



Analysis of Teacher Needs for the Development of Ethno-ESD-Based Science Modules in Elementary Schools

Hesti Widia Astuti^{1*}, Ghullam Hamdu¹

¹ Primary School Teacher Education, Universitas Pendidikan Indonesia, Tasikmalaya, Indonesia.

Received: February 12, 2026

Revised: April 10, 2026

Accepted: May 25, 2026

Published: May 31, 2026

Corresponding Author:

Hesti Widia Astuti

hestiwidia13@upi.edu

DOI: [10.29303/jppipa.v12i5.14801](https://doi.org/10.29303/jppipa.v12i5.14801)

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Abstract: Science learning in elementary schools is frequently dominated by traditional, teacher-centered instruction that fails to systematically cultivate students' 21st-century competencies, particularly critical thinking skills. While ethnoscience and Education for Sustainable Development (ESD) offer powerful contextual frameworks, previous research often addresses them in isolation, leaving a critical gap in integrated instructional designs that are rooted in empirical field needs. This study aims to analyze teacher needs regarding the development of an integrated Ethno-ESD science module to strategically strengthen critical thinking in primary education. Operating within the initial analysis phase of a design-based research (DBR) framework, this study employed a descriptive qualitative approach. Data were collected through semi-structured interviews with two grade IV public elementary school teachers selected via purposive sampling. The thematic analysis revealed distinct categories of structural needs: (1) a shift from rote-memorization tasks toward structured problem-based inquiry, (2) the systematic integration of local cultural contexts—specifically traditional palm sugar production—as core learning frameworks rather than incidental examples, and (3) the inclusion of explicit critical thinking rubrics and argumentation tasks. These findings provide an empirical foundation and design specifications for developing actionable Ethno-ESD learning modules in the subsequent phase of research.

Keywords: Critical thinking; Ethno-ESD module; Needs analysis; Primary school; Science

Introduction

Science learning plays an important role in developing the science literacy and critical thinking skills needed in the 21st century (Abrami et al., 2015). Critical thinking involves the ability to interpret information, analyze cause-and-effect relationships, evaluate evidence, and draw logical conclusions when faced with a variety of issues (Ennis, 2018; Facione & Gittens, 2015)). In the context of science education, these skills require students to not only understand scientific concepts but also use them to analyze natural phenomena and environmental problems in real life (Bramastia et al., 2025; Felix et al., 2025). However, science learning in primary schools is still heavily dominated by traditional, teacher-centered approaches. This instructional pattern heavily emphasizes the

mastery of abstract concepts rather than the development of advanced thinking skills, thereby limiting opportunities for scientific analysis, evaluation, and reasoning. To bridge this gap, contextual learning approaches such as ethnoscience have widely developed, integrating scientific knowledge with local knowledge that develops in the community (Blackie, 2024; Snively & Corsiglia, 2001). In the contemporary era, integrating traditional wisdom into modern elementary science education requires adaptive pedagogical strategies to ensuring that cultural practices remain relevant and engaging for digital-native students (Akmar et al., 2026; Widiastuti & Febriyanto, 2026). This approach allows students to learn scientific concepts through familiar cultural practices, making learning more meaningful, increasing student engagement, and contributing to critical thinking skills (Fadilah et al.,

How to Cite:

Astuti, H. W., & Hamdu, G. (2026). Analysis of Teacher Needs for the Development of Ethno-ESD-Based Science Modules in Elementary Schools. *Jurnal Penelitian Pendidikan IPA*, 12(5), 155–161. <https://doi.org/10.29303/jppipa.v12i5.14801>

2024; Kotimah et al., 2024). Systematic evidence across primary and secondary education levels confirms that ethnoscience-based learning is highly effective in upgrading student scientific literacy by bridging indigenous knowledge with formal school science (Sari et al., 2025)

Concurrently, Education for Sustainable Development (ESD) has emerged as an essential approach that emphasizes increasing students' awareness of environmental and sustainability issues through critical analysis of human-nature interactions (Entang et al., 2024; UNESCO, 2020). Integrating sustainability core values into natural science topics provides a strategic pathway to enhance students' scientific literacy and ecological awareness from an early stage (Aqilah et al., 2025). Integrating ESD in elementary science helps students cultivate vital decision-making skills related to the sustainability of life (Vesterinen & Ratinen, 2024).

While research on both ethnoscience and ESD is on the rise, many studies still consider the two dimensions separately (Solihah et al., 2024). Furthermore, existing research mainly focuses directly on the implementation stage of learning models, leaving a visible scarcity of studies that base their module designs on the early stages of development, specifically teacher needs analysis (Fahrudin et al., 2023; Pratama & Jumadi, 2023). In fact, a comprehensive needs analysis is crucial in development research to determine the actual relevance and acceptance of the product in the field (Plomp & Nieveen, 2013).

Therefore, this study explicitly addresses this gap by analyzing teacher needs regarding the development of an integrated Ethno-ESD-based science module within a Design-Based Research (DBR) framework. This study aims to provide an empirical basis for designing a contextual, systematic, and relevant learning tool that strategically strengthens elementary school students' critical thinking skills.

Method

Research Design

This study employed a descriptive qualitative approach embedded within the initial needs analysis phase of a design-based research (DBR) framework (Plomp & Nieveen, 2013). This design was selected to gain a comprehensive and deep understanding of the existing gaps in primary science learning practices and to determine the necessary specifications for developing effective educational tools.

Participants

The subjects of this study were two fourth-grade teachers from SDN P, a public elementary school located

in Kabupaten Tasikmalaya. The subjects were selected using a purposive sampling technique based on specific criteria: (1) they are actively teaching the Natural and Social Sciences (IPAS) curriculum in grade IV, and (2) they possess direct, hands-on experience in planning, developing, and executing classroom learning materials (Creswell, 2004). These subjects are coded as Teacher 1 (G1) and Teacher 2 (G2) to maintain confidentiality (Creswell, 2004).

Data Collection

Data were gathered through face-to-face, semi-structured interviews to obtain rich, qualitative insights from the participants. The interview protocol was systematically structured around several core indicators, including: (a) The current implementation of primary science instruction and the teaching methods applied in the classroom. (b) The types of instructional materials and student worksheets (LKPD) currently utilized. (c) The integration of local cultural contexts (ethnoscience) and the instillation of sustainability values (ESD) in ongoing practices (UNESCO, 2020). (d) The strategy for developing students' higher-order and critical thinking skills (Ennis, 2018). (e) The teachers' specific expectations regarding the structural and pedagogical design of an integrated Ethno-ESD science module (Snively & Corsiglia, 2001).

All interviews were recorded with the participants' consent and transcribed verbatim to ensure absolute data accuracy before entering the analysis phase.

Data Analysis

The transcribed qualitative data were analyzed chronologically using the interactive analysis model proposed by Miles, Huberman, and Saldaña (2014), which consists of three continuous steps: data reduction, data display, and conclusion drawing/verification. During data reduction, raw interview logs were selected, focused, and coded thematically to identify core patterns regarding learning constraints and instructional needs. The reduced data were then systematically structured and displayed in a logical matrix to map the field findings, gaps, and design implications.

Trustworthiness

To ensure the trustworthiness and validity of the qualitative findings, data triangulation was strictly applied. This included source triangulation—which cross-examined and compared the distinct perspectives between G1 and G2—and theoretical triangulation, which linked the empirical field findings with established theories in educational design, critical thinking, and sustainable development.

Result and Discussion

Findings

The results of the needs analysis indicate that Natural and Social Sciences (IPAS) instruction in the observed school is still dominated by traditional, teacher-centered learning approaches. Based on the interviews with the fourth-grade teachers, the classroom learning process strictly follows the predetermined flow of materials embedded within the standard package books. Teachers primarily deliver concepts using a standard lecture format, followed by asking students to complete routine tasks in standard student worksheets (LKPD).

On several occasions, simple practical activities are carried out to clarify the concepts learned. Although students appear active and enthusiastic during these hands-on activities, the practices are not deliberately or systematically designed to stimulate higher-order cognitive operations (Abrami et al., 2015; Jumanto et al., 2024).

Further analysis of current learning practices reveals a significant gap between actual classroom conditions and 21st-century educational demands. The tasks and problems provided by teachers focus almost entirely on low-level cognitive functions, specifically memorizing and understanding basic scientific concepts. Explicit opportunities for students to analyze, evaluate, and reason scientifically remain severely limited. Consequently, students function largely as passive recipients of information, which restricts their space for genuine scientific exploration and constructivist investigation. This field condition confirms that without structured instructional intervention and intentional design, systematic development of critical thinking capacities cannot be achieved effectively (Delima et al., 2026).

Furthermore, the instructional tools and worksheets currently used by teachers do not provide structural support for developing critical thinking. Available teaching materials consist mainly of dry material summaries and closed exercises rather than open-ended questions that prompt students to formulate evidence-based arguments (Kotimah et al., 2024).

Interestingly, the interviews reveal that teachers recognize an immense, unutilized potential to leverage the regional cultural context as a core learning resource. Specifically, the community environment surrounding the school features prominent local industries centered on traditional palm sugar production. The stages of palm sugar processing directly involve critical physical science concepts, such as heating the sap (heat energy transfer), changes in states of matter, water evaporation, and the formation of sugar crystals.

Moreover, this production process encompasses vital environmental aspects, including the utilization of local natural resources and sustainable interactions with palm tree cultivation (Sudirman et al., 2025; Wilujeng et al., 2019). However, in current practices, this rich local wisdom is only referenced illustratively or incidentally, failing to serve as a structured framework for the core curriculum. This practical gap closely aligns with common challenges in primary schools where local contexts are often treated as peripheral additions rather than central inquiries (Lawe et al., 2025).

Discussion

To resolve these field gaps, the development of an integrated Ethno-ESD science module becomes highly strategic. In accordance with educational design principles, effective learning tools must be systematically structured to foster deep thinking by aligning learning objectives, activities, and assessments (Plomp & Nieveen, 2013). Utilizing specialized modules that embed cultural practices has been widely recognized as a reliable solution to foster constructivist investigation and structural scaffolding in primary classrooms (Ni'mah et al., 2023; Wardani et al., 2023).

The planned Ethno-ESD module will reject abstract lecturing, choosing instead to utilize the local palm sugar production process as the primary, problem-based inquiry starting point. By confronting students with authentic, real-life problems within their cultural environment, learning becomes inherently meaningful and constructivist (Putri et al., 2025; Usulan et al., 2025).

The pedagogical stages within the module will be deliberately mapped onto the core critical thinking indicators established (Facione & Gittens, 2015) namely interpretation, analysis, evaluation, reasoning, and explanation. The specific module implications based on the needs matrix are structured as follows:

Contextual Inquiry Integration: The module uses physical phenomena in palm sugar making (e.g., heating, state changes, evaporation) to guide students through active, hands-on scientific investigation (Sari et al., 2023).

Problem-Based Activities: Rather than relying on closed questions, the module integrates authentic sustainability case studies – such as the balance of palm tree resources – requiring students to critically analyze cause-and-effect relationships and evaluate environmental impacts (Putri et al., 2025). Designing such challenging, integrated activities is empirically proven to stimulate both critical and creative reflective operations in science learning (Salhuteru et al., 2025).

Argumentation and Rubrics: To intentionally shift away from rote memorization, the module incorporates explicit argumentative tasks and critical thinking rubrics, ensuring that students' capacity to draw logical

conclusions is systematically measured and trained (Ennis, 2018).

By embedding these structural components, the resulting module will successfully transition from a purely descriptive report of field issues into an actionable, theoretically sound educational design. This

needs analysis phase ensures that the final product directly aligns with the authentic constraints faced by teachers, minimizing the risk of practical irrelevance during future classroom implementation (Plomp & Nieveen, 2013).

Table 1. Ethno-ESD-Based Science Module Development Needs Analysis Matrix

Analyzed Aspect	Field Findings	Gap	Theoretical Basis	Module Implications
Science learning approach	Learning follows textbooks; lecture method is dominant; worksheets and simple practices are used	Critical thinking activities not explicitly designed	(Facione & Gittens, 2015)	Modules include structured learning steps with explicit critical thinking indicators
Learning activity design	Worksheets guide practical steps and conclusions.	Not based on authentic problems	(Uslan et al., 2025)	Modules include problem-based questions and argumentation tasks
Ethnoscience integration	Palm sugar production used as example	Still illustrative, not the central learning framework.	(Snively & Corsiglia, 2001)	Local phenomena used as inquiry starting point
ESD integration	Teachers mention environmental awareness	Still limited to awareness level	UNESCO (2020)	Modules include sustainability case studies
Critical thinking development	Students active during practice	No explicit indicators or rubrics	(Facione & Gittens, 2015)	Modules include rubrics and analytical tasks
Availability of teaching modules	No Ethno-ESD materials available.	Teaching materials do not integrate Ethno-ESD.	(Plomp & Nieveen, 2013)	Need systematic Ethno-ESD modules

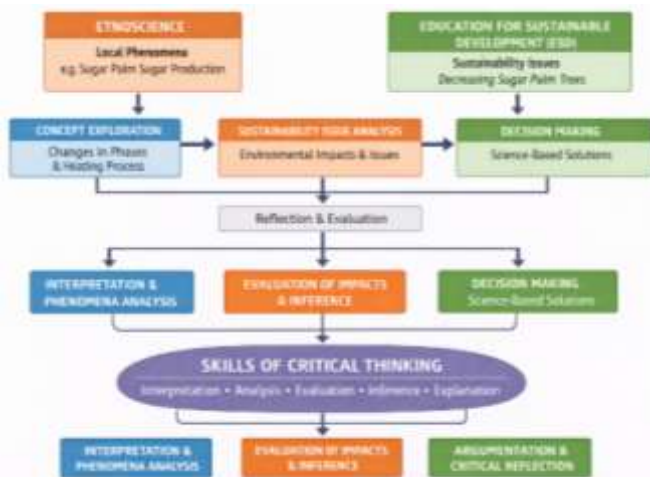


Figure 1. Conceptual model diagram of ethno-ESD-based science module

Conclusion

In conclusion, science learning in elementary schools remains heavily dominated by traditional approaches centered around standard academic textbooks and teacher-centered instruction, which restricts the systematic development of students' critical thinking skills. Advanced analytical activities – such as environmental impact assessment, causal reasoning, and evidence-based decision-making – are currently implemented only incidentally and are not structurally

embedded within existing instructional toolkits. Furthermore, while teachers recognize the pedagogical value of local cultural realities and sustainability dimensions, such as the traditional manufacturing of palm sugar, this ethnoscience context is only utilized as a superficial illustration rather than a structured curricular design. Based on the empirical findings of this needs analysis, there is an urgent requirement for integrated ethnoscience and education for sustainable development (Ethno-ESD) teaching modules. These modules must feature contextual, problem-based learning operations aligned with explicit critical thinking indicators. Ultimately, this study contributes a foundational conceptual framework and empirical design parameters necessary to bridge the gap between current classroom realities and 21st-century competency demands, serving as a critical scientific basis for future instructional tool development in primary science education.

Acknowledgments

The authors would like to express their sincere gratitude to SDN Pondokwaru for granting permission and providing support during the research process. The authors also extend their appreciation to Dr. Ghullam Hamdu, M.Pd., for his valuable guidance, suggestions, and supervision throughout the completion of this research. In addition, the authors would like to thank the Master's Program in Primary School Teacher Education (PGSD), Universitas Pendidikan Indonesia,

Tasikmalaya Campus, for the academic support and facilities that enabled this study to be conducted successfully.

Author Contributions

Conceptualization, H.W.A.; methodology, H.W.A.; formal analysis, H.W.A.; investigation, H.W.A.; data curation, H.W.A.; writing—original draft preparation, H.W.A.; validation, G.H.; writing—review and editing, G.H.; supervision, G.H. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding. The authors received no financial support for the research, authorship, and/or publication of this article.

Conflicts of Interest

The authors declare no conflict of interest.

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