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Needs Analysis for Developing an Ethno-STEM PjBL Module on Keumamah Processing to Enhance Elementary Students' Science Literacy

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ABSTRACT

This study aims to examine the need for developing an Ethno-STEM Project-Based Learning (PjBL) teaching module based on Keumamah processing to enhance elementary students' scientific literacy. The research is motivated by students' difficulties in understanding abstract science concepts due to decontextualized learning that lacks connection to their sociocultural environment. A quantitative descriptive method with a needs assessment design was employed, involving 120 fifth-grade students and 12 science teachers in coastal areas of Aceh selected through purposive sampling. Data were collected using questionnaires, supported by observation and documentation. The findings indicate that from the teachers' perspective, there is a high level of urgency to develop the proposed module (89.1%), largely driven by the limited availability of locally contextualized teaching materials (85.6%). From the students' perspective, most reported difficulties in understanding abstract concepts (78.4%), while a large proportion expressed strong interest in contextual learning (85.0%). Additionally, the availability of scientific literacy assessment instruments remains low (21.5%). This study concludes that there is a critical need to develop an Ethno-STEM-based PjBL module that integrates local wisdom, such as Keumamah processing. This study provides an empirical basis for designing culturally relevant and scientifically meaningful learning tools to support 21st-century literacy skills.

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1. INTRODUCTION

Scientific literacy is a fundamental competency in the 21st century, enabling individuals to critically understand, evaluate, and apply scientific concepts to solve everyday problems [1], [2]. In the global landscape, basic education plays a crucial role as a starting point for instilling scientific reasoning in students' early cognitive development [3].

However, in Indonesia, scientific literacy among elementary school students remains relatively low and is a persistent educational issue [4]. Several national and international assessment reports indicate that students tend to rely on rote memorization rather than analytical reasoning when dealing with scientific problems [5], [6]. This condition reflects that science learning has not yet functioned optimally as a tool for inquiry and reasoning, but rather as a body of abstract knowledge [7], [8].

Field-based evidence further strengthens the existence of this problem in classroom practices. Science learning at the elementary level is still largely dominated by teacher-centered and textbook-oriented approaches that are detached from students' real-life experiences [9], [10]. Teachers frequently encounter difficulties in developing or accessing teaching materials that are relevant to students' local environments [11]. As a result, students are less engaged in the learning process and struggle to construct meaningful understanding. Empirical studies also show that the absence of contextual learning reduces students' motivation and limits their ability to apply scientific concepts in daily life [12]. This issue indicates a mismatch between curriculum expectations and classroom implementation. In addition, the lack of contextualized learning resources further exacerbates the problem of low scientific literacy.

One promising approach to address this issue is the integration of Ethno-STEM (Science, Technology, Engineering, and Mathematics) with the Project-Based Learning (PjBL) model [13], [14]. Theoretically, Ethno-STEM emphasizes the connection between scientific knowledge and local wisdom, allowing students to learn science through culturally relevant contexts [15], [16]. Meanwhile, PjBL facilitates active learning through project-based activities that promote inquiry, collaboration, and problem-solving skills. The combination of these approaches provides a holistic framework that supports both cognitive and contextual learning dimensions. One example of local wisdom that incorporates rich scientific concepts is Keumamah, a traditional fish-processing practice practiced by coastal communities in Aceh. The processes involved, such as boiling, salting, and drying, reflect principles of heat transfer, preservation techniques, and simple biotechnology [17]. Integrating Keumamah into science learning allows students to explore scientific concepts through familiar cultural practices. Thus, this approach has the potential to enhance both scientific literacy and cultural awareness simultaneously.

Despite the growing body of research on STEM and PjBL, several limitations remain in the existing literature. Previous studies have generally focused on measuring the effectiveness of these approaches in improving learning outcomes, often emphasizing experimental results and final product evaluation [18], [19]. However, limited attention has been given to the preliminary stage, particularly the analysis of needs before developing instructional materials. In addition, studies specifically exploring the integration of local wisdom into structured Ethno-STEM modules remain scarce [20]. There is also a lack of empirical evidence regarding teachers' readiness, students' learning needs, and the availability of contextual teaching resources in specific regions. This gap is significant because the success of instructional innovation depends on its alignment with actual classroom conditions. Without a proper needs assessment, the developed learning tools may not effectively address existing

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problems. Therefore, a systematic analysis of needs is essential to ensure the relevance and effectiveness of Ethno-STEM-based learning modules.

Based on the identified gap, this study adopts a mixed-methods approach with a needs assessment design, combining quantitative descriptive analysis with qualitative exploration to comprehensively examine the urgency and requirements for developing an Ethno-STEM-based PjBL teaching module. to examine the urgency and requirements for developing an Ethno-STEM-based PjBL teaching module. This study aims to analyze the need for developing an Ethno-STEM-based PjBL teaching module on Keumamah processing to improve elementary school students' scientific literacy. The study focuses on identifying teachers' perceptions, students' learning difficulties, and the availability of contextual teaching materials. In addition, it seeks to explore the relevance of local wisdom as a learning resource in science education. Theoretically, this research contributes to the development of culturally contextualized science learning frameworks in elementary education. Practically, the findings are expected to provide an empirical foundation for designing effective and relevant teaching modules. Furthermore, this study offers strategic insights for educators, curriculum developers, and policymakers in integrating local culture into science learning. Ultimately, the research is expected to support improvements in scientific literacy while preserving cultural identity in education.

2. METHOD

This research is a preliminary analysis stage (needs assessment) that adapts the first phase of the research and development (R&D) model to design teaching modules [21]. This study employed a mixed-methods approach, integrating quantitative descriptive analysis with qualitative exploration to obtain a comprehensive understanding of the urgency and requirements for developing teaching materials [22]. The quantitative component measured needs in a structured, measurable manner, while the qualitative component provided contextual insights into classroom practices and sociocultural conditions. This integration ensures that the findings are both empirically measurable and contextually grounded.

The research was conducted during the even semester of the current academic year in several elementary schools located in the coastal area of Aceh. The research subjects consisted of 120 fifth-grade students and 12 science teachers, selected through purposive sampling, with inclusion criteria including at least 3 years of teaching experience and exposure to project-based learning [23]. Furthermore, three traditional Keumamah artisans were identified using a snowball sampling technique as expert informants to validate the ethnoscience content [24]. Their involvement ensured the cultural and scientific accuracy of the local knowledge integrated into the study.

Primary data were collected through a Likert-scale questionnaire distributed to teachers and students to measure the urgency of module development, students' learning difficulties, and the availability of contextual teaching materials [25]. Quantitative data were analyzed using descriptive statistics by calculating percentages for each variable using the formula:

$$Percentage = \frac{Total\ obtained\ score}{Maximum\ possible\ score}\ x\ 100\%$$

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The resulting percentages were then interpreted using categorical criteria (e.g., very low, low, moderate, high, very high) to determine the level of need. The mode was also used to identify dominant response patterns among participants.

To complement the quantitative data, researchers conducted participatory observations in classrooms and Keumamah-making centers, as well as a documentation study of teaching syllabi [26]. The validation process for the findings was rigorously conducted through method triangulation (cross-referenced questionnaire results, observation notes, and documents) and source triangulation (comparing the perspectives of students, educators, and cultural practitioners). Member checking procedures were also employed to ensure that the researchers' interpretations of Ethno-STEM practices were free from conceptual bias and aligned with the empirical reality of the target community. In the final stage, quantitative data were analyzed using descriptive statistics to determine precise percentages and modes of need. In contrast, qualitative data were analyzed through thematic reduction and categorization to provide a solid justification for the design of the module prototype [27].

The following table summarizes the main components of the research methods used in this study, including research approaches and subjects, sampling techniques, data collection, and data analysis. This presentation is intended to provide a clear, systematic overview of the research procedures used.

Table 1. Research Method Flow

Stages	Description
Preliminary analysis	Needs assessment for the initial phase of R&D
Approach	Quantitative descriptive + qualitative exploration
Subject	120 fifth-grade students, 12 science teachers, 3 craftsmen
Sampling techniques	Purposive sampling and snowball sampling
Sampling techniques Data collection	Likert questionnaire, participatory observation, documentation
Validation	Triangulation method, source triangulation, member checking
Data analysis	Descriptive statistics (percentage, mode) and thematic analysis

3. RESULTS AND DISCUSSION

3.1. Results

The needs analysis was conducted using Likert-scale questionnaires administered to 120 fifth-grade students and 12 science teachers, supported by classroom observations and document analysis. The analysis aimed to map students' science literacy conditions and identify functional gaps in existing learning tools. To illustrate the distribution and intensity of the identified needs, the quantitative findings are presented in Figure 1.

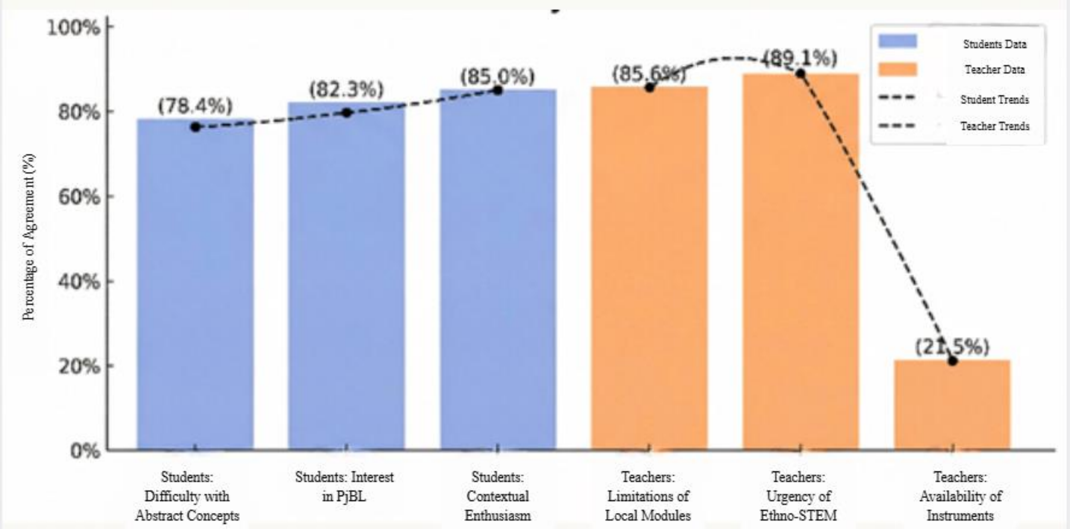

Figure 1. Bar Chart and Line Trend Analysis of Keumamah Etno-STEM PjBL Needs

Figure 1 presents a combined bar chart and trend line showing the distribution of responses from students and teachers. Among students, 78.4% reported difficulty in understanding abstract science concepts. In contrast, 82.3% expressed interest in project-based learning, and 85.0% indicated a preference for contextual learning approaches. From the teacher's perspective, 85.6% identified limitations in culturally integrated teaching modules, and 89.1% emphasized the need for Ethno-STEM-based materials. Meanwhile, only 21.5% reported having adequate science literacy assessment tools.

If student and teacher data are read at the same time, it appears there is a structural gap between student and teacher needs and the condition of learning tools in the field. Students need more concrete, context-based learning, while teachers need teaching modules that connect science with local culture and provide more robust science literacy evaluations. Gaps like this are important to recognize at the needs assessment stage because they are the strongest basis for designing targeted learning products. To further examine the proportional distribution of instructional needs, the results are presented in Figure 2.

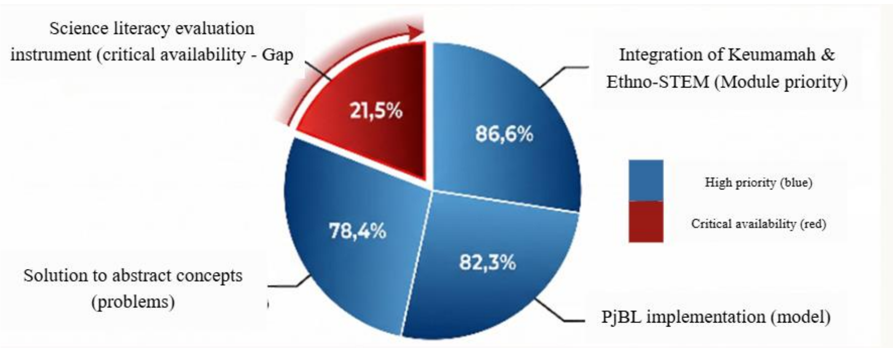

Figure 2. Combined Pie Diagram: Research Needs Priorities and Gaps

Figure 2 illustrates the proportional distribution of key instructional needs. The largest proportion (86.6%) represents the priority of integrating Keumamah within an Ethno-STEM framework. Other major needs include students' difficulties with abstract concepts

(78.4%) and the demand for project-based learning (82.3%). The smallest proportion (21.5%) reflects the limited availability of instruments for assessing science literacy.

Supporting qualitative findings reinforces these results by providing evidence from classroom practice. Classroom observations indicate that students exhibit low cognitive engagement when learning is delivered in a decontextualized manner. Learning interactions tend to be passive, with limited questioning and minimal participation in problem-solving activities. In addition, local context is rarely utilized as a learning resource during instruction. This condition suggests that teaching practices are not sufficiently connected to students' everyday experiences.

Document analysis further shows that teaching materials are predominantly oriented toward urban or industrial contexts. As a result, examples of scientific phenomena are less relevant to students' daily lives in coastal areas. This reduces students' ability to relate abstract concepts to real-world situations. In addition, the integration of local culture within instructional materials remains minimal. These findings indicate a mismatch between instructional content and the sociocultural characteristics of the learners.

Observations at the Keumamah production site reveal that this traditional practice contains various scientific concepts. The processes of boiling, salting, and drying reflect principles of heat transfer, food preservation, material changes, and basic microbiology. These processes provide observable and authentic contexts for science learning. Furthermore, the practices demonstrate how scientific concepts are embedded in everyday cultural activities. This indicates that Keumamah can serve as a relevant contextual resource for science instruction.

Finally, the findings were validated through methodological triangulation, source triangulation, and member checking. Method triangulation involved comparing data from questionnaires, observations, and documentation. Source triangulation was conducted by examining perspectives from students, teachers, and cultural practitioners. Member checking ensured that interpretations of Keumamah practices were consistent with real-world processes. The consistency of findings across multiple sources confirms the reliability and contextual validity of the data.

3.2. Discussion

The findings of this study point to a noticeable gap between how science is currently taught and how students actually learn best in coastal elementary contexts. Many fifth-grade students still struggle with abstract scientific concepts, yet they simultaneously show strong enthusiasm for project-based and context-related learning. This contrast suggests that the issue is less about students' abilities and more about how learning experiences are structured. Students actually have good motivational capital, but need a more active, contextual, and meaningful learning design. This is in line with the findings that context-based learning and real activities tend to strengthen student learning engagement in basic science materials [28]. When scientific ideas are detached from students' daily lives, comprehension becomes fragmented and less meaningful. In this case, strengthening the connection between content and real-life context appears to be a critical step toward improving science literacy.

From the teachers' side, the high demand for Ethno-STEM-based teaching materials reflects practical constraints in existing instructional resources. These findings show that teachers recognize the need for learning tools that not only present science concepts but also integrate local wisdom and the sociocultural context of coastal communities. In line with this, the study of Ethno-STEM in Indonesia shows that integrating science, technology, engineering, and mathematics with local culture is a relevant approach to strengthen meaningful learning [29], [30]. At the same time, the very limited availability of science literacy assessment tools indicates that evaluation practices have not yet evolved to meet instructional needs. In other words, the development of teaching modules must be accompanied by an evaluation tool that accurately and comprehensively measures students' science literacy [32]. Without appropriate instruments, it becomes difficult to capture students' actual learning progress.

When viewed in relation to previous studies, these findings reinforce the well-documented benefits of PjBL and STEM approaches in promoting student engagement and conceptual understanding [18], [19]. However, this study offers a slightly different emphasis, focusing on the importance of needs analysis before instructional design is undertaken. Many earlier studies tend to evaluate the effectiveness of implemented models, while fewer examine whether those models are grounded in real classroom needs [33], [34], [35]. By incorporating local cultural context, such as Keumamah, this research extends the Ethno-STEM perspective in a more context-sensitive, empirically grounded direction.

The use of Keumamah as a learning context also highlights an important shift in how science knowledge can be positioned in the classroom. Rather than being presented as abstract and universal content, science becomes something that students can observe and experience directly through familiar cultural practices. However, this approach requires careful translation from cultural activity into scientific explanation. Without clear conceptual framing, students may engage with the activity without fully understanding the underlying scientific principles. Therefore, integrating local knowledge must be supported by structured instructional design to maintain both cultural relevance and scientific accuracy [31].

Another important issue emerging from this study is the imbalance between instructional innovation and assessment practices. While there is strong potential to develop contextual and project-based learning modules, the absence of adequate science literacy assessment tools may limit their overall impact. Assessment should not be treated as a separate component, but rather as an integral part of the learning design. This means that the development of Ethno-STEM modules must also include instruments capable of capturing higher-order thinking and contextual understanding. Without this alignment, improvements in learning processes may not be fully reflected in measurable outcomes.

A critical reflection on this study suggests that its findings are closely tied to the specific context in which it was conducted. The relevance of Keumamah is particularly strong in Aceh's coastal areas, and similar approaches in other regions would require adaptation to different cultural settings. Nevertheless, the broader principle of integrating local culture into science learning remains applicable across contexts. This indicates that Ethno-STEM should not be viewed as a fixed model, but as a flexible framework that can be adjusted to local conditions. Future studies could explore other forms of local knowledge to expand this approach.

Overall, the results of this study show that the development of Ethno-STEM teaching modules based on Keumamah has a strong empirical foundation. From the student side, there is a need for more concrete and fun learning. From the teacher's side, there is a need for better local teaching materials and evaluation instruments. In terms of cultural context, Keumamah provides authentic, relevant science sources for integration into learning.

Therefore, the results of this study not only explain the field conditions but also provide direction for product development. The modules to be designed should combine science concepts, project-based activities, coastal cultural contexts, and a more robust science literacy evaluation. Thus, this research provides a solid foundation for the design and prototype development stage of the teaching module.

4. CONCLUSION

This study concludes that there is a real and urgent need to develop Ethno-STEM teaching modules for the Keumamah context to improve the science literacy of elementary school students in the coastal areas of Aceh. Based on the quantitative analysis, there is a significant gap between students' and teachers' needs and the availability of learning tools. In which 78,4% of students have difficulty understanding abstract science concepts, while they show very high enthusiasm (85,0%) for learning tied to their contextual environment. On the other hand, 89.1% of teachers expressed the urgency of developing Ethno-STEM modules due to the limited teaching materials with local content (85.6%) and the lack of science literacy evaluation instruments (21.5%). The findings of the observation and documentation indicate that learning so far has remained decontextualized and dominated by urban contexts, resulting in low cognitive involvement among students.

As a practical implication, the results of this needs assessment provide a strong justification for educators and curriculum designers that Keumamah's processing practices, which include the process of heat transfer, preservation, and simple microbiology, have the potential to be transformed into a Project-Based Learning (PjBL) syntax as an authentic natural laboratory. The modules to be designed later must integrate school science with the tacit knowledge (cultural knowledge) of coastal communities and be equipped with comprehensive science literacy evaluation instruments.

This study is limited to coastal areas in Aceh and may not fully reflect the diversity of local cultures in other regions. Therefore, future research should focus on the design, development, and empirical testing of Ethno-STEM modules across diverse cultural contexts to evaluate their effectiveness in improving science literacy outcomes. In addition, further studies are recommended to develop standardized, validated science literacy assessment instruments aligned with contextual and culture-based learning approaches. These directions are essential to ensure the scalability, adaptability, and broader applicability of Ethno-STEM-based instructional innovations.

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