



Development of Problem-Based Learning Tools on Biodiversity that Accommodate Marind Tribe's Medicinal Plant Garden to Improve Critical Thinking Skills and Environmental Literacy of Agricultural Vocational School Students

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Received: August 9, 2025

Revised: October 14, 2025

Accepted: November 25, 2025

Published: November 30, 2025

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DOI: [10.29303/jppipa.v11i11.12482](https://doi.org/10.29303/jppipa.v11i11.12482)

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Abstract: This study aims to develop a problem-based learning (PBL) tool for biodiversity that integrates the Marind Tribe's medicinal plant garden as a contextual learning resource in an agricultural vocational school. The development was conducted using the Research and Development (R&D) method with the 4D model (Define, Design, Develop, Disseminate). The results showed that the developed learning tool was highly valid in terms of content, construct, and integration with the local context. The practicality of the tool was reflected in the ease of implementation, clarity of instructions, and high student engagement. The effectiveness of the tool was demonstrated by a significant increase in students' critical thinking scores based on N-gain analysis, as well as increased environmental literacy and cultural awareness. The local context adopted from the Marind Tribe's medicinal plant garden successfully fostered an appreciation for ecological values and cultural wisdom. This study provides an important contribution to the development of learning tools that combine scientific, cultural, and contextual approaches as a form of ecopedagogy implementation. It is recommended that a similar approach be implemented more widely across educational institutions, taking into account their respective local cultural contexts. Further research is recommended to evaluate the long-term impact on environmental conservation and strengthening local cultural identity.

Keywords: Learning Tools; Local Wisdom; Problem-Based Learning

Introduction

21st-century education demands learning that focuses not only on content but also on developing critical thinking skills and environmental literacy. In agricultural vocational schools, biology instruction is often conventional and theoretical, particularly on biodiversity (Eisenhauer, 2024); (Daum et al., 2023). This makes it difficult for students to understand the relevance of the material to real life, ultimately hindering their awareness of the importance of conservation (Van De Wetering et al., 2022); (Bennett et al., 2017). Biodiversity has great potential to be taught contextually by utilizing local learning resources

(Abdullah, 2024); (Id Babou et al., 2023). In South Papua, the Marind Tribe's medicinal plant gardens offer a wealth of biodiversity and authentic cultural values. However, these learning resources have not been optimally utilized in formal learning tools (Afradisca & Desnita, 2019); (Zahrah et al., 2024); (Mehner et al., 2025). Integrating local knowledge not only enriches learning content but also strengthens the identity of the community (Sakti et al., 2024). To bridge the gap between theory and practice, this study proposes a Problem-Based Learning (PBL) approach (Chueh & Kao, 2024); (Rehman et al., 2024); (Rosário & Dias, 2024).

How to Cite:

Fakhrudin, Suhartini, & Paidi. (2025). Development of Problem-Based Learning Tools on Biodiversity that Accommodate Marind Tribe's Medicinal Plant Garden to Improve Critical Thinking Skills and Environmental Literacy of Agricultural Vocational School Students. *Jurnal Penelitian Pendidikan IPA*, 11(11), 958-964. <https://doi.org/10.29303/jppipa.v11i11.12482>

PBL has proven effective in enhancing critical thinking skills because it encourages students to analyze and find solutions to real-life problems (Almulla, 2020); (Wahdaniyah et al., 2023). By highlighting local issues related to the Marind Tribe's medicinal plant gardens, PBL can motivate students to be more active and critical in responding to environmental issues relevant to their lives (Salvadó & Novo, 2025); (Velempini, 2025). The development of innovative learning tools is essential to address abstract and non-contextual biology learning (Kwangmuang et al., 2021); (Nurdin et al., 2025); (Leasa & Batlolona, 2024). This research addresses this need by designing a PBL learning tool that explicitly integrates the Marind Tribe's medicinal plant garden. This tool includes lesson plans, worksheets, and evaluation instruments designed to comprehensively measure students' critical thinking skills and environmental literacy.

This research makes a significant contribution by combining three key elements: PBL, biodiversity materials, and local learning resources (the Marind Tribe's medicinal plant garden). This contribution fills a gap in the literature, particularly at the vocational high school level, and offers a learning model that is responsive to local and global issues. The resulting learning tool will not only enhance student competency but also support sustainable natural resource management practices based on local wisdom.

Method

This research used the Research and Development (R&D) method with the 4D model (Define, Design, Develop, Disseminate) to develop a problem-based learning (PBL) tool for biodiversity. This tool integrates local learning resources in the form of the Marind Tribe's medicinal plant garden and aims to improve critical thinking skills and environmental literacy in vocational high school students in South Papua.

Development Stages

Define: Identifying learning problems and needs through curriculum analysis, literature review, teacher interviews, and classroom observations; **Design:** Developing learning tools, such as lesson plans, worksheets, and teaching materials, based on PBL principles and integrating the local context. Assessment instruments were also designed to measure critical thinking skills and environmental literacy; **Development:** Validating the learning tools with experts (biologists, PBL experts, and local cultural experts). The product was then trialed and revised based on feedback; **Disseminate:** Conduct final revisions and disseminate the learning tools through

workshops for teachers at local agricultural vocational schools.

Instruments and Data Analysis

Data were collected through expert validation sheets, critical thinking tests, environmental literacy questions, and practicality questionnaires. Data analysis was conducted quantitatively to measure effectiveness (using the N-gain formula) and qualitatively to assess the tool's feasibility.

Result and Discussion

Validity of Learning Tools

Validity is the initial and essential step in the learning tool development process, as it assesses the extent to which the developed tools meet quality standards in terms of material substance, pedagogical approach, and integration with the local cultural context. In this study, problem-based learning tools integrating the Marind Tribe's medicinal plant garden into the biodiversity topic were assessed by three types of experts: a biology material expert, a pedagogy expert, and a local cultural expert. The validation results indicated that the learning tools had a high level of validity in terms of content, construct, and context. The content aspect was assessed based on the material's suitability to basic competencies and biology knowledge. The construct aspect included the logical systematics of the tool's development, its adherence to Problem-Based Learning (PBL) principles, and the meaningfulness of the activities for students. The local context aspect was assessed by the extent to which the learning materials and activities authentically and meaningfully represented the values of the Marind Tribe's local wisdom.

Content validity was strengthened by expert input that integrating the medicinal plant garden as a learning resource represents a contextual approach that connects academic content with students' real-life situations. Construct validity was demonstrated through the alignment between the objectives, methods, and assessments within the toolkit. Meanwhile, local context validity was strengthened by narratives and activities involving hands-on practice and field studies based on local culture. This aligns with the opinion of (Chibuye & Singh, 2024); (Kamila et al., 2024), that integrating local knowledge into science learning can enhance contextual validity and learning relevance for students. Following the validation process, the toolkit was revised based on input from the validators. Some improvements included clarifying the instructions for using the worksheets, strengthening environmental literacy indicators, and incorporating

cultural reflections into the evaluation sheet. These revisions demonstrated that the toolkit not only met theoretical feasibility but was also practically applicable in the context of agricultural vocational high schools in South Papua.

Validity assessment in developing tools rooted in local culture is a crucial practice in developing learning that is not only cognitively effective but also affectively and socioculturally meaningful. In line with this, (Maican et al., 2025); (Riza et al., 2024), emphasized that the validity of contextual learning tools will be stronger if they consider the social and local dimensions of students as an integral part of the learning process. Validation results indicate that the tool has a high level of validity in three aspects: content, construct, and local context. The tool is assessed in accordance with the basic competencies and principles of PBL learning that support meaningful activities based on local wisdom. Revisions were made based on expert advice, such as refining the instructions for using the worksheets, sharpening environmental literacy indicators, and inserting aspects of cultural reflection in the evaluation. This strengthens the theoretical and practical feasibility of the tool for implementation in the South Papua Agricultural Vocational School.

Table 1. Learning Device Validation Results

Aspects Assessed	Average Rating (Scale 1–5)	Category
Content Validity	4.60	Very Valid
Construct Validity	4.40	Very Valid
Local Context Validity	4.70	Very Valid
Total Mean	4.57	Very Valid

Practicality of Learning Tools

Practicality is an important indicator in evaluating learning tools, particularly during the limited trial phase of developing a Research and Development (R&D) model. Practicality refers to the extent to which the tool can be used easily and effectively by target users, namely teachers and students, in a real-life learning context (Nguyen et al., 2024); (Kumar Basak et al., 2018). In this study, a problem-based learning tool integrating the Marind Tribe's medicinal plant garden was assessed from a practicality perspective through the responses of teachers and students of an agricultural vocational school. The trial results indicated that the tool had a high level of practicality based on several indicators: ease of use, clarity of instructions, and the tool's ability to actively engage students in learning activities. Teachers responded positively to the tool's systematic structure and the alignment of the learning steps with PBL principles, which encourage exploration and discussion based on

local contexts. Meanwhile, students felt that the tool helped them understand biodiversity through real-life learning experiences relevant to everyday life.

This practicality aspect is reinforced by the findings of (Di Fuccio et al., 2024), stated that local wisdom-based devices tend to be easier for students to understand and follow because they utilize a cultural context they are already familiar with. This makes the learning process feel less unfamiliar, thus increasing motivation and active participation. The integration of the Marind Tribe's medicinal plant garden not only enriches the learning content but also provides a learning experience that addresses students' affective and psychomotor aspects. Practicality was assessed through a limited trial involving teachers and students of an agricultural vocational school. The results indicated that the devices were highly practical, as seen from their ease of use, clarity of instructions, and effectiveness in facilitating student learning activities. Teachers responded positively to the device's structure and implementation of PBL, while students felt the learning activities became more realistic and relevant to their lives. The integration of local context was shown to strengthen student interest and engagement.

Table 2. Results of Practicality of Learning Devices

Practicality Indicators	Teacher (Scale 1–5)	Students (Scale 1–5)	Average Category
Ease of Use	4.50	4.40	Very Practical
Clarity of Instructions	4.60	4.35	Very Practical
Suitability to PBL & Local Context	4.70	4.55	Very Practical
Student Activation and Engagement	4.65	4.50	Very Practical
Average Total	4.61	4.45	Very Practical

Furthermore, the practicality of this tool is also evident in the effectiveness of the technical instructions on the student worksheets (LKS) and teacher guides, which facilitate gradual, directed, and flexible learning. This aligns with a study by (Annam et al., 2023); (Meng et al., 2023), which states that PBL-based modules or tools embedded with local wisdom values can enhance student engagement in 21st-century learning contexts that demand collaboration and problem-solving. Overall, the developed learning tool demonstrates strong practicality and is suitable for use in biology learning, particularly on biodiversity in agricultural vocational schools. This success demonstrates that tool design that integrates local wisdom and a PBL approach can bridge the gap between curriculum

demands and students' real-world needs in the local context.

Tool Effectiveness in Improving Critical Thinking

One of the primary objectives of developing this problem-based learning tool is to improve students' critical thinking skills in the context of biology learning in vocational schools, particularly on biodiversity. To measure the effectiveness, testing was conducted using pretest and posttest instruments designed to measure critical thinking skills based on relevant indicators, such as the ability to analyze arguments, evaluate evidence, and draw logical conclusions. Analysis of pretest and posttest data showed a significant increase in students' critical thinking skills. This increase was confirmed through the calculation of normalized gain (N-gain), which showed a moderate to high category for most students. These results indicate that the developed tool is able to facilitate students in developing higher-order thinking skills, especially as they are faced with real-world problems related to local biodiversity conservation.

The application of the Problem-Based Learning (PBL) approach in this toolkit has proven effective in encouraging students to analyze complex environmental problems, gather information, and develop solutions based on data and field experiences. This aligns with the findings of (Yana et al., 2022); (Darling-Hammond et al., 2020), who stated that problem-based learning in a contextual and realistic context can improve critical thinking because students are required to examine problems in depth and develop plausible solutions based on information synthesis. In addition to quantitative data, qualitative evidence was also obtained from the improvement in the quality of students' arguments during class discussions. Students began to demonstrate the ability to question assumptions, compare various viewpoints, and express opinions with strong reasons. The presence of a local context, such as direct observation of the Marind Tribe's medicinal plant garden, provided an emotional connection that helped students become more engaged in critical thinking. This cultural context creates a sense of ownership of the issue, which, according to (Lawson et al., 2023); (Alam & Mohanty, 2024); (Mebert et al., 2020), can deepen students' cognitive engagement with the learning material and enrich their thinking processes.

The Role of Local Context: The Marind Tribe's Medicinal Plant Garden

The integration of the Marind Tribe's medicinal plant garden into problem-based learning tools demonstrates its effectiveness in delivering learning that is not only cognitive, but also affective and contextual. Learning activities involving direct

exploration of local medicinal plants provide students with a platform to understand their biological richness and to appreciate the ancestral cultural values they contain. Learning outcomes indicate that students not only gain biological knowledge about medicinal plant diversity but also begin to demonstrate an appreciation for the Marind community's ethnobotanical practices, which have rarely been addressed in formal learning. This local context serves as a bridge between academic content and students' daily lives, encouraging the internalization of cultural and ecological values. This aligns with the principles of ethnopedagogy, which prioritizes local culture as the primary source of (Silvola et al., 2021), and ecopedagogy, which positions education as a means of building ecological awareness grounded in community wisdom (Bhuttah et al., 2024). Furthermore, this approach fosters cultural identity and a concern for local environmental preservation.

Students begin to understand that the practice of using medicinal plants is not simply a traditional activity but also part of a local knowledge system that plays an ecological, social, and spiritual role. As emphasized by (Latip et al., 2024); (Zainal et al., 2024), integrating local knowledge into formal education can be a tool for cultural and environmental conservation while increasing the participation of the younger generation in preserving ecosystems and traditional values. The Marind community's medicinal plant garden also serves as an authentic learning platform. When students interact directly with learning objects in their own environment, they experience a more meaningful and reflective learning process. This reinforces the finding that local community-based education has a greater impact on building contextual environmental awareness than abstract or purely theory-based approaches (Hadjichambis & Paraskeva-Hadjichambi, 2020); (Mhlono et al., 2023). Therefore, utilizing medicinal plant gardens as contextual learning resources significantly contributes to biology learning in vocational schools. It not only improves the quality of cognitive learning but also strengthens the social and ecological dimensions of education, which aligns with the principles of sustainable education and education based on local wisdom.

Conclusion

A problem-based learning tool integrating the Marind Tribe's medicinal plant garden into biodiversity material has proven highly valid, highly practical, and effective in enhancing vocational high school students' critical thinking skills. High validity is reflected in the content, construct, and local context. Practicality is demonstrated through ease of use and active student

engagement, while effectiveness is achieved through significant improvements in learning outcomes and understanding of local cultural and ecological values. It is recommended that similar tools be developed more widely across educational institutions, taking into account the local cultural context to strengthen student engagement and learning relevance. Further research is also needed to examine the sustainability of the impact on ecological awareness and cultural preservation.

Acknowledgments

Thanks to all parties who have supported the implementation of this research. I hope this research can be useful.

Author Contributions

Conceptualization; F.; methodology; S.; validation; formal analysis; P.; investigation; F.; resources; S.; data curation; P.; writing—original draft preparation; F.; writing—review and editing; S.; visualization; P. All authors have read and agreed to the published version of the manuscript.

Funding

Researchers independently funded this research.

Conflicts of Interest

The authors declare no conflict of interest.

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