



Integration of Ethnoscience in the Development of a Problem-Based Learning–Based Science E-Module as a Contextual Learning Medium

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Abstract

This study developed a Problem-Based Learning (PBL)-based science e-module integrating local ethnoscience from Lombok, Indonesia, and examined its validity, practicality, and effectiveness in improving students' problem-solving skills and cognitive outcomes. Using the ADDIE model within a Research and Development (R&D) framework combined with a quasi-experimental design, four ethnoscience contexts of the Sasak community, traditional weaving dye techniques, Rinjani terraced irrigation, coastal salt production, and clay stove cooking, were systematically embedded as authentic problem scenarios across five PBL phases. Expert validation yielded a mean score of 90.1% (very valid). Student response surveys indicated 88.4% practicality. Pre-test and post-test analysis using N-gain showed a score of 0.63 (moderate-high) for the experimental group versus 0.35 for the control group, with a statistically significant difference ($p < 0.001$). Problem-solving skills improved across all four Polya indicators (N-gain 0.52–0.61). The ethnoscience-PBL e-module constitutes a contextually grounded digital learning medium that enhances scientific competence while valorizing indigenous cultural knowledge within the Merdeka Belajar curriculum.

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INTRODUCTION

The low level of scientific literacy among Indonesian students is an urgent issue that requires systematic attention. PISA 2022 data show that Indonesia ranks 68th among 81 countries, with an average score of 383 points, far below the OECD average of 485 points (OECD, 2023). One consistently identified root cause is the mismatch between science curriculum content in schools and students' real-life contexts, resulting in learning that is often abstract and lacks meaning (Suastra & Tika, 2011). Low cognitive learning outcomes and problem-solving skills are direct consequences of this situation.

Ethnoscience offers a relevant approach to bridge scientific knowledge with local wisdom. Ethnoscience examines a community's knowledge and cultural practices, transforming them into scientific knowledge meaningful to students (Sudarmin, 2014). Previous studies have demonstrated the potential of ethnoscience in enhancing science literacy, such as in the production of tempoh (Iqlima & Syukur, 2025), Maduran salt (Hadi & Ahied, 2017), Maduran shrimp paste (Hadi et al., 2019), and traditional snacks (Elisa et al., 2022). However, these studies are generally descriptive and have not

systematically integrated ethnoscience into digital learning media based on Problem-Based Learning.

West Nusa Tenggara, particularly the island of Lombok, holds a wealth of Sasak ethnoscience that has yet to be fully utilized in technology-based science education. This local knowledge encompasses Sasak weaving dyeing techniques (chemical concepts), the terraced irrigation system on the slopes of Mount Rinjani (fluid physics), traditional salt production (chemistry), and clay stove cooking techniques (heat transfer). It is this research gap that distinguishes this study from previous ones: no study has specifically integrated Lombok's local ethnoscience into PBL-based science e-modules whose effectiveness has been experimentally tested.

Problem-Based Learning (PBL) is the most relevant pedagogical framework to combine with ethnoscience. PBL uses authentic problems from real-world contexts as the starting point for learning, encouraging students to identify problems, conduct investigations, develop solutions, and reflect on their thinking processes (Arends, 2012; Hmelo-Silver, 2004; Savery, 2006). Electronic modules (e-modules) as interactive digital media have proven capable of facilitating self-directed learning and improving learning outcomes (Widiastuti, 2021; Huang et al., 2020). The combination of

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ethnoscience, PBL, and e-modules has the potential to create meaningful, authentic learning experiences and develop higher-order thinking skills.

Based on these research gaps, this study aims to: (1) develop PBL-based science e-modules that integrate local Lombok ethnoscience as a valid and practical contextual medium; (2) to map Lombok's local ethnoscience into science concepts and the core competencies of the Merdeka Curriculum; and (3) to analyze the effectiveness of the e-module in improving junior high school students' problem-solving skills and cognitive learning outcomes. The novelty of this study lies in: (a) the systematization of mapping Sasak ethnic science into a digital PBL structure, and (b) empirical testing through a quasi-experimental design that has never been conducted in the context of Lombok's ethnic science.

MATERIALS AND METHODS

Time and place

The research was conducted during the second semester of the 2024–2025 academic year. The analysis and development phase took place in Mataram City, West Nusa Tenggara, and included field observations of local Lombok ethnoscience. The implementation phase was carried out at a public junior high school in Mataram City that has adequate technological facilities but has not yet adopted ethnoscience-based e-modules.

Research design

The study employed a Research and Development (R&D) approach using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The ADDIE model was chosen because it provides a systematic and iterative development framework with formative evaluation at each stage (Branch, 2009). The rationale for selecting this model was its suitability for developing complex learning products requiring phased validation. A quasi-experimental design with a nonequivalent control group was used to test the e-module's effectiveness on problem-solving skills and cognitive learning outcomes.

Research population and sample

The study population consisted of all eighth-grade students at the public junior high school where the study was conducted. The cluster random sampling technique resulted in two sample classes: eighth-grade class A, the experimental class ($n = 32$), using the ethnoscience-PBL e-module, and eighth-grade class B, the control class ($n = 32$), using conventional learning. The equivalence of the initial abilities of the two classes was demonstrated through a test of homogeneity of variances (Levene's test, $p > 0.05$) prior to the treatment.

Research procedure

The Analysis phase comprises three components: (1) a curriculum analysis of the Learning Outcomes (LO) and Learning Objective Sequence (LOS) for 8th-grade Science under the Merdeka Curriculum; (2) student analysis through a needs survey of 64 students and interviews with 4 science teachers; and (3) ethnoscience analysis through field observations and in-depth interviews with Sasak weavers, Rinjani irrigation farmers, salt makers, and traditional leaders.

The Design phase produced an e-module framework comprising four learning units, each following the five-phase PBL syntax (Arends, 2012). Each unit begins with a contextual problem scenario based on local Lombok ethnoscience. Storyboards, concept maps, and problem-solving assessment rubrics based on Polya's indicators (1957) were developed in accordance with the BSKAP criteria of the Ministry of Education, Culture, Research, and Technology.

The Development Phase utilized Canva Education for visual design and Flip PDF Professional for the interactive platform. The multimedia content includes 15 ethnoscience videos, 10 PhET Interactive Simulations, 30 formative quiz questions with automatic feedback, and 4 authentic problem scenarios. Validation was conducted by six validators: two science subject matter experts (Ph.D. holders), two educational media experts, one NTB ethnoscience expert, and one education practitioner.

The Implementation phase was conducted in the experimental class over ten sessions (40 class hours) on the topics of Pressure and Heat. The control class received conventional instruction using identical content, time allocation, and assessment tools. The Evaluation phase included formative assessments throughout the development and implementation phases, as well as summative assessments via pre-tests, post-tests, and student response questionnaires.

Research data analysis

The research instruments included: (1) an expert validation form using a 1–5 Likert scale; (2) a student response questionnaire (25 items); (3) two-tier multiple-choice pre-test/post-test items (30 items) that have been tested for validity ($r > 0.30$) and reliability (Cronbach's $\alpha = 0.87$) to measure cognitive learning outcomes C1–C6 of Bloom's Taxonomy; (4) a problem-solving skills assessment rubric based on Polya's (1957) four indicators; and (5) an observation sheet for the implementation of PBL syntax.

Validation data and student responses were analyzed using a percentage of validity based on Riduwan's (2015) criteria: highly valid/practical (81–100%), valid/practical (61–80%), adequate (41–60%), invalid/impractical (21–40%), and highly invalid/impractical (0–20%). Improvements in learning outcomes were analyzed using N-gain (Hake, 1998): high (≥ 0.7), moderate (0.3–0.7), and low (< 0.3). Significant differences between the experimental and control classes were tested using an independent samples t-test ($\alpha = 0.05$) after meeting the assumptions of normality (Shapiro-Wilk test) and homogeneity (Levene's test).

RESULTS AND DISCUSSION

Result

Inventory and Mapping of Local Ethnoscience in Lombok

Field observations and in-depth interviews identified five major groups of Sasak ethnoscience that are rich in scientific concepts. Table 1 presents a comprehensive mapping of Lombok's local ethnoscience, the scientific concepts it contains, and their relevance as PBL problem scenarios.

Table 1. Mapping of Lombok's Local Ethnoscience into Science Concepts and PBL Problem Scenarios

Local Ethnoscience Concepts	Scientific Concepts (Science)	Relevance in a PBL-Based E-Module
Sasak weaving process using natural dyes (e.g., indigo leaves, tree bark)	Chemistry: oxidation reactions, solution pH, acid–base properties of natural dyes	Contextual problem: why do natural dyes produce different colors at different pH levels?
Determination of planting time based on star positions and seasons by Lombok farmers	Physics: astronomical cycles; Biology: photosynthesis, effect of light on plant growth	Investigation: How does sunlight intensity affect the rate of photosynthesis?
Terraced rice field irrigation techniques (subak-like system) on the slopes of Mount Rinjani	Physics: hydrostatic pressure, Pascal's law, fluid flow	Problem-solving: design a simple irrigation system based on fluid pressure principles
Traditional salt production in the coastal areas of East Lombok	Chemistry: evaporation, crystallization, solubility, colligative properties of solutions	Problem scenario: why does salt concentration affect the boiling point of water?
Use of bamboo weaving in traditional Sasak house construction	Physics: force, stress, elasticity of materials, load distribution	Exploration: How does weaving structure influence the strength of construction?

The five identified ethnoscience groups are strongly linked to interdisciplinary science concepts (physics, chemistry, biology) relevant to junior high and high school levels. This data serves as the foundation for developing e-module content and PBL problem scenarios.

Structure of an Ethnoscience-Based PBL Science E-Module

The e-module consists of four learning units (135 digital pages), each structured consistently according to the five phases of the PBL framework. Table 2 presents the structure of the e-module and the integration of Ethnoscience in each unit.

Table 2. Structure of the Ethnoscience-PBL-Based Science E-Module and Integration of Lombok's Local Wisdom

E-Module Unit/Chapter	Integrated Local Ethnoscience	Dominant PBL Phase
Unit 1: Pressure and Fluids	Terraced irrigation system of Mount Rinjani; traditional salt production in Lombok coastal areas	Problem orientation & investigation
Unit 2: Heat and Heat Transfer	Traditional Sasak cooking techniques (clay stove); The Banyumulek pottery production	Investigation & solution development
Unit 3: Matter and Its Changes	Sasak weaving with natural dyes; local production of tempeh and fermented cassava (tape)	Analysis & evaluation
Unit 4: Ecosystems and Environment	Indigenous knowledge of the Sasak community in conserving the Mount Rinjani National Park forest	Presentation of results & reflection
Final Evaluation & Reflection	Integration of all ethnoscience contexts in solving complex problems	Comprehensive evaluation

E-Module Validation Results

Validation by six expert validators yielded an average overall score of 90.1% (highly valid). Table 3 presents a summary of the validation results by aspect.

Table 3. Results of the Validation of the Ethnoscience-PBL-Based Science E-Module by Experts

Assessed Aspects	Expert 1 (%)	Expert 2 (%)	Mean (%)	Category
Content Feasibility / Alignment with Science Material	92.0	90.5	91.3	Highly Valid
Integration of Ethnoscience in Content	91.3	89.8	90.6	Highly Valid
Alignment with PBL Syntax	90.0	88.6	89.3	Highly Valid
Media and Visual Design Feasibility	88.5	87.2	87.9	Highly Valid
Language and Readability	89.3	91.0	90.2	Highly Valid
Alignment with the Merdeka Curriculum	93.1	90.0	91.6	Highly Valid
Overall Mean	90.7	89.5	90.1	Highly Valid

Alignment with the Merdeka Curriculum received the highest score (91.6%), followed by ethnoscience integration (90.6%). The validators' main recommendations include: adjusting the complexity of the problems to the capabilities of junior high school students, adding a glossary of Sasak language terms, and improving the quality of the ethnoscience videos.

Practicality Test Results

The student feedback survey conducted after 10 sessions yielded an average practicality score of 88.4% (very practical), with the following breakdown: ease of navigation (89.1%), clarity of the ethnoscience content (91.2%), relevance of the PBL problems to real life (92.3%), motivation and active engagement (87.6%), and support for independent learning (81.8%).

Mapping Ethnoscience to the Core Competencies of the Merdeka Curriculum

Table 4 presents a mapping of Lombok's local ethnoscience to the core competencies of the Merdeka

Curriculum, which serves as the foundation for developing e-module content.

Table 4. Pemetaan Etnosains Lokal Lombok ke Kompetensi Dasar IPA Kurikulum Merdeka

Local Ethnoscience	Embedded Science Concepts	Basic Competencies (Merdeka Curriculum)	Educational Level
Terraced irrigation system of Mount Rinjani	Hydrostatic pressure, Pascal's law, fluid flow	Analyzing the concept of pressure in substances and its applications in everyday life	Junior High School (Grade VIII)
Sasak weaving with natural dyes	Chemical reactions, pH, acid-base properties	Analyzing physical and chemical changes and evaluating their impacts on daily life	Junior High School (Grade VII)
Traditional salt production	Evaporation, crystallization, solubility, and colligative properties	Analyzing solution properties, chemical reactions, and factors affecting reaction rates	Senior High School (Grade XI)
Traditional Sasak clay stove	Heat conduction, convection, and radiation	Analyzing the effects of heat and heat transfer in everyday life	Junior High School (Grade VII)
Sasak indigenous practices and Rinjani forest conservation	Ecosystems, interactions among living organisms, and environmental balance	Analyzing ecosystems and interactions among their components	Junior High School (Grade VII)

Outcomes: Improved Learning Outcomes and Problem-Solving Skills

The experimental class achieved an N-gain of 0.63 (moderate-high), while the control class achieved an N-gain of 0.35 (moderate). An independent-samples t-test revealed a significant difference between the post-test means of the experimental class (80.6) and the control class (67.3) at $\alpha = 0.05$ [$t(62) = 6.14, p < 0.001$]. Problem-solving skills improved significantly across all Polya indicators: understanding the problem (N-gain = 0.61), planning the solution (0.58), executing the plan (0.55), and checking the solution (0.52).

Discussion

The Effectiveness of Integrating Ethnoscience as a Source of Contextual Problems in PBL

The findings of this study confirm that integrating Lombok's local ethnoscience as a source of contextual problems in PBL-based e-modules effectively enhances students' problem-solving skills and cognitive learning outcomes. This success can be explained through the Contextual Teaching and Learning (CTL) framework: learning becomes meaningful when new knowledge is linked to real-world experiences and contexts (Susiloningsih, 2016). Sasak ethnic science serves as an epistemological bridge connecting students' everyday world with abstract science concepts (Sudarmin, 2014).

These findings are consistent with those of Iqlima & Syukur (2025), Hadi et al. (2019), and Elisa et al. (2022), each of which highlights the potential of local ethnoscience as a source of contextual learning. However, the novelty of this study lies in a dimension not found in those studies: ethnoscience is not merely used as a descriptive learning resource but is directly operationalized as a source of authentic problems within a structured PBL framework and implemented in a digital e-module platform. Furthermore, this study is the first to test this integration using a quasi-experimental design with a control group, thereby yielding stronger evidence of its effectiveness than previous descriptive studies.

Mukti et al. (2022) assert that integrating ethnoscience into science education can simultaneously enhance students' active engagement and science literacy.

This finding is supported by Cahyani et al. (2021), who found that incorporating local cultural contexts into science education enhances students' intrinsic motivation—consistent with the high practicality score (92.3%) on the problem relevance aspect in this study.

The Role of Interactive E-Modules in Facilitating Ethnoscience-Based Problem-Based Learning

The high validity (90.1%) and practicality (88.4%) of the e-module reflect the success of an instructional design that integrates the principles of the Cognitive Theory of Multimedia Learning (Mayer, 2009; Sweller et al., 2019) with PBL syntax and ethnoscience content. Ethnoscience videos authentically depicting traditional Sasak practices were shown to establish context and initial motivation for learners, consistent with the principles of signaling and personalization in Mayer's theory. PhET interactive simulations linked to ethnoscience phenomena enable the virtual exploration of abstract science concepts within the concrete context of local traditions.

The advantage of e-modules as a platform for PBL in ethnoscience lies in their ability to provide a rich and adaptive learning environment. Formative quizzes with automatic feedback facilitate self-regulated learning (Zimmerman, 2002), while progress trackers enable targeted teacher interventions. These findings align with those of Huang et al. (2020), who demonstrated that interactive, problem-based e-modules significantly enhance problem-solving skills compared to conventional print modules, and are supported by Widiastuti (2021) and Setyowati et al. (2020).

Pedagogical and Cultural Implications

This study has dual implications. Pedagogically, integrating ethnoscience into PBL-based e-modules has proven a valid, practical, and effective strategy for enhancing students' science competencies within the framework of the Merdeka Curriculum, which promotes contextual and project-based learning. Culturally, the local wisdom of the Sasak people has proven to be not merely a cultural heritage to be preserved, but also a living source of knowledge relevant to enriching modern science education (Sudarmin, 2014; Lidi et al., 2022). This integration has the

potential to enhance students' cultural self-esteem, as emphasized by Suastra & Tika (2011).

Limitations of the Study and Recommendations

Several limitations of this study should be noted. First, the implementation was limited to a single school in Mataram City, so generalizations of the results should be made with caution. Second, the relatively short implementation period (10 sessions) may not have been sufficient to measure the long-term impact on problem-solving skills. Third, the assessment of problem-solving skills was conducted in writing and did not measure students' thinking processes in real time.

Further research is recommended to: (1) expand the implementation to schools in rural areas of West Nusa Tenggara that are closer to ethnosience communities; (2) develop similar ethnosience-based e-modules for other regions in Indonesia; (3) investigate the long-term impact on students' science literacy and cultural identity; and (4) integrate augmented reality technology to enhance the virtual ethnosience exploration experience.

CONCLUSION

A PBL-based science e-module that integrates local Lombok ethnosience was successfully developed using the ADDIE model by identifying five main ethnosience groups of the Sasak people. The e-module was found to be highly valid (90.1%) and highly practical (88.4%), and was proven to be significantly effective in improving students' cognitive learning outcomes (experimental N-gain = 0.63 vs. control = 0.35; $p < 0.001$) and problem-solving skills across all Polya indicators (N-gain 0.52–0.61). The novelty of this study lies in the operationalization of ethnosience as a source of authentic problems in digital PBL, not merely a descriptive context, which was empirically demonstrated through an experimental design.

These findings imply that integrating local ethnosience into PBL-based digital learning media is an effective strategy with the potential for widespread application in science education in Indonesia, particularly within the context of the Merdeka Curriculum. This approach simultaneously helps preserve local wisdom as a relevant source of living knowledge. The main limitations of this study are its narrow scope of implementation, confined to a single school, and its short duration. Further research is recommended to expand the pilot study to various school contexts, develop similar modules based on the ethnosience of other regions, and investigate the long-term impact on students' cultural identity and science literacy.

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AUTHOR'S CONTRIBUTION

Table of Author Contribution Statement

Contribution Indicators	Author				
	1	2	3	4	5
Conceptualization	✓	✓	✓	✓	✓
Literature Review	✓		✓		✓
Research Design / Methodology	✓		✓	✓	✓
Instrument Development	✓	✓			
Data Collection	✓		✓		✓
Data Curation	✓	✓			
Formal Analysis	✓	✓	✓	✓	✓
Data Interpretation	✓		✓		✓
Writing – Original Draft	✓				
Writing – Review & Editing	✓	✓	✓		✓
Visualization / Media / Layout				✓	
Digital Media Development (e-module, platform, interactivity)				✓	
Supervision	✓	✓	✓	✓	✓

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