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Development of a Project-Based Learning Module Grounded in Ethnoscience to Enhance Students' Scientific Literacy and Collaboration Skills

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Abstract: This study aims to develop a Project-Based Learning (PjBL) module integrated with ethnoscience in the Pancasila Student Profile (P5) program, which focuses on strengthening students' scientific literacy and collaboration skills. Using the 4D development model (Define, Design, Develop, Disseminate), the module was validated by experts, tested for practicality, and implemented in a rural junior secondary school in West Lombok, Indonesia. The validation results indicated high feasibility, with scores of 87.3% for the module, 88.3% for student worksheets, and 97.2% for assessment instruments. Furthermore, the practicality test reached 92.97%, categorized as highly practical. The classroom implementation of the project "The Sweetness of Science in Palm Sugar" notably increased student participation, contextual understanding of scientific concepts, and teamwork. These findings demonstrate that the developed module is both valid and practical for P5 learning, offering a culturally relevant approach to support 21st-century skills. Moreover, this study contributes by showing how ethnoscience can be systematically embedded into PjBL to improve learning quality and provides implications for adapting this model across diverse Indonesian school contexts.

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Introduction

Human resource development is a central pillar in Indonesia's strategy to face the Fourth Industrial Revolution, where education plays a pivotal role in fostering relevant competencies, including knowledge, skills, and character (Teknowijoyo & Marpelina, 2022). To address these demands, the government has introduced the *Merdeka Curriculum*, which emphasizes the development of the Pancasila Student Profile through contextual, interdisciplinary, and innovative learning approaches (Kemendikbudristek, 2022). One of the core competencies promoted within this curriculum is scientific literacy, which enables individuals to critically respond to global changes and technological advances (Pratiwi et al., 2019).

Despite this effort, Indonesian students' performance in scientific literacy remains low. According to the 2022 PISA results published by the OECD, only 34% of Indonesian students reached Level 2 or above in science, far below the OECD average of 489. This trend is also reflected in SD-SMP Satu Atap 4 Gunungsari, where students struggle to meet expected scientific competencies. Furthermore, students' collaboration skills are still limited, as seen in their reluctance to participate in group activities and express opinions during discussions. Educational constraints in rural areas—such as limited science laboratories and socio-economic challenges—further hinder the development of scientific and collaborative abilities (Ilma et al., 2023; Permanasari et al., 2021).

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Previous studies have demonstrated the potential of Project-Based Learning (PjBL) and ethnoscience in addressing these challenges. Khoirunnisa & Dumiyati (2023) found that PjBL significantly improved educational quality and student engagement when implemented in P5 activities. Integration with digital platforms like Zoom has also proven effective in enhancing collaborative skills. Meanwhile, Herayanti et al. (2025) emphasized the contextual power of ethnoscience-based modules in increasing students' conceptual understanding. Additional research (Hidayanti & Wulandari, 2023; Hidayati & Julianto, 2024) confirms that integrating ethnoscience into assessments and instructional materials can boost students' learning motivation and scientific thinking.

The scientific novelty of this study lies in the development of a PjBL module specifically designed for P5 activities, integrating local wisdom through ethnoscience under the theme *"The Sweetness of Science in Palm Sugar."* Unlike previous studies that treated PjBL and ethnoscience separately, this study combines both within the national curriculum context to directly address scientific literacy and collaboration deficits in under-resourced schools.

This research contributes to bridging the gap between curriculum policy and classroom practice in the implementation of the Pancasila Student Profile (P5). By systematically integrating ethnoscience into Project-Based Learning (PjBL), the study provides empirical evidence that locally grounded learning modules can strengthen students' scientific literacy and collaboration skills. The findings enrich existing knowledge in science education by offering a replicable model that addresses persistent challenges in under-resourced schools. Moreover, the study highlights how culturally relevant pedagogical approaches can be adapted to diverse Indonesian educational contexts, ensuring both sustainability and scalability in the long term. This study aims to describe the development process, content validity, and practicality of an ethnoscience-based PjBL module in P5 activities, aimed at strengthening students' scientific literacy and collaboration skills.

Research Method

This research employed a research and development (R&D) method with the 4D development model (Thiagarajan et al. 1974), which includes the stages: Define, Design, Develop, and Disseminate. In the Define stage, a comprehensive needs analysis was conducted through curriculum review, identification of problems in science learning at the school level, and mapping the potential of local wisdom—particularly ethnoscience elements such as palm sugar production—as contextual learning resources. The Design stage involved constructing the structure of the learning module, designing student learning activities, developing assessment instruments, and integrating the syntax of Project-Based Learning (PjBL) with the flow of Pancasila Student Profile (P5) learning. The Develop stage focused on creating a complete prototype of the module, which included content, activities, visual layout, and assessment tools. This prototype was then subjected to expert validation and revised based on feedback to ensure quality and feasibility. Finally, in the Disseminate stage, the module was implemented on a limited scale to examine its practicality and usability in real classroom settings, particularly in a rural school environment with limited resources.

This study was conducted at SD-SMP Satu Atap 4 Gunungsari, located in West Lombok, during the odd semester of the 2024/2025 academic year. The implementation took place from October to December 2024, aligning with the scheduled activities for the Pancasila Student Profile (P5) program. The research involved a mixed-grade class of students from Grades 7 to 9, consistent with the integrated structure of the Satu Atap school model. Four science teachers participated as facilitators, supporting the delivery of project-

based learning activities. Additionally, three expert validators—consisting of a science content expert, a language expert, and an educational practitioner—were involved in evaluating the quality of the developed module. As a qualitative classroom-based development study, the researcher took an active role within the learning environment, engaging directly with students and teachers through observation, documentation, and co-facilitation of the learning process.

The instruments used in this study were categorized into feasibility instruments and practicality instruments, both designed to assess the module's content validity and usability. The feasibility instruments consisted of validation sheets for the ethnoscience-based PjBL module, student worksheets (LKPD), and assessment tools. These instruments evaluated the alignment of the module with curriculum objectives, the integration of ethnoscientific content, and the effectiveness of the module in developing scientific literacy and collaboration skills. Validation was conducted by expert reviewers using a quantitative rubric that assigned percentage scores to each component. Meanwhile, the practicality instrument took the form of observation sheets used during classroom implementation to evaluate the module's usability from both teacher and student perspectives. Data collection was carried out through multiple methods, including expert validation, classroom observations, interviews with science teachers, and student response questionnaires. These various sources provided a comprehensive understanding of the module's quality and practicality in real learning environments.

Quantitative descriptive analysis was employed to process and interpret data from both the validation and practicality tests. The scores obtained from expert validators and classroom observations were converted into percentages using the formula:

$$P = \left(\frac{\sum X}{N}\right) x\ 100\%$$

Where P represents the percentage score, $\sum X$ is the total score obtained, and N is the maximum possible score. The resulting percentages were then categorized according to predetermined criteria: ≥85% (highly feasible/practical), 70–84% (feasible/practical), 55–69% (fairly feasible/practical), and <55% (not feasible/practical). These categories were used to interpret the level of validity and practicality of the module. The results were subsequently presented in tables and charts to provide a clearer visual representation of the module's feasibility and usability in real classroom contexts. The interpretation of percentage scores followed these criteria:

Table 1. Criteria for Module Validation Percentage Interpretation

Percentage Range	Category	Interpretation
≥ 85%	Highly Feasible	Excellent, usable without revision
70% – 84%	Feasible	Good, usable with minor revision
55% – 69 %	Fairly Feasible	Needs major revision
< 55%	Not Feasible	Not usable without full revision

Practicality scores from classroom observations were analyzed using the same formula and interpreted as:

Table 2. Criteria for Module Practicality Percentage Interpretation

Percentage Range	Category	Interpretation
≥ 85%	Highly Practical	Very practical, ready to use
70% – 84%	Practical	Practical, with minor

		adjustments
55% – 69 %	Fairly Practical	Needs significant improvement
< 55%	Not Practical	Not usable without comprehensive revision

Results and Discussion

The module development followed the 4D model (Thiagarajan, Semmel, & Semmel, 1974), consisting of the stages: Define, Design, Develop, and Disseminate. The module was designed as a Project-Based Learning (PjBL) teaching material integrated with ethnoscience, contextualized within the Pancasila Student Profile (P5) project, aiming to cultivate 21st-century skills—particularly scientific literacy and collaborative competence among students.

Define Stage

This stage was a crucial foundational step. Needs analysis conducted at SD-SMP Satu Atap 4 Gunungsari, West Lombok, revealed that science learning remained dominated by conventional, theoretical methods with limited relevance to students' everyday lives. The rural environment of Mekarsari Village—with cultural practices such as palm sugar production—holds great potential as a contextual learning resource. Integrating ethnoscience fosters more meaningful science education rooted in local values, bridging the gap between scientific concepts and local practices. This aligns with Festiyed et al. (2022), who found that ethnoscience boosts learning motivation.

The module was also designed to develop 21st-century skills: scientific literacy (understanding concepts, investigating data, scientific communication) and collaborative skills (teamwork, communication, and conflict resolution). These competencies align with the goals of PISA and the *Merdeka Curriculum*. The module was synchronized with Phase D science learning outcomes and P5 dimensions (Critical Thinking, Independence, Collaboration). The 10 learning hours per week allocated for P5 provide ample space for in-depth, exploratory project-based learning, overcoming time constraints often faced in intradisciplinary instruction. The flexibility of P5 supports a more engaging and participatory learning environment, promoting soft skills and character development.

Design Stage

This stage involved the systematic construction of the module by aligning it with the learning flow of Project-Based Learning (PjBL) and the Pancasila Student Profile (P5). The module was structured to include essential components such as module identity, learning objectives, driving questions, mapping of P5 dimensions, weekly lesson plans, and assessment strategies. The integration of PjBL syntax—comprising essential question formulation, project planning, scheduling, progress monitoring, result evaluation, and reflection—with the P5 stages of Introduction, Contextualization, Real Action, and Reflection ensured that the learning process emphasized not only the achievement of project outcomes but also the development of students' character and values. Learning activities were designed in three main formats: explorative activities involving direct observation of palm sugar production, experimental and discussion-based activities for analyzing scientific concepts, and presentation and reflection sessions aimed at scientific reporting and self-evaluation. Ethnoscience was embedded as a core instructional element rather than being treated as peripheral content. The traditional palm sugar production process served as a contextual gateway for introducing scientific principles such as heat transfer, evaporation, filtration, and crystallization. To enhance student engagement, the module employed

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communicative language and visually appealing illustrations tailored to the characteristics of junior secondary students.

Develop Stage

This stage focused on the comprehensive compilation of the module, encompassing instructional content, project-based learning activities, assessment components, and visual presentation. The PjBL syntax was carefully adapted to the structure of the P5 learning flow—covering concept exploration, contextualization, real action, and reflection—to ensure coherence with both co-curricular learning objectives and the principles of scientific reasoning. The developed module was then subjected to expert validation involving three evaluators: a science content expert, a language expert, and a practicing science teacher. To assess the quality and appropriateness of the module, three validation instruments were employed, namely the module validation sheet, the student worksheet (LKPD) validation sheet, and the assessment instrument sheet. Feedback obtained from the experts was used to revise and refine the module, thereby enhancing its feasibility and readiness for practical classroom use.

Disseminate Stage

This stage involved limited-scale implementation at SD-SMP Satu Atap 4 Gunungsari. The school was selected due to its implementation of the *Merdeka Curriculum* under the "Mandiri Berubah" category and its limitations in resources, geography, and diverse socio-economic student backgrounds. The module was used in a P5 project titled *"The Sweetness of Science in Palm Sugar"* over a ten-week period. Teachers acted as facilitators, guiding students through the integrated PjBL and P5 syntax. The objectives were to evaluate the module's practicality, assess initial teacher and student responses, and identify implementation challenges.

Module Validation Results

The module received an average feasibility score of 87.3%, categorized as "Highly Feasible". This indicates that the module meets quality standards in terms of content relevance, integration of learning syntax, and incorporation of ethnoscience. The ethnoscience integration aspect—particularly the use of palm sugar production—scored the highest at 93.3%, confirming that local context significantly enhances students' comprehension of scientific concepts. Minor revisions were recommended for improving visual design, refining scientific content, and clarifying ethnoscience values.

The LKPD scored 88.3%, also falling into the "Highly Feasible" category. The highest scores were for content relevance and language clarity (91.7%), indicating that the LKPD is well-aligned with science learning objectives and easy to understand. The integration of PjBL and ethnoscience also scored 91.7%, demonstrating explicit and contextual implementation. The LKPD effectively fostered scientific literacy and collaboration skills (91.7%) through activities such as experiments, group discussions, and project reporting. Slightly lower scores in structure and layout (83.3%) suggest minor visual and technical revisions are needed.

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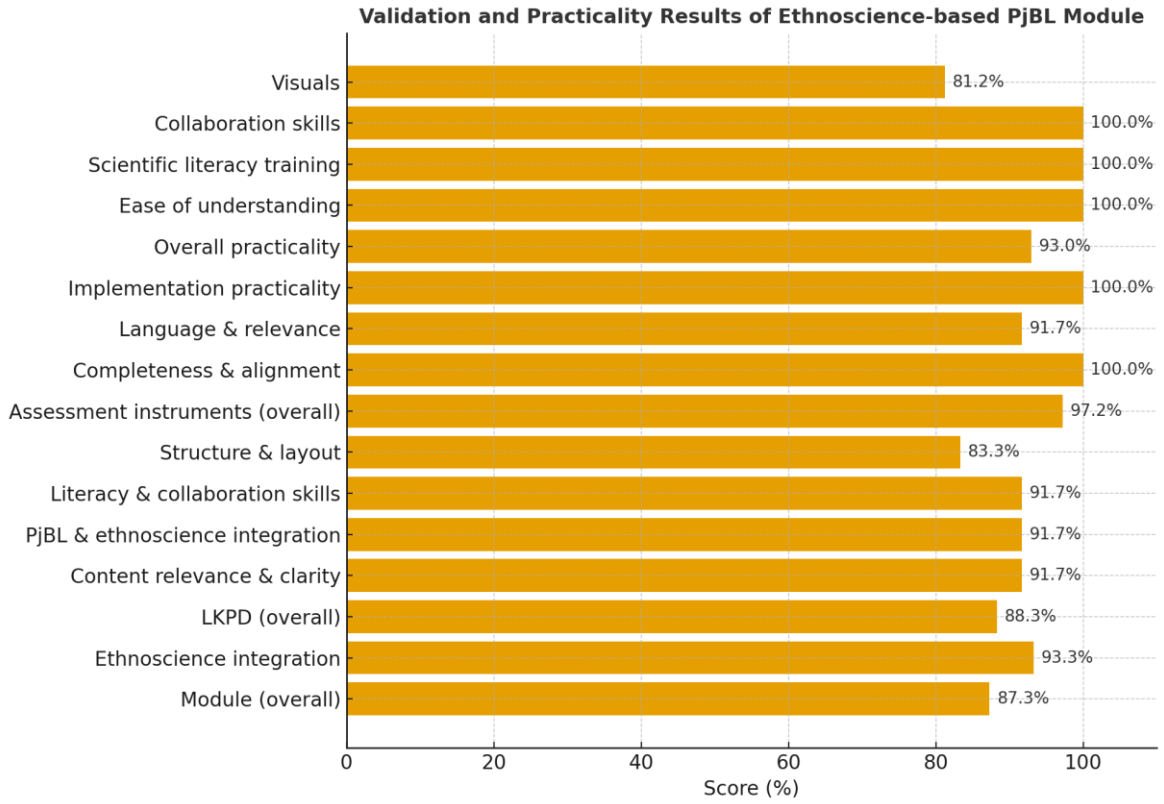

Figure 1. Validation and Practicality Results of the Ethnoscience-based PjBL Module

The assessment instruments achieved a 97.2% feasibility score, with perfect ratings (100%) for completeness, clarity, consistency, and alignment with learning indicators. This indicates that the rubric adequately captured all dimensions of scientific literacy and collaboration. Language and relevance aspects scored 91.7%, while implementation practicality for teachers scored 100%, a significant advantage in under-resourced schools. The 91.7% score indicates room for improvement in adapting the instruments for students with lower literacy backgrounds or unique socio-cultural environments.

The implementation of *"The Sweetness of Science in Palm Sugar"* over ten weeks showed an increase in student enthusiasm and active participation. The use of local cultural context made science learning feel real and relevant. This supports the findings of Mustaqim et al. (2024), who reported that project-based learning rooted in cultural traditions significantly boosts student engagement. Scientific activities—such as observing crystallization, heating sap, and measuring temperature—were directly connected to everyday experiences, leading to deeper conceptual understanding.

The overall practicality score of the module reached 92.97%, placing it in the **"**Highly Practical**"** category. This result indicates that the module was not only implementable but also effective in supporting the learning process. Three core aspects received perfect scores of 100%. First, in terms of ease of understanding, the module featured a logical structure, clear instructional flow, and supportive visual elements, all of which contributed to fostering student independence during project implementation. Second, regarding scientific literacy training, the learning activities guided students through complete scientific processes—such as observation, experimentation, data analysis, and communication—within a culturally relevant context rooted in palm sugar production. Lastly, in developing collaboration skills, the module encouraged productive teamwork through clearly defined roles in each project phase and embedded the P5 value of *gotong royong* (mutual cooperation), which enhanced

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students' socio-emotional and interpersonal competencies. The only aspect that scored slightly lower (81.25%) was "Attractive and Educational Visuals", which is still in the "Practical" category. This suggests the need for further enhancement in visual presentation to increase learning motivation.

Discussion

The integration of palm sugar production as a local context in the ethnoscience-based PjBL module significantly enhanced student engagement and learning relevance. Students exhibited heightened enthusiasm and participated more actively in science lessons when the material was contextualized through culturally familiar practices. Scientific activities, such as observing crystallization and heating sap, became more meaningful and stimulated deeper conceptual understanding and critical thinking. This occurred because ethnoscience serves as a pedagogical bridge between abstract scientific knowledge and concrete cultural experiences. When students engage with content rooted in their own environment and traditions, their ability to internalize and retain concepts improves significantly. This finding aligns with the results of Mustaqim et al. (2025) and Herayanti et al. (2025), who demonstrated that culturally contextualized project-based learning improves student engagement and enhances problem-solving skills.

Beyond these findings, this study also emphasizes the potential for adaptation and implementation of the ethnoscience-based PjBL module in diverse Indonesian school contexts. Since the design of the module is rooted in local cultural practices, it can be flexibly contextualized by incorporating region-specific ethnoscience resources, such as traditional food production, local crafts, or agricultural knowledge. This adaptability ensures that the module is not restricted to palm sugar production but can serve as a broader model for culturally relevant science education. To ensure sustainability, the module can be embedded into regular P5 activities and supported through teacher professional development programs, while scalability requires institutional support from schools and local education authorities. In the long term, this approach contributes not only to enhancing students' scientific literacy and collaboration skills but also to advancing Indonesia's national agenda for strengthening 21st-century competencies.

In addition to boosting engagement, the integration of PjBL and ethnoscience proved highly effective in fostering scientific literacy and collaborative skills. The module achieved a perfect score of 100% in these areas, with students participating in full cycles of inquiry—from posing questions, conducting investigations, and analyzing data to presenting findings collaboratively. Project-Based Learning by nature encourages active involvement and teamwork; when enriched with ethnoscientific content, it becomes even more meaningful as it connects academic tasks with students' lived realities. Inquiry-based tasks help develop scientific literacy, while the structured collaboration inherent in PjBL strengthens interpersonal skills and promotes shared responsibility, reflecting the core values of the Pancasila Student Profile. These results are supported by Hidayanti and Wulandari (2023) as well as Herayanti et al. (2022), who confirmed that ethnoscience-based PjBL enhances both scientific reasoning and team-based problem-solving abilities.

Moreover, the practicality of the module was evident even in resource-limited educational settings. Scoring 92.97%, the module was deemed highly practical and easily implementable by both teachers and students at SD-SMP Satu Atap 4 Gunungsari, a rural school with minimal infrastructure. The success of its implementation can be attributed to the module's design, which was responsive to real classroom conditions. Rather than relying on advanced laboratories or digital technology, it made use of readily available local materials. Clear instructions, structured lesson flow, and accessible language reduced the cognitive and

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technical burdens on educators, enabling them to function more effectively as facilitators. This is consistent with the findings of Indriani et al. (2023), who stressed that for project-based learning innovations to be effective, they must be tailored to local school contexts. Similarly, Khairani & Rosita (2025) highlighted that practical and userfriendly assessment tools are essential for sustaining innovation in curriculum implementation. This study demonstrates that the developed ethnoscience-based PjBL module is both valid and practical for improving scientific literacy and collaborative skills, particularly in resource-constrained educational settings. The findings are consistent with literature advocating contextual and culture-based learning. This module contributes meaningfully to empowering education in diverse school conditions across Indonesia.

Conclusion

This research has established that the integration of ethnoscience into a Project-Based Learning (PjBL) framework within the Pancasila Student Profile (P5) program presents a highly effective pedagogical approach for fostering key 21st-century competencies—specifically scientific literacy and collaboration skills—among students. The findings confirmed that the module developed through the 4D model is both theoretically sound and practically implementable. It is not merely a teaching tool, but a learning innovation that connects scientific reasoning with real-life cultural experiences, thereby transforming abstract knowledge into meaningful understanding.

The incorporation of ethnoscience, particularly through the contextual theme of palm sugar production, enabled science learning to be more grounded in students' social realities. This contextualization played a crucial role in enhancing students' engagement and motivation, which are critical foundations for deeper cognitive processing and retention. When science is taught through locally relevant projects, it becomes more accessible, especially for students in rural or under-resourced schools. This suggests that cultural knowledge should no longer be seen as peripheral but positioned as an essential entry point into scientific inquiry and classroom innovation.

Furthermore, the project-based model provided opportunities for students to engage in authentic scientific processes such as observation, experimentation, data analysis, and communication, while simultaneously practicing teamwork, responsibility-sharing, and mutual cooperation. These learning experiences align closely with the dimensions of the Pancasila Student Profile, indicating that such an approach does not only meet cognitive goals but also supports the formation of national character.

In essence, the study affirms that an ethnoscience-based PjBL module is a powerful educational strategy for bridging the gap between curriculum policy and classroom practice. It addresses the realities of schools with limited infrastructure while fostering meaningful learning rooted in culture and community. Therefore, this model offers a replicable and scalable approach for implementing the P5 program more effectively across diverse school contexts in Indonesia.

Recommendation

Building on the findings of this study, several directions for implementation and future research are proposed to expand the development and impact of ethnoscience-based Project-Based Learning (PjBL) modules within the Pancasila Student Profile (P5) framework. To strengthen implementation, it is essential to increase teacher awareness through workshops, reflective discussions, and dissemination of best practices. At the same time, teacher capacity can be enhanced by integrating training on ethnoscience-based PjBL into

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professional development programs, providing practical teaching guides, and offering mentoring opportunities. These strategies ensure that teachers are not only aware of the approach but also equipped with the necessary skills and resources to apply it effectively in diverse school contexts. These directions are presented along with potential challenges that may arise during implementation:

1) **Expansion to Other Local Wisdom Themes**
   Future research should explore the development of similar modules by integrating diverse themes of local wisdom from different regions in Indonesia. For example, traditional crafts, indigenous ecological knowledge, or local food systems can serve as contextual foundations for science and interdisciplinary learning. However, challenges may arise in documenting and translating cultural practices into scientifically valid and pedagogically appropriate materials.
2) **Application Across Educational Levels and Disciplines**
   The module's adaptability can be tested at various educational levels—such as elementary or senior high school—and across other subjects beyond science, including social studies or language learning. This will help determine the versatility of the PjBL-ethnoscience approach. Nevertheless, adjustments in content complexity and instructional design would be necessary, and alignment with specific curriculum standards may pose challenges.
3) **Large-Scale Effectiveness Studies**
   Future studies should include broader samples and experimental designs (e.g., pretest-posttest with control groups) to evaluate the module's impact on cognitive achievement, scientific attitudes, and character development. Conducting such research on a larger scale may be hindered by differences in teacher readiness, school resources, and consistency in module delivery across sites.
4) **Enhancement of Visual and Interactive Features**
   Further research could focus on optimizing the module's visual and interactive elements to improve student engagement. This might include the use of educational technology, such as embedded QR codes, animations, or simple augmented reality experiences. However, limitations such as unequal access to digital tools and lack of design expertise in rural schools may constrain implementation.
5) **Teacher Training and Professional Development**
   The success of ethnoscience-based PjBL modules largely depends on teachers' pedagogical understanding and facilitation skills. Therefore, future research should develop and evaluate sustained professional development programs that equip teachers to apply PjBL, integrate ethnoscience, and assess learning authentically. Barriers may include time constraints, limited training opportunities, and varying levels of teacher motivation or technological fluency.
6) **Sustainability and Long-Term Impact Studies**
   To understand the enduring value of the module, longitudinal studies should be conducted to assess how sustained use affects students' competencies over time. These studies could explore the institutionalization of the module within school systems, including policy integration and community involvement. Potential challenges include funding limitations, administrative turnover, and variability in curriculum priorities.

By addressing these future directions and acknowledging the associated challenges, researchers and educators can collaboratively strengthen the contribution of ethnoscience-

based PjBL modules in promoting contextual, character-based, and skill-oriented education across Indonesia.

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