuto Senior high schools. The study was carried out after obtaining permission from the relevant institutions and schools. The involvement of teachers and students as research subjects was carried out in accordance with research ethics principles, including providing information regarding the research objectives and procedures, obtaining informed consent in accordance with applicable regulations, and protecting the confidentiality of respondents' identities and data.

The research locations were selected using a purposive approach, taking into account the schools' suitability for conducting product trials on different scales. Telaga State High School 1 was selected as the site for a small-scale trial involving 28 tenth-grade students, while Boliyohuto State High School 1 was selected as the site for a large-scale trial involving 59 tenth-grade students. Both schools were involved in testing the readability and practicality of the e-module based on feedback from teachers and students, as well as its effectiveness in learning. The small-scale pilot aimed to provide an initial overview of the product's usability and identify aspects requiring refinement, while the large-scale pilot aimed to provide a broader perspective on the product's practicality and effectiveness among a larger user group.

Research subjects were selected through purposive sampling, taking into account the inclusion criteria: students enrolled in 10th grade at the study schools, at a learning level appropriate for the plant diversity material, and willing to participate in the series of research activities according to established procedures. The number of students in the small-scale and large-scale trials was determined based on the need to test the product during the research and development phase, taking into account the availability of student groups meeting the criteria at each school and the objectives of the product evaluation. A total of 28 students in the small-scale trial were used to obtain an initial overview of the product's readability, practicality, and effectiveness, while 59 students in the large-scale trial were used to collect test data from a broader user group. In addition to the students, biology teachers were involved as respondents in the assessment of the e-module's practicality.

Research Procedure

This research procedure followed the ADDIE development model, which consists of five stages: *Analysis, Design, Development, Implementation, and Evaluation*. *The analysis* stage was conducted to identify learning needs through an analysis of the curriculum, student characteristics, and the availability of media and technology. This analysis includes an examination of learning outcomes and objectives for biodiversity content, students' academic characteristics and digital literacy, as well as the readiness of learning support resources. The results of the analysis were used as the basis for developing the e-module, which integrates the local wisdom of Gorontalo's traditional plants into the Modutu ritual.

The design stage involves developing the structure and visual layout of the e-module, integrating local knowledge into the learning content and activities, and designing research instruments. The instruments designed include expert validation sheets, observations of learning implementation and student activities, teacher and student response questionnaires, as well as pretest and posttest questions to measure the validity, practicality, and effectiveness of the product.

The development stage involved transforming the design into an e-module product that integrates biodiversity content with the local wisdom of Gorontalo's traditional plants as practiced in the *Modutu* ritual. The product includes descriptions, scientific names, classifications, characteristics, cultural significance, illustrations, and interactive features. Next, product validation involved two expert faculty members as validators, each of whom assessed the content and media aspects, respectively. Content validation covered the alignment of content with learning objectives, the accuracy of biodiversity concepts, the systematic presentation, and the integration of local wisdom regarding Gorontalo's traditional wedding plants (*Modutu*). Media validation covers aspects of appearance, layout, readability, navigation, and the functionality of the e-module. The results of the two validators' assessments were used as the basis for determining the product's feasibility and making improvements prior to the implementation phase.

The implementation stage was conducted through a limited pilot test at SMAN 1 Telaga senior high school, involving one biology teacher and 28 tenth-grade students, as well as a large-scale pilot test at SMAN 1 Boliyohuto senior high school, involving one biology teacher and 59 tenth-grade students . At this stage, data were collected

through observations of instructional delivery and student activities, teacher and student response questionnaires, and pretest and posttest results to obtain information regarding the practicality and effectiveness of the e-module.

The evaluation stage was conducted through an analysis of the validation results, as well as the practicality and effectiveness of the product. The evaluation included expert assessment, the implementation of the learning process, student activities, user feedback, and improvements in learning outcomes. The results of the analysis are used as the basis for final improvements to ensure that the e-module meets the criteria of being valid, practical, and effective as a learning medium for biodiversity based on Gorontalo's local wisdom.

Data Analysis Techniques

Data analysis in this study was conducted to determine the validity, practicality, and effectiveness of the developed e-module. These three aspects were assessed using a rating scale, which was then converted into specific categories according to predetermined criteria, as presented in table 1.

Table 1. Rating Scale (Source: Rahmawati et al., 2022)

No.	Criteria	Score
1	Strongly Agree	4
2	Agree	3
3	Disagree	2
4	Strongly Disagree	1

The data on validity, practicality, and effectiveness were then summed and analyzed to determine the product's feasibility level using the following formula (Bannang et al., 2023).

$$P = \frac{\sum X}{N} \text{ x } 100$$

Notes:
P = Percentage
∑X = Total score obtained
N = Maximum score

Validity Analysis

After the product was validated by two expert instructors, the scores were then totaled and interpreted using the following assessment criteria in Table 2.

Table 2. Data Validation Criteria (Source: Pratama & Saregar, 2019)

No.	Achievement Level	Description
1	81–100%	Highly valid
2	61–80%	Valid
3	41–60%	Culkulp valid
4	21–40%	Invalid
5	<20%	Highly invalid

Practicality Analysis

Practicability data were obtained based on observations of classroom instruction and questionnaires completed by teachers and students. The data were then analyzed by calculating the scores obtained and interpreting them based on the following criteria in table 3.

Table 3. Criteria for the Feasibility of Learning (Source: Maslahah & Budiyanto, 2023)

No.	Percentage	Value Range
1	81–100%	Excellent
2	61–80%	Good
3	41–60%	Fair
4	21–40%	Insufficient
5	0–20%	Very Low

Table 4. Criteria for Media Practicality (Source: Sriwijayanti et al., 2020)

No.	Category	Percentage
1	Very Practical	81–100%
2	Practical	61–80%
3	Fairly Practical	41–60%
4	Not Very Practical	21–40%
5	Very Impractical	0–20%

Effectiveness Analysis

Data on the effectiveness of the media were obtained through observation of student activities and measurement of improvements in learning outcomes based on pretest and posttest scores. Learning outcomes were measured using a test instrument consisting of 10 multiple-choice questions developed based on learning indicators. The tests were administered before and after the use of the media to determine changes in student learning outcomes. The data obtained were analyzed by calculating test scores and improvements in learning outcomes, then interpreted based on the criteria presented in table 5.

Table 5. Criteria for Student Activities (Source: Yajie & Lestari, 2024)

No.	Value Range	Category
1	86–100%	Very Good
2	76–85%	Good
3	60–75%	Fair
4	55–59%	Poor
5	≤ 54%	Very Poor

Table 6. Classification of Average Gain (Source: Harianja et al., 2024)

No.	Gain	Category
1.	(g) ≥ 0.7	High
2.	0.3 ≤ (g) < 0.7	Moderate
3.	< g > < 0.3	Low

Table 7. Categories of N-Gain Effectiveness Interpretation (Source: Musa et al., 2023)

No.	Percentage (%)	Interpretation
1.	< 40	Ineffective
2.	40–50	Less Effective
3.	56–75	Fairly Effective
4.	> 75	Effective

RESULTS AND DISCUSSION

The e-module developed integrates five types of plants used in the Gorontalo (*Modutu*) traditional wedding customs as a representation of local wisdom in biodiversity education. The selection of these five plants was based on their connection to the cultural practices of the local community as well as their potential as subjects for the study of plant diversity from a biological perspective. The identities and types of traditional plants integrated into the e-module are presented in Table 8 as follows.

Table 8. Traditional Plants in the Gorontalo Traditional Wedding Ceremony (*Modutu*)

No.	Common and Local Names	Scientific Name	Traditional Philosophical Meaning
1	Bali Orange (*Limu*)	*Citrus maxima*	Bali orange, also known as Limu, is the name of a fruit that is described in the Gorontalo language as limomota, meaning "perfect." The word "perfect" or "perfection" is intended to signify that a suitor or prospective partner is considered a perfect individual, free from mistakes, shortcomings, or flaws.
2	Sugar Cane (*Patodu*)	*Saccharum officinarum*	"Tebu" or "patodu" in the Gorontalo language refers to sugarcane, which corresponds to the word "po'olingalio" meaning "sweetener". The hope embodied in this meaning is the sincerity of both parties, expressed through beaming facial expressions that reveal gentle gestures and a tender gaze. The most important implication is that a man from who proposes marriage wants the woman he proposes to always have a gentle heart as well as a gentle face.

No.	Common and Local Names	Scientific Name	Traditional Philosophical Meaning
3	Coconut (*Bongo*)	*Cocos nucifera*	One of the parts of the coconut used in Gorontalo wedding ceremonies is the coconut shoot, known as "Tumula"—a term synonymous with "biisalawa," which means "initial conversation." The word "awal" is derived from the term "tunas," because "tunas" in the Gorontalo language means "to begin" or "the beginning." Therefore, the significance of this ritual is associated with the concepts of "speech, agreement, or commitment," which are communicated to the community and relatives as part of the marriage ceremony on the wedding day. In addition, the part of the coconut tree used is the young leaves, known as "janur" or "lale." The presence of these lale or janur indicates that an event or celebration is taking place.
4	Pineapple (*Nanati*)	*Ananas comosus*	"Nanas" or "Nanati" is a term derived from the word "nana," which means "mother." It refers to people who have a significant influence on community life and are therefore worthy of respect and honor.
5	Jackfruit (*Langge*)	*Artocarpus heterophyllus*	Nangka or Langge is defined as a word meaning langgelo. The term "langgelo" in the Gorontalo language means "to look up to.". the meaning of this term is not merely to imitate arrogant or conceited people, as people often compare themselves to those of higher social status. Rather, in this context, it means that every action must always adhere to the commandments of Allah SWT, as exemplified by the Prophet Muhammad SAW.

Based on Table 8, the five plants integrated into the e-module demonstrate the connection between plant diversity and the cultural practices of the Gorontalo people. The inclusion of these plants not only enriches the presentation of biodiversity material through contextual objects but also provides students with an opportunity to understand the relationship between the utilization of biological resources and the preservation of local cultural values. Therefore, the integration of indigenous plants into the e-module serves as a means of linking biological concepts to the realities of community life, thereby giving learning both ecological and sociocultural relevance. This aligns with the view of Muhartini & Bakar (2023), who argue that contextual learning that is closely tied to students' lives can help them connect academic material with real-world experiences, making learning more meaningful, easier to understand, and easier to remember.

Furthermore, the presentation of information regarding the functions, philosophical significance, and uses of plants in the Modutu tradition highlights that biodiversity holds not only ecological value but also social and cultural value, the sustainability of which must be preserved. Consequently, the e-module developed not only supports the mastery of biological concepts but also contributes to strengthening the values of sustainable cultural and environmental conservation. In line with Gombo (2025) view, integrating local culture into learning through the use of local media and cultural contexts can enhance students' understanding of the community's noble values, while also creating a more contextual, meaningful, and enjoyable learning experience.

Validity

The validity of the materials and media was assessed based on the evaluation results provided by experts serving as validators (Wira, 2021). The validity of the developed learning materials was determined by calculating the percentage of the achieved score relative to the ideal (maximum) score for each assessed aspect; the average percentage of the validators' ratings was then calculated and interpreted based on predetermined eligibility criteria (Latjompoh, 2018).

Content Validation

Based on the results of the subject-matter expert validation, all aspects received percentages that fell within the "valid" category. The aspects of curriculum alignment and learning objectives received percentages of 81% and 88%, respectively; content appropriateness received 89% and 93%; presentation of content received 80% and 90%; learning aspects received 81% and 75%; and language received the highest percentage 100% from both validators. The overall average of the material validation results was 88%, indicating that the material presented in the e-module aligns with the learning outcomes, the needs of the learners, and the intended learning objectives.

The high scores in the content validity aspect indicate that the material on indigenous plants presented includes concepts that are relevant, accurate, and aligned with the competencies students are expected to master. The integration of indigenous plants into the e-module also provides a learning context that is closely tied to students' lives, thereby supporting the implementation of contextual learning. According to a

study by Nisa et al., (2025), the use of locally-based materials brings learning closer to students' experiences, making it easier for them to understand scientific concepts.

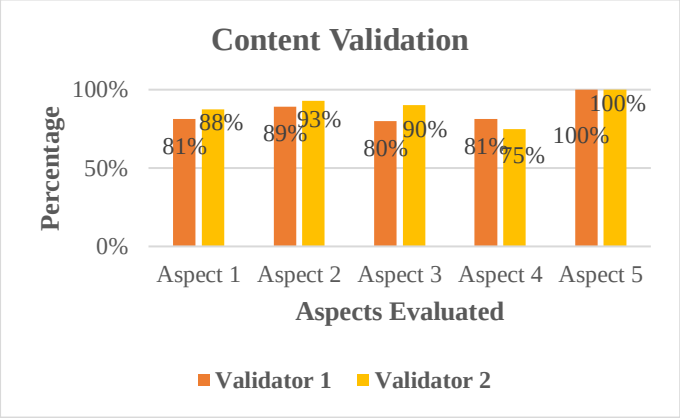


Figure 3. Graph of Content Validation Results
Legend: Aspect 1: Curriculum and Objective Alignment; Aspect 2: Appropriateness of Content; Aspect 3: Presentation of the Material; Aspect 4: Learning; Aspect 5: Language

The language aspect received a perfect score from both validators. These results indicate that the language used in the e-module adheres to the principles of communicative clarity, ease of understanding, and appropriateness for the learners' developmental level. Clear and simple language is a key factor in the successful use of digital instructional materials, as it reduces misconceptions and helps learners understand the material independently. This finding aligns with the research by Talitha et al., (2025), which states that the use of clear, communicative, and grammatically correct language is one of the strengths of e-modules that reinforces their suitability as learning resources.

Media Validation

The results of the media validation showed that the e-module received high scores across all evaluation criteria. The visual design aspect received scores of 90% and 100%, visual media 75% and 94%, interactivity 100% and 88%, readability and navigation 75% and 83%, and technical aspects 75% from both validators. The average media validation result based on the assessments of both validators was 85%, meaning that the developed e-module falls into the "highly valid" category and is suitable for use in the pilot testing phase after revisions are made based on feedback from the validators.

The high ratings for the visual design aspect indicate that the e-module has an attractive, consistent layout that is effective in stimulating learners' interest in learning. Good visual design can help students focus their attention on the material, making the learning process more effective. This aligns with the view expressed by Mayer (2019), who states that the use of various forms of representation such as text, images, and audio can help students better understand the material and improve their retention of the information they have learned.

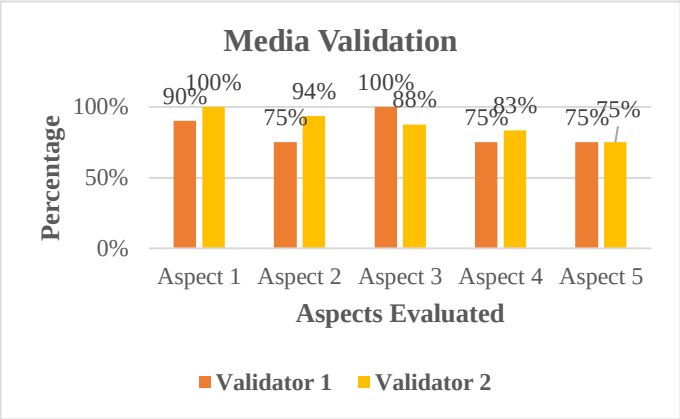


Figure 4. Graph of Media Validation Results
Legend: Aspect 1: Visual Design; Aspect 2: Visual Media; Aspect 3: Interactivity; Aspect 4: Readability and Navigation; Aspect 5: Technical

In addition, the aspects of readability and navigation also received a "valid" rating, indicating that users can easily operate the e-module. Ease of navigation is one of the key indicators in digital media development because it affects user comfort during the learning process. Research by Al-Sa'di & Khrypko (2024) reveals that consistent and simple learning navigation helps learners access materials more efficiently while supporting improved knowledge retention.

Practicality

The purpose of the practicality test is to assess the ease of use, level of feasibility, and usefulness of the instructional media when used in teaching and learning activities (Irawan & Hakim, 2021).

Feasibility of Learning

The results of observations on the implementation of the learning process during the limited-scale pilot study showed that all stages of learning were carried out very well. The implementation rate for introductory activities reached 100% in both sessions, while that for core activities increased from 88% to 94%, and the implementation rate for concluding activities reached 97% in both the first and second sessions. Even higher results were obtained in the large-scale pilot study, with a 99% implementation rate for introductory activities, 98% for core activities, and 100% for closing activities in both sessions.

The high level of instructional implementation indicates that the e-modules are easy to use for both teachers and students and are capable of supporting the implementation of the instructional sequence as planned. This suggests that the features available in the e-modules can help teachers manage instruction in a more systematic and focused manner.

This finding aligns with research conducted by Hayati (2017), which states that the practicality of developed learning tools is determined by observing real-world conditions; specifically, the results of the implementation of the developed learning tools show that the observed implementation falls into the "high" category.

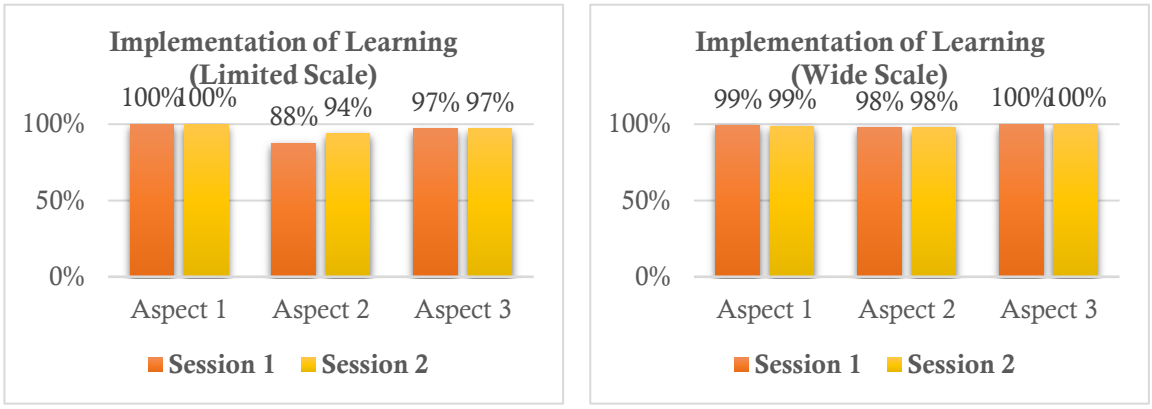


Figure 5. Graph of Learning Feasibility Results on a Limited and Broad Scale
Notes: Aspect 1: Introductory Activities; Aspect 2: Core Activities; Aspect 3: Closing Activities

Teacher Responses

The results of the teacher feedback survey indicate that the e-modules received very positive ratings. In the limited-scale pilot test, the ease-of-use aspect received a 100% rating, the learning efficiency aspect 75%, the classroom implementation aspect 94%, and the benefits aspect 94%. In the large-scale pilot, all aspects received a 100% rating.

These results indicate that teachers found the e-modules easy to use, helpful in improving learning efficiency, easy to implement in the classroom, equipped with features that support learning activities, and beneficial to the learning process. The high ratings from teachers demonstrate that e-modules can serve as an alternative digital teaching resource that supports 21st-century learning. These findings are supported by research by Nurdianti & Ramadan (2025), which shows that teachers view the use of e-modules positively because they are considered useful, aligned with learning needs, and capable of supporting a more engaging and interactive learning process. Ragil et al., (2026) also argue that the use of digital e-modules can reduce reliance on printed teaching materials while increasing teachers' flexibility in managing the learning process.

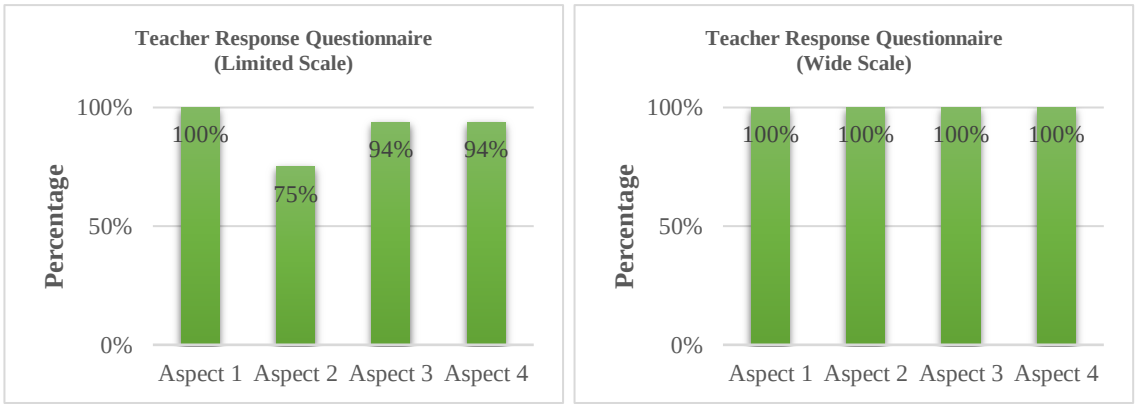
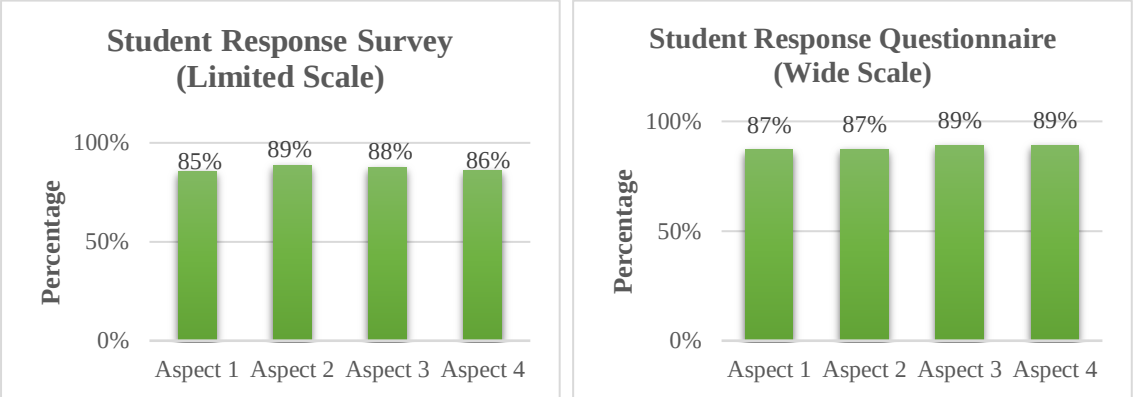


Figure 6. Graph of Survey Results: Teacher Responses on a Limited and Broad Scale
Legend: Aspect 1: Ease of Use; Aspect 2: Learning Efficiency; Aspect 3: Implementation in the Classroom; Aspect 4: Benefits

Student Responses

The results of student responses in the limited-scale pilot test showed a percentage of 85% for ease of use, 89% for engagement, 88% for understanding of the material, and 86% for feasibility. Meanwhile, in the large-scale pilot test, the percentages were 87% for ease of use and appeal, and 89% for understanding of the material and feasibility. These percentages indicate that students responded positively to the use of the e-module. The e-module was rated as easy to learn independently, visually appealing, providing interactive activities, and helping students understand the biology concepts being studied.



(Source*: Primary Data*)

Figure 7. Graph of Student Response Survey Results: Limited and Broad Scales
Legend: Aspect 1: Ease of Use; Aspect 2: Interest; Aspect 3: Understanding of the Material; Aspect 4: Feasibility

These results support the findings of Rahmawati et al., (2025), who state that interactive e-modules can increase students' motivation to learn because they combine text, images, videos, and learning activities into a single medium. Furthermore, Surani et al., (2025) found that e-modules not only serve as a means of distributing learning materials but also enhance students' interest in learning and their engagement throughout the learning process.

Effectiveness

An effectiveness test was conducted to determine the extent to which e-modules can improve students' understanding after being used in the learning process (Marsilia et al., 2025).

Student Activities

Observations of student activities during the small-scale pilot study showed improvements in most aspects of learning activities from the first session to the second. Improvements were evident in engagement with the e-module, active participation in group discussions, observational and analytical skills, group collaboration, presentations of discussion outcomes, and participation in presentations.

In the large-scale pilot study, all aspects of learning activity fell into the "very high" category, with percentages ranging from 88% to 96%. The highest percentage was recorded for group collaboration at 96%, while the other aspects also demonstrated very high levels of student engagement.

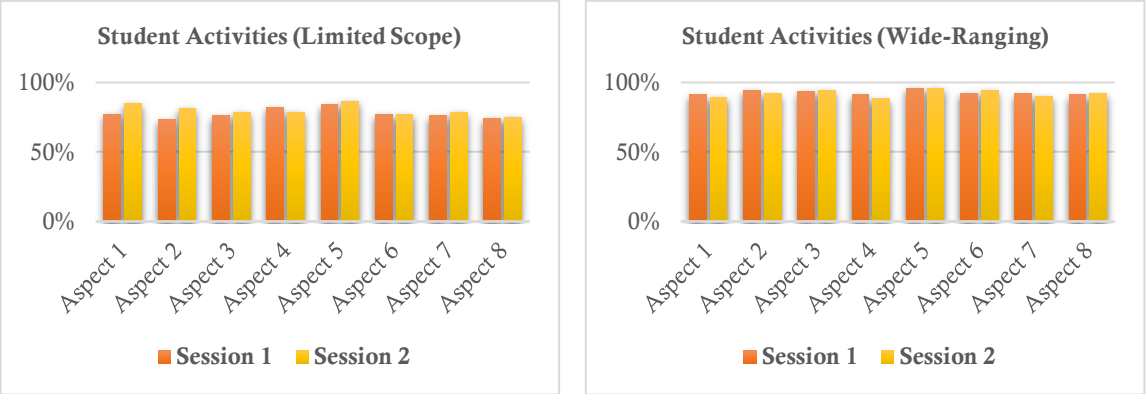


Figure 8. Graph of Student Activity Results: Limited and Extensive Scales
Legend: Aspect 1: Engagement in E-Module Exploration; Aspect 2: Active Participation in Group Discussions; Aspect 3: Observation/Analysis Skills; Aspect 4: Accuracy in Completing Worksheets; Aspect 5: Group Collaboration; Aspect 6: Ability to Answer the Teacher's Questions; Aspect 7: Presentation of Discussion Results; Aspect 8: Participation in the Presentation

The high level of learning activity indicates that the e-module is capable of facilitating *student-centered learning*. Through the various activities available in the e-module, students not only passively receive information but also actively explore the material, engage in discussions, analyze information, and communicate their learning outcomes. These findings are consistent with the research by Anisa et al., (2025), which states that interactive e-modules foster a more participatory learning process, so that students do not merely act as recipients of information but are also actively involved in exploring and discovering the concepts being studied. Research by Mangasak et al. (2025) also shows that the integration of digital media into learning can significantly increase student participation and engagement.

Student Learning Outcomes (Pretest–Posttest)

The results of the N-Gain Score analysis in the limited-scale pilot study showed an average of 0.8148, which falls into the high category. Meanwhile, in the large-scale pilot study, the average N-Gain Score was 0.7100, which also falls into the high category. N-Gain values in the high category indicate that the use of e-modules significantly improved students' conceptual understanding after completing the course. According to Handayani et al., (2023), the effectiveness of e-modules is demonstrated by N-Gain scores in the high category, indicating that the developed e-modules positively contribute to improvements in student learning outcomes.

The findings of this study are supported by research by Dewi & Lestari (2020), which suggests that the use of interactive e-modules integrated into the learning process supports students' active engagement and has the potential to improve learning outcomes. Similar results are also reported in a study conducted by

Nurdiansyah et al., (2025), which indicates that interactive e-modules are effective in improving students' cognitive learning outcomes, particularly for material that emphasizes conceptual understanding and visual representation.

Table 9. N-Gain Score & Percent Data (Limited Scale)

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**St. Deviation**
Ngain_score	28	0.25	1.00	0.8148	0.22407
Gain_percent	28	25.00	100.00	81.4810	22.40748

Table 10. N-Gain Score and Percentage Results (Broad Scale)

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**St. Deviation**
Ngain_score	59	0.20	1.00	0.7100	0.25647
Gain_percent	59	20.00	100.00	71.0042	25.64723

The results of the N-Gain Percent analysis in the limited-scale trial showed an average of 81.48%, which falls into the "highly effective" category, while the large-scale trial yielded an average of 71.00%, which falls into the "effective" category. These results indicate that the use of e-modules contributes significantly to improving student learning outcomes. Although there was a slight decrease in the average score in the large-scale trial compared to the small-scale trial, the effectiveness category remained at a high level. This indicates that e-modules are still capable of maintaining their effectiveness when applied to a larger number of students. These findings are supported by research by Topuha et al., (2025), which revealed that the use of digital media that is well-integrated into learning can improve students' learning outcomes. Based on the learning outcomes, N-Gain Score, and N-Gain Percent, it can be concluded that the e-module developed is effective in increasing student engagement and learning outcomes in the Biology material studied.

CONCLUSION

The e-module featuring Gorontalo's traditional wedding plants (*Modutu*) in the context of biodiversity was successfully developed using the ADDIE model and meets the criteria for validity, practicality, and effectiveness as a learning medium. The validity aspect showed highly valid results, with an average content validation percentage of 88% and a media validation percentage of 85%. The practicality aspect was demonstrated through the implementation of the learning process, which achieved a 96% success rate in the limited-scale pilot test and 99% in the large-scale pilot test both falling into the "very good" category—along with an average teacher response rate of 95% and an average student response rate of 87%, both categorized as "very practical". The effectiveness of the e-module is reflected in student engagement of 86% and improved learning outcomes, as indicated by an average N-Gain Score of 0.8148 in the limited-scale pilot and 0.7100 in the large-scale pilot, both of which fall into the "high" category. The respective N-Gain Percent values were 81.48% (classified as

"highly effective") and 71.00% (classified as "effective"). These results indicate that the e-module is suitable for use as a learning medium to support student engagement, understanding of biological concepts, and the integration of local wisdom into biodiversity education. However, the findings of this study are limited to testing the product within the context of the instructional content, student characteristics, and the two schools involved in the research; therefore, generalizing these results to educational institutions with different characteristics requires further testing.

REFERENCES

Ahmad, J., Utina, R., & Suparno, Y. A. (2024). *Ethnobotany of Medicinal Plants Among Ethnic Communities* (First edition). Deepublish. https://doi.org/10.62383/aliansi.v2i6.1393

Alfian, M., Putra, A. D., & Surahman, A. (2022). Application of Augmented Reality (Family Medicinal Plants) Toga as an Android-Based Learning Medium Using the Marker Method. *J. Inform. and Software Engineering*, 3(1), 77–85. https://doi.org/10.33365/jatika.v3i1.1863

Al-Sa'di, A., & Khrypko, Y. (2024). User Experience for Online Course Strategies: The EduFlex Framework. *In 2024 9th International Conference on Business and Industrial Research (ICBIR).* (pp. 1587–1592). IEEE. https://doi.org/10.1109/icbir61386.2024.10875962

Anisa, P., Zahra, F. A., Yanto, F., & Wati, F. (2025). Development of an Interactive PBL-Based E-Module on Dynamic Electricity to Improve Student Learning Outcomes. *Jurnal Mudabbir (Journal of Research and Education Studies), 5*(2), 2894–2904. https://doi.org/10.56832/mudabbir.v5i2.1780

Bakari, I., Kandowangko, N. Y., Akbar, M. N., Febriyanti, F., & Mustaqimah, N. (2025). Development of banana morphology-based augmented reality cards for teaching biodiversity in high school. *Nusantara: Indonesian Journal of Education, 5*(2), 511–525. https://doi.org/10.62491/njpi.2025.v5i2-19

Bannang, A., Uloli, R., & Abdjul, T. (2023). Development of Instructional Materials Using a Cooperative Learning Model with an Inquiry Approach on the Topic of Static Fluids. *Aksara: Journal of Nonformal Education, 9*(1), 749-760. http://dx.doi.org/10.37905/aksara.9.1.749-760.2023

Cahya, U. D., Simarmata, J., Iwan, Suleman, N., Nisa, K., Nasbey, H., ... & Rahmadani, E. (2023). *21st-Century Digital-Based Learning Innovations* (First edition). Kita Menulis Foundation.

Dai, W. U., Musa, W. J., & Laliyo, L. A. (2021). The Effect of Modifying the Stages of Quartet Media Use and Motivation on Fourth-Grade Students' Science Learning Outcomes. *Normalita (Journal of Education), 9*(3), 519–529.

Dewi, A.M.S. and Lestari, P.N.A. (2020). The Effect of Project-Based Interactive E-Modules on Student Learning Outcomes. *Scientific Journal of Education and Learning, 4*(3), 433–441. https://doi.org/10.23887/jipp.v4i3.28035

Fadhilah, A., Sumarni, S., Hartono, & Syafruddin. (2025). Optimizing local wisdom-based learning through digital media. *Indonesian Research Journal in Education (IRJE), 9*(01), 231–251. https://doi.org/10.22437/irje.v9i01.39459

Gombo, M. (2025). Integration of Te Aro Naweak Lako Local Wisdom into Character Education in Elementary Schools. *Haga: Journal of Community Service, 4*(1), 15-27. https://doi.org/10.57094/haga.v4i1.2978

Handayani, R., Mamoh, O., Ahzan, Z. N., & Fitriani, F. (2023). The Effectiveness of Using E-Modules on Student Learning Outcomes and Engagement in the Elementary Linear Algebra Course. *Journal of Education and Teaching Review (JRPP), 6*(4), 2071–2078. https://doi.org/10.31004/jrpp.v6i4.20987

Harianja, M. R., Yusup, M., & Siahaan, S. M. (2024). N-Gain test on the effectiveness of using games with the SGQ strategy to improve computational thinking in energy literacy. *Jurnal Intelektualita: Islam, Social Sciences, and Science, 13*(2), 303-310. https://doi.org/10.19109/intelektualita.v13i2.25168

Hayati, H. (2017). Development of Inquiry-Based Computer-Assisted Learning Media. *Educational Science: Journal of Educational Theory and Practice, 2*(1), 16-21. https://doi.org/10.17977/um027v2i12017p016

Hidayat, A., Kandowangko, N. Y., Latjompoh, M., Katili, A. S., & Pagalla, D. B. (2025). Development of a Genetic Diversity Module for Gorontalo Local Corn for High School Biology Learning. *Biodik, 11*(02), 420–429. https://doi.org/10.22437/biodik.v11i02.44614

Hinta, E., Masie, S.R., Ntelu, A., & Malik, H.S. (2021) Introduction to the Meanings and Symbols of Traditional Plant Tools in the Modutu Antaran Ritual of Gorontalo. *Jurnal Obsesi: Journal of Early Childhood Education, 5*(2), 1293–1303. https://doi.org/10.31004/obsesi.v5i2.835 .

Irawan, A., & Hakim, M. A. R. (2021). The Practicality of Mathematics Comics as Learning Media for Set Theory in 7th Grade Junior High School/MTs. *Pythagoras: Journal of the Mathematics Education Study Program, 10*(1), 91–100. https://doi.org/10.33373/pythagoras.v10i1.2934

Jibu, S. A., & Kustiawan, M. T. (2021). Shifts in Traditional Values and Culture in Marriage Among the Gorontalo Community During the COVID-19 Pandemic. Ahkam: Journal of Islamic Law, 9(1), 129–154. https://doi.org/10.21274/ahkam.2021.9.1.129-154

Latjompoh, M. (2018). The Validity of Science Process Skills-Oriented Learning Materials for Developing Critical Thinking Skills and Instilling Character in High School Students in Gorontalo City. *Proceedings of the Hayati National Seminar*, Vol. 6, pp. 470–477. Kediri: Biology Education Study Program, Nusantara PGRI University, Kediri. https://doi.org/10.29407/hayati.v6i1.607

Maharani, A. (2025). Utilization of the Development of Android-Based Interactive Science E-Modules for Junior High School Students. *Journal of Science and Education, 3*(01), 24–30.

Mangasak, A., Ervianti, E., & Gasong, D. (2025). Development of Digital-Based Learning Modules for the 8th-Grade Computer Science Course at Kandora Christian Junior High School. *Journal of Teacher and Learning Studies, 8*(3), 1565–1575. https://doi.org/10.30605/jsgp.8.3.2025.6817

Mardin, H., Dama, L., Hasan, A. M., Yusuf, F. M., Latjompoh, M., & Hayati, N. (2024). Development of Website-Based Biology Instructional Media Based on Differentiated Instruction on the Topic of Environmental Pollution. *Biogenerasi Journal, 9*(2), 1232–1237. https://doi.org/10.30605/biogenerasi.v9i2.4178

Marsilia, I. D., Kubillawati, S., Hidayah, N. R., & Fitri, D. M. (2025). The Effectiveness of Nutrition Education in Raising Adolescents' Awareness of Anemia Through an E-Learning Module. *Jurnal Ners, 9*(4), 6318–6324. https://doi.org/10.31004/jn.v9i4.50559

Maslahah, F., & Budiyanto, M. (2023). Improving Eighth-Grade Science Learning Outcomes on the Topic of Vibrations and Waves by Applying the Guided Inquiry Learning Model Assisted by Audiovisual Media. *Journal of Science Education, 13*(2), 544–550. https://doi.org/10.37630/jpm.v13i2.1100

Muhartini, M., Mansur, A., & Bakar, A. (2023). Contextual Learning and Problem-Based Learning. Lencana: *Journal of Educational Innovation, 1*(1), 66–77. https://doi.org/10.55606/lencana.v1i1.881

Maulia, T. P., Wulandari, P., Mahsar, S., & Alonemarera, A. A. (2026). Utilization of Family Medicinal Plants (Toga) as a Contextual Learning-Based Teaching Medium to Improve Understanding of Biodiversity Concepts. *Batanghari Academia Journal*, *1*(1), 34–47.

Mayer, R. E. (2019). *Multimedia learning.* Cambridge University Press

Mulyasari, P. J., & Sholikhah, N. M. (2021). Development of STEM-Based E-Modules to Enhance Learning Autonomy in Distance Learning for Economics. *Edukatif: Journal of Educational Sciences, 3*(4), 2220–2236. https://doi.org/10.31004/edukatif.v3i4.1158

Musa, L. A. D., Hardianto, H., Tanal, A. N., & Munir, N. P. (2023). The Effectiveness of a Numerical Methods Textbook Using Microsoft Excel for Mathematics Education Students. *Aksioma: Journal of the Mathematics Education Study Program, 12*(1), 689-696. https://doi.org/10.24127/ajpm.v12i1.6362

Nisa, K., Viani, A., Zainuri, A., & Zahra, F. F. (2025). The Concepts of Local Wisdom and Science in the Use of Locally-Based Materials in the "Love-Based" Curriculum at Madrasah Ibtidaiyah. *Digital Footprint: Multidisciplinary Scientific Journal, 1*(6), 4552–4561. https://doi.org/10.62383/aliansi.v2i6.1393

Nurdiansyah, F., Khumaedi, M., & Kriswanto, K. (2025). E-Module-Assisted Learning to Improve Cognitive Learning Outcomes on the Functions of Milling Machine Parts. *Panthera: Scientific Journal of Science and Applied Education, 5*(3), 642-653. https://doi.org/10.36312/panthera.v5i3.549

Nurdianti, I., & Ramadan, Z. H. (2025). Development of a Technological Knowledge (TK)-Based E-Module on the Topic of Energy Conversion for Fourth-Grade Elementary School Students. *Joecy Journal, 5*(2), 11697–11709. https://doi.org/10.31004/joecy.v5i2.1696

Perdana, F. F. H., Azhar, R., Musyafa, H. R., & Rahayu, G. S. (2025). The Application of Technology-Based Learning in Developing 21st-Century Skills. *Sibatik Journal: Scientific Journal in the Fields of Social Sciences, Economics, Culture, Technology, and Education, 4*(11), 3625–3642. https://doi.org/10.54443/sibatik.v4i11.3593

Polii, F. F., & Ahmadi, A. (2024). Integration of Local Wisdom for Liberating Education in Language and Literature Instruction in Elementary Schools. *Deiksis, 16*(2), 234. https://doi.org/10.30998/deiksis.v16i2.23021

Pratama, R.A. and Saregar, A. (2019). Development of Scaffolding-Based Student Worksheets (LKPD) to Train Conceptual Understanding. *Indonesian Journal of Science and Mathematics Education, 2*(1), pp. 84–97. https://doi.org/10.24042/ijsme.v2i1.3975

Rachmawati, R. N., Hermawan, H., Haerani, Y., Wijaya, D. I., & Ningsih, S. N. (2024). Preserving biodiversity through classroom learning processes and assignments. *Journal of Science Education Studies, 4*(2), 360–369. https://doi.org/10.52434/jkpi.v4i2.42791

Ragil, V. P. P., Mardhotillah, E. R., Yacob, L., Septiani, Y., & Zaidi, Z. (2026). The Transformation of Conventional Teaching Materials into Digital Teaching Materials: A Literature Review in the Context of Modern Education. *Tambusai Education Journal, 10*(1), 2338-2344. https://doi.org/10.31004/jptam.v10i1.36398

Rahmawati, T. I. N., Fajriyah, K., & Ysh, A. S. (2022). Development of a Flipbook Media Based on Local Wisdom from Jepara Regency for Theme 8, Subtheme 3, Grade 4 in Elementary School. *Didaktik: Scientific Journal of PGSD STKIP Subang, 8*(1), 647–658. https://doi.org/10.36989/didaktik.v8i1.337

Rahmawati, L., Bachri, B. S., & Maureen, I. Y. (2025). Literature Review: The Effect of Interactive E-Modules on Student Motivation and Engagement in Learning. *Paedagogie, 20*(2), 1-12. https://doi.org/10.31603/paedagogie.v20i2.14025

Sari, N. F., Ritonga, N., & Gultom, H. S. B. (2019). Analysis of learning difficulties among public junior high school students in the Medan Kota subdistrict in biology using concept maps and questionnaires. *Nukleus Journal of Learning and Biology*, 5(2), 40–48. https://doi.org/10.36987/jpbn.v5i2.1331

Sriwijayanti, R. P., Qomariyah, R. S., & Nurma, I. F. (2020). Development of PAKEM-Based Adobe Flash Media in Elementary Schools. *Jurnal Pedagogi*, 7(2), 92–105.

Sriyati, S., Sura, S., & Lembang, A. (2026). Integrating potential and local wisdom into digital biology learning: A study on the efficacy of e-modules for enhancing

students' critical thinking. *Indonesian Journal of Science Education*, *15*(2), 319–329. https://doi.org/10.15294/jpii.v15i2.49339

Surani., Aryola, G., & Setiadi, H. W. (2025). Analysis of the Effect of E-Modules on Improving Students' Learning Motivation. JIMU: *Multidisciplinary Scientific Journal*, *4*(01), 1792–1799. https://doi.org/10.70294/jimu.v4i01

Suryani, E. (2025). Development of a Biology Learning Module Based on Local Wisdom of Bima City on the Topics of Ecology and Biodiversity. *JIMU: Multidisciplinary Scientific Journal, 3*(04), 789-793. https://doi.org/10.70294/jimu.v3i04

Talitha, S., Budiana, S., Nurjaman, A., & Fadillah, V. (2025). Development of an E-Module for Teaching Negotiation Text Writing for 10th-Grade Vocational High School Students. Proceedings of the Atma Jaya Annual Linguistics Conference (Kolita), 23(23), Article 7178. https://doi.org/10.25170/kolita.v23i23.7178

Topuha, O. K., Rizal, R., Aqil, M., Gagaramusu, Y. B. M., & Fasli, M. (2025). The Effect of Digital Media Use on Student Learning Outcomes in Indonesian Language Classes in Elementary School. *Attadrib: Journal of Elementary Madrasah Teacher Education, 8*(1), 174–183. https://doi.org/10.54069/attadrib.v8i1.866

Viratama P. I., Putri, A. G. P., Herawati, M. A., Karim, N. I., & Ramadhani, D. A. (2025). Concrete-Based Science Learning Strategies to Overcome Abstract Thinking Difficulties in Elementary School Students in Understanding Scientific Concepts. *Algoritma: Journal of Mathematics, Natural Sciences, Earth and Space Sciences, 3*(4), 255–266. https://doi.org/10.62383/algoritma.v3i4.680

Widiastari, N. G. A. P., & Puspita, R. D. (2024). The Use of Digital Learning Media in Developing Learning Motivation Among Fourth-Grade Students at SD Inpres 2 Nambaru. *Elementary: Journal of Elementary Education Innovation, 4*(4), 215–222. https://doi.org/10.51878/elementary.v4i4.3519

Wira, Alsyabri. (2021). Validity and Effectiveness of Android-Based Learning Media for the Subject of Basic Computers and Networks. *Journal of Education Informatic Technology and Science, 3*(1), 1-10. https://doi.org/10.37859/jeits.v3i1.2602

Yajie, M. U., & Lestari, N. (2024). Efforts to Improve Student Learning Activities through the STAD (Student Team Achievement Division) Cooperative Learning Model in Theme 4 "Various Jobs" for Fourth Grade at UPT SPF SDN 101981 Galang. *Journal on Education, 6*(3), 16685–16694. https://doi:10.31004/joe.v6i3.5581

How To Cite This Article, with *APA style* :

Maunu, D. F., Kandowangko, N. Y., Ahmad, J., Musa, W. J. A., Hasan, A. M., & Latjompoh, M. (2026). Development of a Biodiversity Learning E-Module Based on Traditional Plants Used in Gorontalo Wedding Ceremonies (Modutu). *Jurnal Pembelajaran dan Biologi Nukleus*, *12*(3), 1039-1059. https://doi.org/10.36987/jpbn.v12i3.9583

Conflict of interest **:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contributions **:** All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was submited by [**Deisy Fitriana Maunu**]. All authors contributed on previous version and revisions process of the manuscript. All authors read and approved the final manuscript.