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Development of a Problem-Based Learning (PBL) Ethnoscience E-Module on the Biodiversity of Herbal Plants to Enhance Junior High School Students Critical Thinking and Environmental Literacy

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Abstract

This study aims to develop and validate an ethnoscience-based Problem-Based Learning (PBL) e-module on the biodiversity of herbal plants to enhance junior high school students' critical thinking and environmental literacy. The research used a modified 4D development model (Define, Design, Develop, Disseminate) involving content analysis, expert validation, and practicality testing. The e-module integrates local cultural knowledge with science learning through contextual material and interactive problem-solving activities. Validation was conducted by subject matter and media experts, while practicality was tested by one science teacher and 25 students. Results show the e-module received a content validity score of 90.34% (very valid) and a media validity score of 78.62% (valid). The characteristics assessment by three experts yielded an overall score of 92.69%, categorized as highly suitable for educational use. Practicality scores from teacher and student evaluations were 92.88% and 91.42%, respectively, indicating that the module is easy to use, relevant, and engaging. The findings conclude that the e-module is pedagogically appropriate, practical, and effectively integrates local wisdom into science learning. It supports the development of students' critical thinking and environmental awareness and can be used as an innovative instructional resource in junior high school science education.

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INTRODUCTION

Education plays a strategic role in shaping high-quality and adaptive human resources to face the challenges of the times. In this era of globalization and rapid technological advancement, students are required to master various 21st-century skills, such as critical thinking, communication, collaboration, as well as creativity and innovation (Mu'minah, 2021).

Among these, critical thinking has become a central focus in education due to its significant role in logical and rational decision-making and problem-solving (Halim, 2022). Critical thingking skills among Indonesian students remain quite underdeveloped. According to the results of the Programme for International Student Assessment (PISA), Indonesia ranks among the lowest-performing countries (OECD., 2024). This situation underscores the pressing necessity for innovative educational strategies, especially within science education, which holds significant promise for fostering critical thinking skills.

In addition to critical thinking, environmental literacy is an essential skill to address future global challenges. Environmental literacy refers to an individual's ability to understand, interpret, and demonstrate a conscious attitude towards maintaining environmental balance. This includes knowledge and proactive solutions to environmental issues (Kurniati et al., 2022)). Students understanding of environmental issues continues to be inadequate, which is mainly attributed to instructional methods that do not effectivaly connect with their real life contexts (Fidan & Ay, 2016). Science education in schools—such as that observed at SMP Negeri 02 Jatiyoso—continues to rely heavily on teacher-centered and conventional methods, which are insufficient in fostering critical thinking and environmental awareness among students (Indraningrum et al., 2018).

One promising strategy to improve both critical thingking and environmental literacy is the application of the Problem-Based Learning (PBL) model. PBL encourages active student participation, information exploration, and real word problem-solving (Pratiwi & Setyaningtyas, 2020). Instructional media that align with the Problem Based Learning (PBL) approach such as electronic modules have proven effective in improving students' motivation, conceptual comprehension, and critical thinking skilss (Ravilla et al., 2023). E-modules also offer flexible and interactive learning experiences that promote students autonomy (Laili et al., 2019).

Another meaningful learning strategy integrating local values values through ethnoscience. Ethnoscience connects scientific concepts with the cultural pratices and indigenous knowladge of local communities (Rahayu & Sudarmin, 2015), such as the use of herbal plants in daily life. This approach has the potential to increase student engagementm cultivate appreciation for local culture, and improve scientific understanding (Faedah & Ngazizah, 2024). However, modern technological developments have shifted the younger generations's attention toward global culture and away from local wisdom, making it increasingly important to integrate local knowledge into education (Anggara Nenohai et al., 2022).

Most prior studies have concentrated on the use of either Problem Based Learning (PBL) or ethnoscience based modules independently, with limited attention given to their combined application. For example Pitorini et al., (2024) found that an e-module integrating PBL and Socratic Dialogue significantly improved students' critical thingking skills in environmental education. Similarly, Pangsuma et al., (2020) created an Education for Sustainable Development (ESD) module based on Bugis local wisdom, which effectively improved students critical thinking skills as well as their environmental literacy.

The novelty of this study lies in the design of a Problem Based Learning (PBL) e-module that integrates ethnoscience content related to the biodiveristy of herbal plants. This approach is intended to deepen students scientific understanding while simultaneously fostering an appreciation for local cultural wisdom and encouraging environmental sustainability. The approach is designed to both deepen students' understanding of science and instill of value for local cultural wisdom while promoting sustainability in the environment. Given the low levels of critical thingking and environmental literacy among Indonesian students, as highlighted by international assessments like PISA, and the continued reliance on conventional teaching methods, this research is both timely and urgent. By addressing these issues, the study seeks to cintribute to the advencemnet of science education that is both effective and culturally responsive.

M ETHOD

This study employed a Research and Development (R&D) approach following the 4D model (Define, Design, Develop, Disseminate) originally proposed by Thiagarajan, Semmel, and Semmel (1974). This model was adapted to develop a Problem-Based Learning (PBL) eth-

noscience e-module on the biodiversity of herbal plants, aimed at enhancing critical thinking and environmental literacy among junior high school students at SMP Negeri 02 Jatiyoso. The choice of the 4D model was based on its systematic stages for instructional design, which have been widely used and validated in educational product development (Branch, 2009).

1. Define Stage

The initial phase involved needs analysis through semi-structured interviews with science teachers to identify challenges in teaching biodiversity topics. This was complemented by concept and task analyses to structure the content systematically. Learning objectives, prerequisite skills, learning outcomes, and instructional strategies were formulated at this stage, ensuring alignment with the 2013 Indonesian Curriculum (Kementerian Pendidikan dan Kebudayaan Republik Indonesia, 2013). This step ensures the instructional goals meet both educational standards and learner needs.

2. Design Stage

In the design phase, an initial prototype of the e-module was created integrating PBL principles (Hmelo-Silver, 2004) and ethnoscience elements, which connect scientific concepts to local cultural knowledge (Rahayu & Sudarmin, 2015). This phase included selecting relevant instructional materials, multimedia features, and interactive activities that encourage active learning and real-world problem exploration related to herbal plants.

3. Develop Stage

During development, the e-module underwent validation by two experts: a subject matter expert for content accuracy and a media expert for instructional design and usability. The expert feedback guided revisions to improve clarity, interactivity, and cultural relevance. Following validation, a practicality test was conducted by distributing questionnaires to 35 students representing the target population. The questionnaire assessed the e-module's attractiveness, usability, and effectiveness in facilitating learning, based on established usability and instructional design criteria (Reiser & Dempsey., 2017).

Data Collection and Analysis

This study employed both qualitative and quantitative methods for data collection. Qualitative data were gathered through semi-structured interviews with science teachers and documentation during the product development process. Quantitative data were obtained from expert validation sheets and student questionnaires to evaluate the validity, practicality, and characteristics of the developed e-module.

Descriptive statistical analysis was used to process the quantitative data. Each response was scored and then converted into percentage values using the following formula.

$$P = \frac{x}{xi} x\ 100\%$$

(Arikunto, 2018)

Description:
P = Percentage score
x = Obtained score
xi = Maximum possible score

The resulting percentage scores were then classified according to the interpretation criteria shown in Table 1.

Table 1. Research Design

Percentage Range	Category
80% - 100%	Very Valid
61% - 80%	Valid
41% - 60%	Quite Valid
21% - 40%	Less Valid
0% - 20%	Not Valid

(Sugiyono, 2015)

The developed product was considered valid if it achieved scores in the "Valid" or "Very Valid" categories. Feedback and criticism from validators served as the basis for revisions. If the revisions involved significant changes in product structure or content, the validation process was repeated. However, if the revisions were minor or technical improvements, the product was deemed ready to proceed to the next stage.

After validation, the product's characteristics were assessed to ensure alignment with user needs and the learning context. This assessment covered content, design, interactivity, and the integration of PBL and ethnoscience elements. Results were converted into percentages and categorized according to Table 2.

Table 2. Product Characteristics Criteria

Characteristic Level	Category
85% - 100 %	Highly suitable to user needs and expectations
70% - 85 %	Good, but some aspects need improvement
50% - 70 %	Adequate but requires significant development
0% - 50 %	Not suitable and requires thorough revision

(Asri & Dwiningsih, 2022)

Characteristics were considered satisfactory if categorized as "Highly Suitable" or "Good." If results fell in the lower categories, further development of the e-module was conducted.

Following validation and characteristic analysis, a practicality test was performed. The practicality test involved administering questionnaires to 35 students of SMP Negeri 02 Jatiyoso, selected as representatives of the target population. The aim was to determine whether the product was attractive, easy to use, and effective in supporting learning. Practicality results were categorized according to Table 3.

Table 3. Product Practicality Criteria

Percentage Range	Practicality Category
81% - 100%	Very Practical
61% - 80%	Practical
41% - 60%	Adequate but requires significant development
21% - 40%	Not suitable and requires thorough revision
≤ 20%	Not Practical

(Sari et al., 2019)

The product was declared practical if the analysis showed results in the "Practical" or "Very Practical" categories. This stage served as the final benchmark before the e-module was deemed suitable for broader use in learning.

RESULT AND DISCUSSION

Profile E-Modul

The developed Problem-Based Learning (PBL) Ethnoscience E-Module on the Biodiversity of Herbal Plants was designed to integrate local cultural knowledge into science education, aiming to enhance students' critical thinking and environmental literacy while fostering appreciation for Indonesia's rich biodiversity. The module presents herbal plant diversity as a contextual and relevant theme for junior high school students, connecting scientific content to everyday life and cultural heritage.

Structurally, the e-module is composed of several key sections: an introduction, a content map, contextual material exploration, problem-based learning activities, and assessment tools. Each part was carefully designed to support inquiry-based learning and promote active student engagement. Table 4 outlines the features and functions of each section of the e-module.

Table 4. Interface and Features of The E-Module

Interface/Feature	Description
Cover Page	Displays the module title, author information, institutional identity, and an illustrative image of herbal plants. The design is visually appealing to increase student motivation.
Introduction	Provides background on the importance of herbal plant biodiversity, states the learning objectives, and includes a brief overview of the module content.
Material Exploration	Presents the main content on herbal biodiversity in an interactive and contextual format, incorporating reading texts, visual aids, and ethnobotanical facts linking science with local culture.
Learning Activities	Guides students through problem-solving steps including identifying problems, gathering information, discussing findings, and formulating solutions—encouraging critical thinking and environmental literacy
Assessment	Contains practice exercises and reflective questions designed to measure cognitive understanding, affective responses, and skills development.

The validation results indicated that the e-module met the "Valid" criteria in terms of content accuracy, pedagogical alignment, and cultural integration. Student feedback showed that the module was "Very Practical," highlighting its ease of use, relevance to students' lives, and motivational aspects. These outcomes reflect the effectiveness of combining PBL with ethnoscience in creating engaging, meaningful, and culturally responsive instructional materials.

More importantly, the integration of ethnoscience within a PBL framework encourages students to connect classroom learning with

real-world cultural practices, thereby reinforcing their identity and environmental responsibility. This is especially vital in today's educational context, where sustainable development and cultural preservation are central to global learning goals (UNESCO, 2017).

In summary, this study demonstrates that contextualized science education, grounded in local wisdom and supported by interactive digital media, can be a powerful tool for improving critical thinking and environmental literacy. The developed e-module offers a model that can be adapted for other scientific topics and cultural settings, particularly in diverse educational environments.

Validation of the E-Module

The validation of the PBL Ethnoscience E-Module on the Biodiversity of Herbal Plants was conducted by two experts who assessed the module's feasibility in terms of both content and media aspects. The evaluation was based on three primary indicators: applicability, content quality, and language use.

The results of the content validation revealed a validity percentage of 90.34%, which falls into the "Very Valid" category. This indicates a strong alignment between the instructional content and educational standards. The expert provided constructive feedback on several points, including the clarity of the learning objectives, the consistency between learning outcomes (CP), learning trajectories (ATP), and subtopics, as well as the appropriateness of scientific terminology. Editorial suggestions were also made to improve readability and overall presentation. These results are detailed in Table 5.

Table 5. Content Expert Validation Results

No	Assessment Aspect	Item	Max	Total	%
1	Applicability	14	70	58	90.34
2	Content	12	60	59	
3	Language	3	15	14	
Total		29	145	131	

Meanwhile, the media validation produced a validity score of 78.62%, which falls under the "Valid" category. Although the media design was generally effective, the experts recommended further improvements in navigation and interactive design elements to enhance the user learning experience. These suggestions support the continuous development of the module for better accessibility and engagement. Details of the media validation results are presented in Table 6.

Table 6. Media Experrt Validation Results

No	Assessment Aspect	Item	Max	Total	%
1	Applicability	14	70	45	78.62
2	Content	12	60	57	
3	Language	3	15	12	
Total		29	145	114	

Overall, the validation process confirms that the e-module meets quality standards in content, language, and media design. According to Novitasari (2022), content validity is a critical indicator for determining the effectiveness of instructional materials in developing students' competencies. Sanjaya and Ratnasari (2021) emphasize that critical thinking skills can only be fostered effectively when a PBL approach is implemented with high fidelity. Additionally, Sihafudin and Trimulyo (2020) note that accurate language use in instructional texts significantly aids student comprehension and minimizes conceptual misunderstandings.

In conclusion, the validated e-module is considered suitable for implementation in science learning activities focused on developing critical thinking and environmental literacy.

Characteristics of the E-Modul

The ethnoscience-based Problem-Based Learning (PBL) e-module focusing on the biodiversity of herbal plants was evaluated by three experts, comprising two science education lecturers and one science teacher. The evaluation results are summarized in Table 7.

Table 7. Expert Evaluation of the Ehnoscience PBL E-Module

Evaluation Aspect	Expert I	Expert II	Expert III	Max
Uniqueness and Novelty of the E-Module	17	22	21	60
Content Relevance and Learning Goals	23	23	22	68
Pedagogical and Technical Aspects	22	22	20	64
Critical Thinking Skills	24	24	29	77
Environmental Literacy Skills	18	17	13	48
Total Score	104	108	105	317
Percentage	92.69%			

Practicality of the E-Module

The practicality of the PBL Ethnoscience E-Module on the Biodiversity of Herbal Plants was assessed to determine its effectiveness and

ease of use in classroom instruction. The assessment involved two groups of practitioners: one science teacher and 25 seventh-grade students. The practicality instrument focused on three core aspects: ease of use, material presentation, and perceived benefits.

The science teacher evaluated the module in terms of operational simplicity, clarity of material delivery, and instructional benefits. As presented in Table 8, the average score was 92.88%, which falls under the "Highly Practical" category. This result indicates that the e-module is user-friendly, well-structured, and significantly supports instructional objectives.

Table 8. Practicality Assessment by Educator

No	Assessed Aspect	Score	Percentage	Category
1.	Ease of Use	18	90%	Highly Practical
2.	Material Presentation	29	96%	
3.	Usefulness	23	92%	
Total		70	278,66	
Average			92.88%	

The consistently high practicality scores from both teachers and students indicate that the e-module is suitable for use in real learning environments. The integration of PBL with local ethnoscientific content enriches the instructional context and enhances student engagement. These findings align with Lidrawan and Erniwati (2022), who assert that a learning product is considered practical if it can be effectively applied in actual teaching conditions.

This result reinforces the module's potential to function not only as a digital learning tool but also as an educational innovation that fosters meaningful, localized, and active science learning experiences.

CONCLUSION

This study concludes that the developed ethnoscience-based PBL e-module on herbal plant biodiversity is valid, practical, and pedagogically relevant for science education at the junior high school level. The module effectively enhances students' critical thinking and environmental literacy through culturally contextualized learning. The integration of local wisdom into scientific learning not only enriches the content but also promotes meaningful engagement and sustainability values. This e-module can serve as an innovative learning resource aligned with curriculum goals and 21st-century skills development. Future research may explore the module's impact on student outcomes across different regions and its integration with digital learning platforms for broader implementation.

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