

Developing a Culturally Integrated E-Module on *Madurese* Herbal Knowledge to Enhance Students' Ecoliteracy Skills

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Submitted: 24-06-2025

Accepted: 30-06-2025

Published: 10-08-2025

Abstract

The lack of learning media makes the learning process monotonous and boring, and the lack of introduction to local wisdom makes students less familiar with the surrounding culture. E-modules can be a solution to convey material on elements, compounds, and mixtures that are integrated with *Madurese* herbal medicine. The aim of this research is to design, validate, and evaluate the effectiveness of an integrated e-module that combines science learning materials with *Madurese* herbal medicine local wisdom to enhance students' ecoliteracy. The method used in this study was research and development with four stages, namely, define, design, develop, and disseminate. Data collection techniques included observation techniques, interviews, and questionnaires. The results of this study, at the validation stage, showed there were four aspects that were assessed, namely content feasibility, which obtained a value of 90%; presentation aspect, 86.67%; linguistic aspect, 94.47%; and graphic feasibility, 93.33%. The total percentage obtained was 91.12%, which means that the developed e-module is valid and feasible to use. Meanwhile, the results of ecoliteracy skills in the cognitive aspect obtained an N-gain of 0.5 and were included in the moderate category. Other results in the attitude aspect obtained 92.39%, and the results of the skills aspect obtained 93.12%, so that they were classified as very effective. In conclusion, integrating local wisdom into science learning through a well-designed e-module not only strengthens students' understanding of scientific concepts but also fosters cultural appreciation and environmental responsibility, thereby supporting the development of ecoliterate future generations.

Keywords: e-module, local wisdom, ecoliteracy

INTRODUCTION

As one of the core subjects in education, science plays a crucial role in shaping students' understanding of the world around them. Science is a systematic discipline that explores natural phenomena and the components of the physical world through observation, experimentation, and analysis (Khomairroh et al., 2024). Its application extends beyond the acquisition of factual knowledge, as it fosters curiosity, environmental awareness, and problem-solving skills among learners (Muttaqin et al., 2022; Syahfitri et al., 2024). In contemporary education, science plays a critical role in developing 21st-century competencies, including ecoliteracy defined as the ability to understand ecological principles and apply them to live sustainably and harmoniously with the environment (Maimunah & Fahrimal, 2023; Tyas et al., 2021). As future agents of change, students must be equipped not only with scientific knowledge but also with environmental consciousness and ethical behavior in response to ecological challenges.

Despite the emphasis on science education, various national assessments indicate that students' ecoliteracy levels in Indonesia remain unsatisfactory. According to the Indonesian National Assessment Program (INAP), 73.61% of students demonstrated insufficient performance on environment-related tasks (Tyas et al., 2022). Research shows that this problem is due to students not being exposed enough to ecological ideas and not having enough environmental values included in their lessons. Interviews conducted in local schools confirmed that students have a low understanding of ecoliteracy, attributed to the lack of structured learning programs that connect science concepts with students' cultural and environmental realities.

One promising approach to enhance ecoliteracy is through the integration of local wisdom into science learning. Local wisdom defined as inherited cultural knowledge and practices passed down through generations often embodies principles of sustainability and environmental stewardship (Ruhana & Furqan, 2023; Vioreza et al., 2022). Embedding such cultural values into science education can provide contextual and meaningful learning experiences that resonate with students' lives and surroundings (Kurniasari et al., 2020). In this regard, traditional herbal medicine or *jamu* represents a significant form of local ecological knowledge that remains relevant in contemporary Indonesian society.

Bondowoso Regency, an area rich in *Madurese* cultural heritage, offers a valuable case for incorporating local wisdom into science learning. Incorporating local wisdom into science learning can enhance students' understanding of both their cultural identity and scientific principles. By integrating traditional practices and knowledge from the *Madurese* culture, educators can create a more relevant and engaging curriculum that resonates with students' experiences. The region is known for its traditional *jamu* practices, rooted in *Madurese* ethno-botany, which reflect empirically derived knowledge about natural ingredients used for health and healing (Hairul, 2022). *Jamu* has been recognized as one of Indonesia's intangible cultural heritages by UNESCO (Santosa et al., 2024), acknowledging its significance not only as a medicinal tradition but also as a cultural asset (Isnawati, 2021). However, recent findings suggest a generational decline in the knowledge and use of *jamu* among students, partly due to the shift in preference toward modern health products and the marginalization of traditional practices in formal education (Rosadi et al., 2023). This trend raises concerns about the preservation of *jamu* and the potential loss of cultural heritage, as younger generations may become disconnected from these traditional practices. Efforts to integrate *jamu* education into school curricula and promote its benefits could help bridge this gap and foster a renewed

appreciation for Indonesia's rich medicinal traditions (Fadya et al., 2022). Interviews conducted in local schools also indicate that most students lack awareness of *jamu* as a form of cultural heritage and as a scientifically relevant topic within the context of environmental education.

The integration of digital technology in education presents an opportunity to address these challenges. Interactive and multimedia-based learning tools, such as e-modules, enable the development of engaging, accessible, and contextually relevant educational content (Lastri, 2023; Safitri et al., 2023). E-modules are particularly effective in facilitating independent learning and in delivering complex concepts through a combination of text, visuals, audio, and animation (Noorrizki et al., 2025; Putra, 2022). Despite their potential, the use of e-modules remains underutilized in many schools, where traditional textbooks and generalized curricula dominate, often neglecting the unique cultural context of learners.

Interviews with science teachers in *Bondowoso* revealed a lack of teaching resources that integrate local culture and ecological knowledge. Consequently, students' understanding of their own cultural heritage and its environmental significance remains limited. This underscores the urgent need to develop localized, digital learning materials that incorporate culturally embedded ecological content. Specifically, there is a gap in the availability of science teaching materials that link the concepts of elements, compounds, and mixtures with the ecological and cultural practices surrounding *Madurese jamu*. Therefore, this study aims to develop an integrated science e-module based on *Madurese* herbal medicine local wisdom to enhance students' ecoliteracy. The research evaluates the e-module's validity, practicality, and effectiveness as a pedagogical tool, addressing the identified gap in culturally responsive and environmentally focused science education.

METHOD

This study employed a Research and Development (R&D) approach with the primary objective of producing, validating, and evaluating an integrated science e-module that incorporates the local wisdom of *Madurese* herbal medicine to enhance students' ecoliteracy. The use of R&D was considered appropriate because it allows for the systematic creation of educational products through iterative testing and refinement, ensuring both pedagogical relevance and empirical validity. The development process followed the 4D model introduced by Thiagarajan which includes four sequential phases: Define, Design, Develop, and Disseminate (Putri et al., 2023). Each stage was conducted to progressively construct and refine the e-module, ensuring it aligns with curricular goals and local contextual relevance.



Figure 1. Flowchart of the 4D development model

In the Define stage, an initial needs analysis was conducted to identify the specific challenges in current science learning, particularly related to students' low ecoliteracy and the limited integration of local cultural knowledge. Data were collected through interviews with science teachers, classroom observations, and curriculum document analysis. This stage involved analyzing student and teacher needs, learning objectives, conceptual content related to elements, compounds, and mixtures, and the relevance of

local herbal practices. The Design stage involved planning the structure and format of the e-module. Based on the findings from the define phase, instructional strategies, content layouts, media types (text, images, videos, animations), and assessment instruments were carefully selected to ensure alignment with students' cognitive levels and cultural context. The draft version of the e-module was created using digital authoring tools, following principles of interactive and student-centered learning.

In the Develop stage, the prototype e-module underwent expert validation and field testing. Two material experts and one practitioner evaluated the content, presentation, language, and graphical design of the module using standardized validation instruments. Based on their feedback, revisions were made to improve accuracy, clarity, and pedagogical alignment. After revisions, the module was tested by Grade VIII students from three junior high schools (*Sekolah Menengah Pertama Negeri/SMPN*): SMPN 3 Tamanan was used for the small-scale trial, while SMPN 1 Tamanan and SMPN 2 Tamanan were used for the dissemination test. These schools were selected purposively because they had not yet implemented local wisdom-based digital learning media in science education. The Disseminate stage focused on the limited implementation and academic publication of the final product. The e-module was distributed to science teachers in selected schools and introduced as a supplementary learning resource. Efforts were also made to publish the findings to contribute to broader academic discourse on local wisdom integration in science education. To evaluate the quality of the developed e-module, both qualitative and quantitative data were collected. Qualitative data included teacher interviews and observational notes during the implementation process. Quantitative data consisted of validation scores, student response questionnaires, and results from pre-tests and post-tests.

The validation data were analyzed by calculating the percentage of the total score obtained from expert reviews using the formula

$$V_a = \frac{TS_a}{TS_h} \times 100\%$$

Information:

V_a = Percentage of validity

TS_a = Total actual score obtained

TS_h = Maximum possible score

Table 1. Validity Test Criteria

Percentage Range	Category
85 % < V_a ≤ 100%	Very Valid
70 % < V_a ≤ 85 %	Valid
50 % < V_a ≤ 70%	Not enough Valid
01 % < V_a ≤ 50%	Invalid

Practicality was assessed using student response questionnaires and analyzed with the formula:

$$V_p = \frac{TS_p}{TS_h} \times 100\%$$

Information:

V_p = Percentage score from sheet questionnaire

TS_p = Total score obtained from user

TS_h = Maximum possible score

Table 2. Practicality Test Criteria

Percentage Range	Category
$85 \% < V_a \leq 100\%$	Very Practical
$70 \% < V_a \leq 85 \%$	Practical
$50 \% < V_a \leq 70\%$	Not enough Practical
$01 \% < V_a \leq 50\%$	Not Practical

Effectiveness was measured by analyzing cognitive improvement through the normalized gain (N-Gain) formula:

$$N-Gain = \frac{\text{skor posttest} - \text{skor pretest}}{\text{skor maksimal} - \text{skor pretest}}$$

The N-Gain formula is used to measure the relative improvement in student learning outcomes. It calculates the proportion of the maximum possible gain that a student achieved after instruction

Table 3. Normalized Gain Criteria

N-Gain Score	Category
> 0.7	Tall
$0.3 - 0.7$	Currently
< 0.3	Low

Additionally, student responses related to attitudes and ecological skills were analyzed using descriptive statistics and presented in percentage form:

$$V_{au} = \frac{T_{se}}{TS_h} \times 100\%$$

Table 4. Questionnaire Attitude and Skills

Percentage Range	Category
$85 \% < V_a \leq 100\%$	Very Valid
$70 \% < V_a \leq 85 \%$	Valid
$50 \% < V_a \leq 70\%$	Not enough Valid
$01 \% < V_a \leq 50\%$	Invalid

All data analyses were conducted to assess the overall quality of the developed e-module in terms of validity, practicality, and effectiveness in enhancing students' ecoliteracy.

FINDINGS AND DISCUSSION

Findings

This section presents the findings of the study, structured according to the 4D development model: Define, Design, Develop, and Disseminate. The aim was to produce an e-module that integrates local *Madurese* herbal medicine wisdom into science learning on elements, compounds, and mixtures to enhance students' ecoliteracy. The discussion highlights how the module met the criteria of validity, practicality, and effectiveness.

Define Phase

In the define phase, five key analyses were conducted to identify the foundation for product development: (1) Teacher needs analysis: Interviews and classroom observations revealed that science instruction primarily relied on lectures and textbook-based materials. Teachers had not previously used e-modules or integrated local cultural content into science lessons. Teachers expressed a need for innovative, contextual learning resources that could enhance student engagement and environmental awareness. (2) Student needs analysis: Students demonstrated low understanding of ecoliteracy concepts due to the absence of environment-focused education. However, they showed interest in learning materials that included local cultural elements, particularly those related to herbal medicine. (3) Concept analysis: The curriculum content on elements, compounds, and mixtures was mapped and connected to real-life contexts, such as traditional herbal preparations, to enhance conceptual relevance and contextual learning. (4) Task analysis: Activities were designed to allow students to explore local medicinal plants, differentiate between mixture types, and collaboratively produce traditional herbal drinks. These tasks aimed to develop both scientific understanding and environmental awareness. (5) Learning objectives formulation: Learning goals were structured to align scientific concepts with traditional knowledge, including the identification of materials used in *Madurese* herbal medicine, classification of mixtures, and waste management practices in herbal preparation processes.

Design Phase

The design phase involved the development of the e-module framework through the following steps: (1) Assessment development: Pre-test and post-test consisting of multiple-choice items were constructed to assess cognitive gains, while questionnaires were developed to evaluate ecoliteracy-related attitudes and skills. (2) Media selection: An interactive digital e-module was chosen as the delivery medium due to its accessibility, multimedia capabilities, and suitability for integrating text, visuals, and animations on herbal medicine content. (3) Format selection: The e-module consisted of three main components an introductory section (cover, foreword, contents, ATP, concept maps), the main content (scientific concepts and local wisdom integration), and the closing section (glossary, bibliography, and E-Module barcode). (4) Preliminary design: A prototype of the e-module was created incorporating ecoliteracy components and *Madurese* herbal knowledge. Initial drafts were reviewed and refined based on expert input.

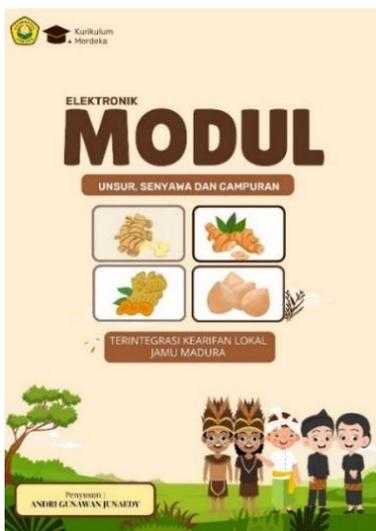


Figure 2. E-Module Cover View



Figure 3. Wisdom Local *Madurese* Herbal Medicine



Figure 4. Ecoliteracy Page



Figure 5. Students Make *Madurese* Herbal Medicine

Develop Phase

The development phase included validation, effectiveness testing, and student trials. Validation Results: The e-module was evaluated by two subject-matter experts and one practitioner. As shown in Table 5, the overall validity score was 91.37%, categorized as “very valid”. Each component content (90%), presentation (86.67%), language (94.47%), and graphic design (93.33%) met high standards of quality, confirming that the module is pedagogically sound and contextually appropriate.

Table 5. E-Module Validation Summary

Rated aspect	Average%	Category
1. Content Eligibility	90	Very valid
2. Aspects Presentation	86.67	Very valid
3. Aspect Linguistics	94.47	Very valid
4. Eligibility Graphics	93.33	Very valid
Overall Average	91.37	Very valid

Effectiveness Results (Small-Scale Test): The cognitive gain was evaluated using a pre-test/post-test design with N-Gain analysis. As shown in Table 2, the average pre-test score was 68, increasing to 84 post-test, yielding an N-Gain of 0.5 (moderate category), indicating effective improvement in conceptual understanding.

Table 6. Cognitive Ecoliteracy Results – Small-Scale Test

Indicator	Amount Student	Average Score		N-Gain	Category
		Pretest	Post-Test		
Indicator Cognitive 1		60	85		
Indicator Cognitive 2		75	85		
Indicator Cognitive 3	10	65	80	0.5	Moderate
Indicator Cognitive 4		70	80		
Indicator Cognitive 5		70	90		
Amount		68	84		

Ecoliteracy is also included in the aspect attitudes. The results presented in the table indicate a strong development in students' attitudes related to ecoliteracy. Each indicator shows a high percentage of achievement, with Indicator 1 reaching 95.62%, Indicator 2 at 95%, Indicator 3 at 88.33%, and Indicator 4 at 90.62%. The average final score across all indicators is 92.39%, which falls into the "very effective" category. Complete results are presented in the table.

Table 7. Results of Attitude Values of Small Scale Test

Indicator	Amount Student	Total Value Per Indicator	Maximum Value	Final score (%)
Indicator Attitude 1		153	160	95.62
Indicator Attitude 2	10	152	160	95
Indicator Attitude 3		106	120	88.33
Indicator Attitude 4		145	160	90.62
Average Final Grade (%)				92.39

Next, assess the skill aspects in improving ecoliteracy. The data indicates a high level of student proficiency in ecoliteracy-related skills after using the integrated e-module. Indicator Skill 1 achieved 93.75%, while Indicator Skill 2 reached 92.5%, resulting in an average final score of 93.12%. These results classify the e-module as "very effective" in enhancing students' practical abilities,

Table 8. Results of Small Scale Test Skills Scores

Indicator	Amount Student	Total Value Per Indicator	Maximum Value	Final score (%)
Ind. skill 1	10	75	80	93.75
Ind. skill 2		74	80	92.5
Average Final Grade (%)				93.12

Practicality Test: Student feedback from 10 participants yielded an average practicality score of 91.56%, placing the e-module in the "very practical" category.

Table 9. Response Results Small Scale Test Students

Trials	Amount Student	Average Score (%)	Category
Limited Scale Test	10	91.56	Very Practical

Disseminate Phase

In the dissemination phase, the e-module was implemented at SMPN 1 Tamanan and SMPN 2 Tamanan.

Cognitive Ecoliteracy Results: At SMPN 1, the N-Gain was 0.79 (high), while SMPN 2 achieved 0.66 (moderate), both indicating substantial improvement in students' understanding (Table 10).

Table 10. Aspect Results Cognitive Ecoliteracy Disseminate Test

School	Amount Student	Pretest Average	Post-test Average	N-gain	Category
SMPN 1 Tamanan	26	68.9	93.5	0.79	Tall
SMPN 2 Tamanan	31	75.5	91.6	0.66	Currently

The results of the attitude assessment during the dissemination phase show consistently high scores across both schools. At SMPN 1 Tamanan, the average final score across all four indicators was 91.11%, while SMPN 2 Tamanan achieved a slightly higher average of 91.8%. These scores fall within the "very effective" category, indicating that the integrated e-module significantly enhanced students' environmental attitudes (Table 11).

Table 11. Attitude Value Results *Disseminate*

School	Indicator	Total Value Per Indicator	Maximum Value	Final score (%)	Average Final Grade (%)
SMPN 1 Tamanan	1	376	416	90.38	91.11
	2	386	416	92.79	
	3	285	312	91.34	
	4	374	416	89.9	
SMPN 2 Tamanan	1	444	496	89.52	91.8
	2	457	496	92.14	
	3	343	372	92.2	
	4	463	496	93.35	

Following the attitude results presented in the previous table, the skills assessment also demonstrated strong outcomes. At SMPN 1 Tamanan, students achieved scores of 93.75% and 91.35% across the two skill indicators, resulting in an average final grade of 92.55%. Similarly, at SMPN 2 Tamanan, students scored 94.58% and 91.67%, with an average of 93.12%. These results indicate that the integrated e-module was highly effective in enhancing students' practical ecoliteracy skills.

Table 12. Results of Disseminating Skills Values

School	Indicator	Total Value Per Indicator	Maximum Value	Final score (%)	Average Final Grade (%)
SMPN 1	1	195	208	93.75	92.55
Tamanan	2	190	208	91.35	
SMPN 2	1	227	240	94.58	93.12
Tamanan	2	220	240	91.67	

Practicality Evaluation: Questionnaire responses showed excellent acceptance, with practicality scores of 91.92% and 93.17% for SMPN 1 and SMPN 2 respectively (Table 8).

Table 13. Response Results Disseminate Test Students

Test School	Amount Student	Average Score (%)	Category
SMPN 1 Tamanan	26	91.92	Very Practical
SMPN 2 Tamanan	31	93.17	Very Practical

The findings demonstrate that the developed e-module is valid, practical, and effective for enhancing ecoliteracy through science content integrated with *Madurese* herbal knowledge. The integration of local wisdom not only contextualizes scientific concepts but also fosters cultural appreciation and environmental awareness—key components of ecoliteracy (Maimunah & Fahrimal, 2023; Tyas et al., 2021). This is aligned with previous research advocating for place-based science education to bridge scientific understanding and cultural heritage (Ruhana & Furqan, 2023; Vioeza et al., 2022).

The observed cognitive improvements, along with highly positive attitudes and skills development, reinforce the pedagogical value of the E-module. Moreover, high practicality scores reflect the accessibility, clarity, and cultural relevance of the E-module. These results support the conclusion that interactive, locally contextualized digital media such as e-modules are effective tools for modern science education especially in promoting ecoliteracy among students as agents of environmental change.

Discussion

The development of an e-module integrating Madurese local wisdom in herbal medicine into science education was guided by the 4D model, Define, Design, Develop, and Disseminate, to enhance students' ecoliteracy. In the Define phase, comprehensive analyses highlighted the lack of contextual and digital teaching materials in current classroom practice. Teachers relied heavily on conventional textbooks and lecture-based instruction, with little to no incorporation of local cultural content (Muttaqin et al., 2022). Students also exhibited limited understanding of ecoliteracy, though they showed keen interest in learning materials that reflected their cultural background, especially traditional herbal medicine. This aligns with research suggesting that connecting scientific content to students' cultural contexts increases motivation and conceptual understanding (Kurniasari et al., 2020; Vioeza et al., 2022).

In the Design phase, the e-module's structure was intentionally crafted to promote scientific literacy and environmental awareness through engaging, interactive content. The inclusion of multimedia elements such as visuals and animations served to make abstract concepts like mixtures, compounds, and elements more relatable through the lens of traditional herbal practices (Latri, 2023; Noorizki et al., 2025). Moreover, formative assessments and ecoliteracy questionnaires were embedded to assess not only cognitive achievement but also attitudes and skills. These design choices are supported by prior findings indicating the effectiveness of digital learning resources in promoting active learning and higher-order thinking (Putri et al., 2023; Putra, 2022).

During the Develop phase, expert validation confirmed the e-module's pedagogical and contextual soundness, with high scores in content accuracy, presentation, and visual design. The overall validity rating of 91.37% indicated that the e-module met high academic standards (Latri, 2023). Small-scale testing also demonstrated its effectiveness: post-test scores significantly increased from pre-test averages, yielding an N-Gain of 0.5 in the moderate category. This suggests a meaningful improvement in conceptual understanding of environmental science (Khomairroh et al., 2024). These results reinforce existing literature advocating for the integration of local knowledge in science education to improve learning outcomes (Fadya et al., 2022; Tyas et al., 2021).

The e-module also significantly enhanced students' ecoliteracy-related attitudes and practical skills. Attitudinal assessments during small-scale testing yielded a high average score of 92.39%, reflecting increased environmental awareness and cultural appreciation. Similarly, students' practical skills in identifying local herbs, preparing traditional herbal drinks, and managing waste showed an average score of 93.12%, categorized as "very effective." These findings confirm that combining hands-on tasks with culturally relevant content can enhance ecological responsibility and practical competence, echoing previous research on the value of experiential and place-based science education (Ruhana & Furqan, 2023; Maimunah & Fahrimal, 2023).

The Disseminate phase further validated the module's impact through implementation at two schools, SMPN 1 Tamanan and SMPN 2 Tamanan. Both institutions showed substantial cognitive gains (N-Gains of 0.79 and 0.66, respectively), indicating strong comprehension improvements. Attitude and skill evaluations were also consistent, with both schools achieving scores above 91% across indicators. Additionally, student feedback rated the e-module as "very practical" (over 91% at both schools), confirming its user-friendliness, cultural relevance, and accessibility. These dissemination results mirror previous findings on the positive reception and impact of locally contextualized learning tools in Indonesian education (Safitri et al., 2023; Santosa et al., 2024).

In other words, the study affirms that integrating local Madurese herbal wisdom into science education through digital modules can significantly enhance students' ecoliteracy. The module was not only valid and effective but also practical in real classroom settings. Its success supports broader educational strategies that emphasize cultural contextualization, digital engagement, and environmental responsibility (Hairul, 2022; Isnawati, 2021). As supported by Vioeza et al. (2022) and Tyas et al. (2022), this approach not only reinforces scientific understanding but also nurtures students as environmentally conscious citizens, an essential goal in 21st-century science education.

The findings of this study confirm that the integration of Madurese local herbal wisdom into science education via a digital e-module has the potential to significantly enhance students' ecoliteracy. By embedding indigenous knowledge, such as the

preparation and classification of traditional herbal medicines, into scientific concepts like elements, compounds, and mixtures, the module bridges the gap between abstract science content and students' everyday cultural experiences. This contextualization not only improves content relevance but also increases learner engagement, particularly in regions where such traditions are still practiced (Isnawati, 2021; Hairul, 2022). As previous research has suggested, incorporating local cultural practices into the curriculum can deepen students' understanding while simultaneously fostering respect for their heritage (Fadya et al., 2022; Kurniasari et al., 2020).

Moreover, the module's effectiveness and practicality in actual classroom settings support the growing body of evidence promoting the use of digital learning tools in science education. With validation results indicating high scores in content quality, design, and user accessibility, and positive responses from both students and teachers, the e-module has proven to be both pedagogically sound and user-friendly. Digital media formats allow for greater interactivity and accessibility, aligning with contemporary educational approaches that advocate for technology-enhanced, student-centered learning (Putri et al., 2023; Safitri et al., 2023). These results also support Lastri's (2023) claim that digital modules offer an effective medium for integrating multimedia content, improving cognitive performance, and enabling differentiated instruction.

Finally, this study highlights the broader implications of place-based and culturally responsive science education. As Vioeza et al. (2022) and Tyas et al. (2022) emphasize, ecoliteracy education must not only equip students with scientific knowledge but also develop their awareness of environmental issues within their local context. By connecting learning objectives to the preservation of local ecological practices, such as sustainable herbal medicine preparation and waste management, the module cultivates both ecological responsibility and cultural pride. Thus, students are not only gaining scientific literacy but also being nurtured as environmentally conscious citizens who are capable of making informed decisions for their communities and ecosystems. This aligns with global educational goals that position students as active participants in sustainable development and environmental stewardship.

CONCLUSION

This study aimed to develop and evaluate an interactive science e-module integrating *Madurese* traditional herbal medicine to enhance students' ecoliteracy. The findings reveal that the e-module meets the criteria of validity, practicality, and effectiveness. In terms of validity, expert assessments yielded an average score of 91.12%, with content validity rated at 90%, presentation at 86.67%, language clarity at 94.47%, and visual design at 93.33%. These results indicate that the e-module aligns well with curriculum standards, is pedagogically sound, culturally relevant, and visually engaging making it highly suitable for use in classroom settings. Regarding effectiveness, the module significantly improved students' understanding of concepts related to elements, compounds, and mixtures, as shown by a moderate N-gain score of 0.5 in cognitive tests. Additionally, attitude and skill assessments scored 92.39% and 93.12% respectively, categorizing the e-module as highly effective in fostering positive environmental attitudes and practical ecoliteracy skills. The practicality of the e-module was confirmed through student responses, which yielded an average score of 91.56%. Students found the module easy to use, visually appealing, and contextually relevant to their daily lives and cultural background. These responses reflect a strong alignment between the module's design and learners' needs and preferences. In conclusion, the

integrated e-module successfully addresses the research objective by promoting ecoliteracy through the integration of local cultural wisdom. It not only supports conceptual understanding but also nurtures environmentally responsible attitudes and behaviors. Therefore, this e-module is recommended for broader implementation across junior high school science curricula as an innovative and culturally responsive educational tool. Future studies may explore its scalability and long-term impact on sustainable education and cultural preservation.

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