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Integrating Traditional Fish-Processing Ethnoscience and Digital Interactive Boards in Deep Learning to Enhance Coastal Elementary Students' Scientific Literacy

Trisniati*, Aynin Masfufah, Ratna Ekawati, Riska Pristiani, Slamet Arifin

Universitas Negeri Malang, Malang, Indonesia
*Corresponding author, e-mail: trisniati.2521038@students.um.ac.id

Abstract
The Programme for International Student Assessment (PISA) 2022 reported that Indonesia's science literacy score reached only 383, placing the country 67th out of 81 participating nations, with students in coastal areas facing even greater challenges due to limited access to contextual learning resources. Science instruction in coastal elementary schools remains predominantly theoretical and disconnected from students' daily experiences with marine resources, while local wisdom in traditional fish processing, rich in scientific principles such as osmosis, evaporation, and fermentation, has yet to be systematically integrated into the curriculum. This literature study aims to analyze the integration of traditional fish processing ethnoscience and digital interactive boards within the deep learning framework to enhance science literacy among coastal elementary school students. The study employed a qualitative literature review approach, with data collected from ten relevant articles published between 2015 and 2026, sourced from Google Scholar, ERIC, and ScienceDirect, and analyzed using content analysis techniques. The findings reveal three key contributions: first, traditional fish processing practices contain scientific concepts that can be reconstructed into contextual learning materials; second, digital interactive boards effectively facilitate visualization, simulation, and collaboration essential for deep learning; and third, the synergy between ethnoscience and digital technology within the deep learning framework offers a holistic pedagogical model. The study's primary contribution is the formulation of a conceptual framework demonstrating that the simultaneous integration of ethnoscience, digital interactive boards, and deep learning principles, mindful, meaningful, and joyful learning, can serve as an evidence-based pedagogical strategy to bridge the gap between formal science education and the socio-cultural realities of coastal communities, thereby offering a practical reference for developing contextual science instruction in similar settings.

Keywords: Ethnoscience, Traditional Fish Processing, Digital Interactive Board, Deep Learning, Science Literacy

Introduction

Science literacy is a fundamental competency that students must master in the 21st century to understand natural phenomena, interpret scientific information, and make evidence-based decisions in everyday life. This ability encompasses not only mastery of scientific facts and concepts but also critical thinking skills, scientific reasoning, and the application of knowledge in real-world contexts (Marfilinda & Andoko, 2022; Nurfathurrahmah et al., 2024). The Programme for International Student Assessment (PISA) defines science literacy as an individual's capacity to use scientific knowledge, identify scientific questions, and draw evidence-based conclusions to understand nature and its changes through human activity (Dewi et al., 2019). However, the 2022 PISA results reveal that Indonesia's average science score stands at 383, significantly below the OECD average of 485, placing the country 67th out of 81 participating nations (OECD). Furthermore, only 34% of Indonesian students achieved Level 2 competency, the minimum proficiency level for explaining scientific phenomena, while less than 1% attained the advanced Levels 5 and 6 (Ayu et al., 2025). These figures underscore systemic weaknesses in inquiry-based science learning, particularly in developing critical thinking and scientific investigation skills essential for 21st-century competencies.

The national PISA data carries particular significance for coastal elementary schools, where geographical isolation, limited educational infrastructure, and socio-economic constraints exacerbate the challenges of science instruction. In these settings, students often lack access to science laboratories, libraries, and digital learning resources that are more readily available in urban schools (OECD, 2023). Moreover, science curricula in coastal areas frequently remain disconnected from students' daily experiences with marine ecosystems, fishing practices, and traditional knowledge systems. This disconnect is reflected in PISA findings that Indonesian students perform best in personal contexts but struggle to apply scientific knowledge to broader local and global issues, a gap that becomes more pronounced in resource-limited coastal environments (Allathifah & Suliyanah, 2022; Haryanto et al., 2024). Consequently, Science and Social Studies (IPAS) learning in elementary schools still tends to be theoretical and teacher-centered, while experiments and direct observations that build meaningful understanding are rarely conducted (Junus et al., 2025; Tubagus et al., 2024). The subject matter feels abstract and difficult to understand, causing students to lose the connection between what they learn at school and the reality they experience daily (Putri et al., 2025).

Amidst these challenges, coastal communities possess a wealth of local knowledge (ethnoscience) that holds significant potential for integration into science learning. Ethnoscience is defined as the study of how specific cultural groups organize, classify, and understand the natural world based on knowledge and practices developed within their specific cultural and environmental contexts (Ansya et al., 2024; Sudarmin et al., 2021). In the context of coastal communities, traditional fish processing practices, such as salting, drying, smoking, and fermentation, are cultural heritage passed down through generations that implicitly contain fundamental scientific principles. The salting process, for example, involves osmosis and diffusion phenomena that can be explained through chemical and biological concepts (Nafsiyah et al., 2025; Perwitasari et al., 2016). Similarly, the fish drying process reflects the principles of evaporation and heat transfer (Perwitasari et al., 2016; Sholahuddin et al., 2021). The fermentation process aligns with microbiology and biochemistry concepts, including anaerobic respiration and the role of lactic acid bacteria in food preservation (Oxtariani et al., 2022). By explicitly linking these practices to scientific literacy indicators, such as explaining phenomena scientifically, interpreting evidence, and using scientific knowledge in local contexts, educators can design learning experiences that are both culturally responsive and academically rigorous.

However, the reality on the ground shows that this local knowledge has not been optimally integrated into the curriculum and learning practices in coastal elementary schools. Research on ethnoscience in science education in Indonesia reveals several critical shortcomings. First, the majority of ethnoscience studies still focus on secondary school level, with very limited research reaching primary education, especially in coastal areas (Yasir, 2024; Dewi et al., 2019). Second, existing studies predominantly examine ethnoscience integration in general science subjects without specifically exploring the unique potential of traditional fish processing practices as systematic learning resources for developing scientific literacy (Perwitasari et al., 2016; Oxtariani et al., 2022). Third, while digital interactive boards have been widely studied in science education, research specifically investigating their integration with ethnoscience-based learning materials remains scarce. Studies have primarily focused on general pedagogical benefits without examining how these devices can serve as mediating tools to bridge indigenous knowledge and formal scientific concepts (López et al., 2018; Mâță et al., 2016). Fourth, although the deep learning framework has been proposed to create mindful, meaningful, and joyful learning experiences, very few studies have integrated it with ethnoscience and digital technology simultaneously (Amri et al., 2025). Fifth, and most critically, there is a notable absence of an integrated conceptual model that synthesizes ethnoscience, digital interactive boards, and deep learning into a coherent pedagogical framework for improving science literacy among coastal elementary school students.

The rapid development of information and communication technology opens new opportunities to present more innovative learning experiences, one of which is through digital interactive boards or Interactive Flat Panels (IFP). A digital interactive board combines the functions of a traditional whiteboard with touchscreen capabilities, allowing teachers to display digital content, write, draw, save notes, and interact with content dynamically. The Ministry of Primary and Secondary Education is currently distributing IFP devices to various schools as part of the Learning Digitalization program mandated by Presidential Instruction Number 7 of 2025, targeting 288,865 schools across Indonesia. However, the presence of interactive boards alone does not guarantee pedagogical effectiveness. The theoretical basis for IFP's educational potential lies in its capacity to support multimodal representation and collaborative knowledge construction. IFP enables the visualization of abstract concepts, simulation of scientific processes, and access to rich digital learning resources (Gani et al., 2025). Recent studies confirm that IFP-assisted learning significantly improves student engagement and interaction, while enhancing teachers' creativity (Layara et al., 2025). Research on IFP implementation within deep learning frameworks reveals that 81% of teachers have utilized IFPs to support mindful, meaningful, and joyful learning, with 94% of students perceiving tangible benefits (Tyas et al., 2026). Empirical findings also demonstrate that IFP-assisted project-based learning yields higher learning outcomes compared to conventional instruction (Hasanah, 2026). These findings establish that the pedagogical effectiveness of IFPs depends on thoughtful integration with student-centered lesson designs, adequate teacher technological literacy, and consistent school-level support. When combined with ethnoscience-based content and deep learning principles, IFPs have the potential to serve as effective tools for overcoming the abstraction of scientific concepts while increasing students' active engagement.

The Deep Learning (DL) approach offers a highly relevant pedagogical framework for uniting ethnoscience integration and digital technology utilization. It is crucial to emphasize that deep learning, within the educational context, is understood as a pedagogical approach, not as artificial intelligence technology. Deep learning as a pedagogical concept is defined as a cognitive process that transcends mere memorization, involving deep conceptual understanding, the ability to apply knowledge in new contexts, critical analysis, synthesis, and evaluation (Ashari et al., 2025). The deep learning framework rests on three interconnected pillars that create a holistic learning experience. First, mindful learning emphasizes students' self-awareness of their learning processes, encouraging them to regulate their strategies and internal motivations. Second, meaningful learning occurs when students connect new knowledge with prior experiences, values, and real-world contexts, making learning relevant to their everyday lives. Third, joyful learning creates a positive, motivating atmosphere that enhances students' intrinsic motivation to learn (Syafi'i, 2025; Nofi'ah & Faruq, 2025). The relationship between these three pillars and ethnoscience integration is profound. Meaningful learning is directly served when traditional fish processing practices are used as authentic contexts for understanding scientific concepts. Mindful learning is cultivated when students reflect on how their community's cultural practices embody scientific principles. Joyful learning is achieved when interactive technologies are used to visualize processes, simulate experiments, and facilitate collaborative exploration (Rizal et al., 2025; Rahmaniati & Bulkani, 2025). When ethnoscience content is delivered through a deep learning lens, it moves beyond being a mere cultural addition to becoming a powerful pedagogical strategy for fostering critical thinking, scientific reasoning, and appreciation for both science and cultural heritage.

Several previous studies have demonstrated the effectiveness of integrating ethnoscience into science learning, as well as the positive impact of interactive digital media on student learning outcomes. A study by Ramadhani & Zainil (2025) proved that an ethnoscience integration model in thematic learning can foster students' local wisdom. Another study by Surbakti & Chantrin (2025) confirmed that digital-based interactive media significantly increases student motivation. Meanwhile, studies on Deep Learning integrated with STEAM and edutainment approaches have proven valid and effective for improving elementary school students' understanding of science concepts (Resty, 2025). However, recent reviews reveal that although publications on ethnoscience have increased significantly, there is still a gap in research specifically examining the synergy between ethnoscience integration and interactive digital technology within the Deep Learning framework to improve the science literacy of coastal elementary school students (Fiqry & Agustinasari, 2025). Research combining these three elements simultaneously is still very limited.

Based on the identification of this research gap, this literature study aims to analyze the integration of traditional fish processing ethnoscience and digital interactive boards in deep learning within the context of improving the science literacy of coastal elementary school students. Specifically, this study seeks to: (1) identify and synthesize the scientific concepts embedded in traditional fish processing practices that can be reconstructed into contextual science learning materials; (2) analyze the pedagogical affordances of digital interactive boards in facilitating ethnoscience-based science instruction within a deep learning framework; (3) examine the alignment between ethnoscience content, interactive board features, and the three pillars of deep learning; and (4) formulate a conceptual integration model that demonstrates how these three components can be synergistically combined. This study produces several scientific outputs: a conceptual synthesis that systematically maps the relationships between ethnoscience practices, interactive board functionalities, deep learning principles, and science literacy indicators; a pedagogical integration model outlining practical strategies for implementation in coastal elementary classrooms; and pedagogical propositions including guidelines for reconstructing local knowledge into scientific concepts, integrating interactive board features, and designing learning experiences that foster mindful reflection, meaningful connection, and joyful engagement. The results are expected to serve as an evidence-based reference for educators, curriculum developers, and policymakers seeking to design culturally responsive and technologically-enhanced science instruction in coastal contexts, while also providing a foundation for future empirical research to test and refine the proposed integration model.

Method

This research employs a qualitative approach with a literature study design. A literature study is a research approach carried out by examining various library sources such as scientific writings, books, and research reports related to the problem under study to build a solid theoretical foundation and conceptual framework (Powell & Connaway, 2010). In the context of this research, the literature study is utilized to explore the integration of traditional fish processing ethnoscience and digital interactive boards in deep learning within the context of improving the science literacy of coastal elementary school students, referring to findings from previously published research.

The data sources for this research were obtained from scientific articles published in national and international journals relevant to the research topic. Ten scientific articles were used in this study, sourced from various journal databases such as Google Scholar, ERIC, and ScienceDirect. The article selection process was conducted by applying several keywords that were substantively related to the integration of traditional fish processing ethnoscience, digital interactive boards, Deep Learning, and science literacy. All selected articles were then analyzed to find ideas, strategic approaches, and various findings related to the research topic (Gale et al., 2013).

Data collection in this research used documentation techniques. Documentation techniques were carried out by gathering relevant scientific articles, carefully examining their content, and recording important information related to the core research problem (Sugiyono, 2013). The instrument used in this research was an article analysis sheet or literature review table covering several components, including the researcher's name and publication year, research title, research objectives, methods used, and research findings related to traditional fish processing ethnoscience, digital interactive boards, Deep Learning, and science literacy. Using this instrument, research data can be organized systematically, thus facilitating the data analysis process.

The data analysis technique in this research applied content analysis methods. Content analysis was performed by deeply examining the content of the collected scientific articles, then identifying ideas, findings, and information relevant to the core research problem (Drisko & Maschi, 2016). The data analysis procedure in this research includes the following steps: (1) collecting relevant scientific articles, (2) reading and interpreting the entire content of the articles, (3) identifying research findings related to the integration of traditional fish processing ethnoscience, digital interactive boards, Deep Learning, and science literacy, (4) grouping data based on research themes or variables, (5) synthesizing the research results, and (6) drawing conclusions based on the literature analysis findings (Braun & Clarke, 2006). Through this analysis technique, it is expected to obtain a complete and comprehensive overview of traditional fish processing ethnoscience, digital interactive boards, Deep Learning, and science literacy.

Results and Discussion

Results

Below, the researcher presents the results of the analysis of 10 relevant articles, from both national and international journals, collected from various database sources. The presentation is made in a table containing the following components: researcher name and year, title, research objectives, research methods, and research findings.

Table 1. Article Analysis

No	Researcher	Title	Objectives	Method	Findings
1	Amri, H., Rapsanjani, H., Fredy, F., Yohanes, R. A., & Rahim, A. (2025)	Culture as a Source of Learning: Integration of Merauke Local Wisdom in Deep	To analyze the integration of Merauke local wisdom into deep learning.	Qualitative literature study with Miles & Huberman approach.	Ecological values in sasi and yur relevant for meaningful learning; spiritual and social values of "Izakod Bekai Izakod

No	Researcher	Title	Objectives	Method	Findings
		Learning Approach			Kai" relevant for mindful learning; traditional celebrations contribute to joyful learning. Challenges: infrastructure, teacher competence, scientific validation.
2	Pratama, D. H. & Jumadi (2023)	Analysis the Implementation of Ethnoscience Approach in Learning Science	To provide a literature review on the use of the ethnoscience approach in science learning.	Content analysis with qualitative descriptive approach, analyzing 20 articles from 2017-2023.	The ethnoscience approach effectively improves various student abilities such as thinking skills, problem-solving, process skills, and science literacy at the junior high school level.
3	Risamasu, P. V. M., Pieter, J., & Gunada, I. W. (2023)	Reconstruction of Scientific Knowledge Based on Local Wisdom of Communities on the Outskirts of Lake Sentani, Jayapura	To explore natural scientific knowledge and reconstruct it into scientific knowledge for science learning.	Qualitative phenomeno-logical ethnoscience with in-depth interviews, observation, documentation.	Local wisdom of the Homfolowkhouw Tribe includes traditional medicinal plants (sago leaves, forest betel, bitter leaf, noni), work tools (wauw, femca, ropeng), tifa musical instruments, tassel crafts, and astronomy to determine planting seasons and fishing times.
4	Oxtariani, M., Sumarni, W., Sumarti, S. S., & Mahatmanti, F. W. (2022)	Indigenous Science in Making Pekasam Fish (Fish Fermentation) in the Local Malay Community of Jambi	To reconstruct the local wisdom knowledge of the Malay Jambi community in making pekasam fish into scientific knowledge	Qualitative descriptive through in-depth interviews, direct observation, document study.	There are 12 local wisdoms from the pekasam making process that can be reconstructed into scientific knowledge, including concepts of fermentation, salt compounds, anaerobic processes, lactic acid, and CO_2 gas.
5	Sholahuddin, A., Hayati, N., Iriani, R., Saadi, P., & Susilowati, E. (2021)	Project-based Learning on Ethnoscience Setting to Improve Students' Scientific Literacy	To analyze the effect of Project-based Learning using Banjar traditional food ethnoscience learning resources on students' scientific literacy.	Quasi-experiment with Pretest-Posttest Nonequivalent Control Group Design.	N-gain of experimental class (PjBL) 0.76 (high category) higher than control class (expository) 0.65 (medium category). T-test showed significant difference ($t= 2.867$, $p < 0.05$). Ethnoscience-based PjBL is superior in

No	Researcher	Title	Objectives	Method	Findings
					improving scientific literacy.
6	Dewi, C. A., Khery, Y., & Erna, M. (2019)	An Ethnoscience Study in Chemistry Learning to Develop Scientific Literacy	To develop student scientific literacy through ethnoscience pedagogy in chemistry learning.	Qualitative descriptive with direct observation, questionnaires, interviews.	Needed: curriculum reinforcement emphasizing chemical literacy development, lecturer skills in designing learning based on local potential, and emphasis not only on chemical content but also context, process, and attitude.
7	López, V., Grimalt-Álvaro, C., & Couso, D. (2018)	How does the Interactive Whiteboard (IWB) Help to Promote Inquiry and Modeling Practices in the Science Classroom?	How does the Interactive Digital Whiteboard (IDW) help promote inquiry and modeling practices in the science classroom?	To analyze the potential of the interactive digital whiteboard in promoting inquiry and modeling practices in science class. Video analysis of 20 experimental workshops in physics, chemistry, biology (340 clips, 21 episode types).	IDW facilitates: (1) Organization and discussion of students' initial ideas via drag-drop; (2) Planning of experimental inquiry; (3) Storage and comparison of predictions with experimental results; (4) Interpretation of experimental graphs; and (5) Narration of dynamic processes via dragging objects.
8	Mâţă, L., Lazăr, G., & Lazăr, I. (2016)	Interactive Whiteboards for Teaching and Learning Science: Ascertained Research	To analyze recent research on the use of interactive whiteboards in science learning.	Content analysis of research from 2001-2014.	Research divided into two categories: (1) IWB as a tool to support science learning (cognitive, engagement, behavior, attitudes); (2) IWB as a tool to enhance science teaching (knowledge, pedagogical support, social aspects, technology). Most research in science and mathematics at the secondary school level.
9	Perwitasari, T., Sudarmin, & Linuwih, S. (2016)	Improving Science Literacy Through Learning Energy and it's Changes Charged with Ethnoscience in Fish Smoking	To determine the results of applying energy concept learning charged with fish smoking ethnoscience to	Quasi-experiment with Pretest-Posttest Control Group Design.	N-gain of experimental class 0.443 (medium category) higher than control class 0.164 (low category). T-test showed significant difference (Sig. 0.000

No	Researcher	Title	Objectives	Method	Findings
			improve student science literacy.		< 0.05). Ethnoscience learning on fish smoking effectively improves student science literacy.
10	Saraç, H. & Özarslan, M. (2016)	Relationship Between Attitude of Students at the Level of Primary Education Towards Interactive Board and Their Motivation for Process of Learning Science	To determine the relationship between primary school students' attitudes towards interactive boards and their motivation in the science learning process.	Cross-sectional research with interactive board attitude scale and permanent science learning motivation scale (632 students).	Student attitudes towards interactive boards were high ($\bar{X}$=3.63). No difference in motivation based on gender. 8th-grade student motivation was significantly higher. There is a low positive relationship between attitude towards interactive boards and motivation to learn science (r= 0.175, p < 0,01).

Discussion

Integration of Ethnoscience in Science Learning to Improve Science Literacy

The analysis of the ten articles shows that integrating ethnoscience into science learning has a positive effect on improving students' science literacy. Research by Dewi et al. (2019) proved that ethnoscience pedagogy in chemistry learning can develop students' science literacy in terms of content, competence, context, and attitude. This finding is reinforced by Perwitasari et al. (2016), who showed that applying the concept of energy and its changes, charged with fish smoking ethnoscience, effectively improves student science literacy with an N-gain of 0.443, categorized as medium. This improvement in science literacy occurs because ethnoscience learning bridges formal scientific knowledge with concrete experiences students have from their cultural environment. This aligns with Sudarmin's (2014) view that ethnoscience serves as a transformation of the community's original scientific knowledge into academically accountable scientific knowledge. Thus, integrating ethnoscience into science learning not only improves conceptual understanding but also strengthens students' appreciation of the local wisdom in their surroundings.

Effectiveness of Digital Interactive Boards in Supporting Science Learning

Findings from various studies indicate that the use of digital interactive boards contributes positively to the science learning process. López et al. (2018) identified that digital interactive boards can facilitate inquiry practices and scientific modeling through various interactive features such as dragging objects, rewriting on displayed information, and saving and restoring student-produced results. Research by Saraç & Özarslan (2016) revealed that students' attitudes toward using interactive boards were in the high category (mean 3.63 on a 5-point scale), and there was a significant positive relationship between attitudes toward interactive boards and students' motivation to learn science. This finding is supported by Mâţă et al. (2016), who concluded that digital interactive boards act as tools to support science learning by improving learning outcomes, motivation, engagement, and student participation. The ability of interactive boards to present multimodal information and enable collaboration among students makes them ideal tools for creating interactive and meaningful learning environments, as emphasized by Kennewell & Beauchamp (2007) that the interactivity features of digital boards significantly influence the learning process.

Integration of Ethnoscience and Digital Interactive Boards in Deep Learning

The synergy between ethnoscience and digital interactive boards within the Deep Learning framework is an important finding emerging from the literature synthesis. Research by Amri et al. (2025) shows that integrating local wisdom into the Deep Learning approach, which includes mindful learning, meaningful learning, and joyful learning, can strengthen students' cultural literacy, ecological awareness, and character development. The principle of meaningful learning in Deep Learning aligns with the findings of Sholahuddin et al. (2021), who proved that project-based learning using Banjar traditional food ethnoscience learning resources significantly improved student science literacy, with an N-gain of the experimental group reaching 0.76 (high category) compared to the control group at only 0.65. Meanwhile, the principle of joyful learning can be realized through the use of digital interactive boards, which, according to López et al. (2018), can create a social space for participatory and enjoyable knowledge construction. The combination of these three approaches creates a learning ecosystem that not only transfers knowledge but also builds deep, critical, and applicable understanding. This is relevant to the concept of deep learning proposed by Fullan & Langworthy (2014) as a process of building new competencies through exploration, collaboration, and connection with the real world.

Reconstruction of Indigenous Scientific Knowledge into Formal Science

The process of reconstructing the community's indigenous scientific knowledge into formal science is a fundamental step in integrating ethnoscience into the curriculum. Risamasu et al. (2023) reconstructed the local wisdom of communities on the outskirts of Lake Sentani into formal scientific concepts, including the use of warm papeda to heal wounds, which can be explained through the concepts of heat transfer and antibacterial mechanisms. Research by Oxtariani et al. (2022) also reconstructed 12 local wisdoms in the process of making pekasam (fish fermentation) into scientific knowledge covering concepts of fermentation, lactic acid, microorganisms, and anaerobic conditions. This reconstruction process is important because the community's original knowledge has so far only been transmitted orally and has not been formally structured scientifically. Sudarmin (2014) asserts that transforming traditional scientific knowledge into formal science can change the image of indigenous knowledge, often considered myth or superstition, into useful and accountable science. Thus, the results of this reconstruction can serve as authentic contextual learning resources for elementary school students in coastal areas.

Contribution to Science Literacy of Coastal Elementary School Students

Implementing the integration of ethnoscience and digital interactive boards within the Deep Learning framework has a strategic contribution to improving the science literacy of elementary school students in coastal areas. Pratama & Jumadi (2023) concluded in their study that applying the ethnoscience approach in science learning effectively improves various student abilities and skills, including thinking skills, problem-solving abilities, process skills, and science literacy. Research by Perwitasari et al. (2016) specifically proved that learning charged with ethnoscience in the fish smoking process (a common practice among coastal communities) can improve the three indicators of science literacy: identifying scientific questions (N-gain 0.509), explaining scientific phenomena (N-gain 0.475), and using scientific evidence (N-gain 0.345). These findings are highly relevant to the characteristics of coastal elementary students who interact daily with marine product processing activities. By integrating traditional fish processing practices into IPAS learning with the help of digital interactive boards, students can build meaningful science understanding because the material studied is directly related to their life realities. This approach simultaneously preserves local wisdom and prevents the erosion of cultural values by the currents of globalization.

Implementation Challenges and Opportunities

Although various studies show the effectiveness of integrating ethnoscience and digital technology, its implementation in the field is not without challenges. Amri et al. (2025) identified several main obstacles, including limited technological infrastructure in remote areas, teachers' low pedagogical competence in integrating local culture, and epistemological challenges related to the scientific validation of local knowledge. Research by Mâţă et al. (2016) also revealed that although interactive boards have proven beneficial, most research still focuses on secondary school level, and very few have examined their effectiveness in higher education, let alone in coastal elementary schools. However, development opportunities are wide open given that the Kurikulum Merdeka (Independent Curriculum) provides flexibility for educational units to develop diversified curricula according to regional and student potential (Ministerial Decree No. 56 of 2022). With appropriate policy support, continuous teacher training, and the development of innovative learning media based on local wisdom, the integration of ethnoscience and digital interactive boards in deep learning can be optimally implemented in coastal elementary schools.

Implications of the Research

This research makes a threefold contribution to science education theory, with each contribution addressing a distinct gap in the existing literature.

First, this study enriches ethnoscience pedagogy theory by moving beyond the general integration of local culture into science learning. While existing systematic reviews have predominantly focused on secondary education and general science subjects (Widarti et al., 2025; Hikmah et al., 2025), this study specifically examines traditional fish processing practices-salting, drying, smoking, and fermentation, as a systematic learning resource for coastal elementary schools. This differs from prior ethnoscience reviews that either examined broad cultural practices or focused on different educational levels (Muyassaroh et al., 2025). By mapping each practice to specific scientific concepts (osmosis, evaporation, anaerobic respiration) and scientific literacy indicators (explaining phenomena, interpreting evidence, using scientific knowledge), this study offers a contextualized framework for ethnoscience integration in coastal settings where students' daily lives are intertwined with marine resources (Widarti et al., 2025).

Second, this research expands the scope of educational technology theory by reconceptualizing digital interactive boards (IFPs) not merely as instructional tools for content delivery, but as mediating artifacts for bridging indigenous knowledge and formal scientific concepts. Previous studies on interactive whiteboards have primarily focused on general pedagogical benefits such as visualization and student engagement (Widarti et al., 2025). This study diverges by identifying specific IFP affordances, drag-and-drop for classifying traditional practices, saving and retrieving student productions for comparing predictions with experimental results, and overlaying scientific explanations onto cultural artifacts, that can operationalize ethnoscience-based instruction within a deep learning framework. This contribution addresses the underdeveloped intersection between ethnoscience and digital literacy identified in recent systematic reviews (Hikmah et al., 2025).

Third, this study integrates three domains, ethnoscience, digital technology, and deep learning pedagogy, that have been predominantly examined in isolation. While prior research has validated deep learning's potential in science education (Dipayana et al., 2026; Rizal et al., 2025), and ethnoscience-based modules have shown effectiveness in improving scientific literacy (Widarti et al., 2025; Sudirman et al., 2025), no study has systematically synthesized all three elements into a coherent framework for coastal elementary education. The resulting integrative conceptual model extends existing deep learning theory by demonstrating how the three pillars, mindful learning (reflection on cultural-scientific connections), meaningful learning (contextualizing abstract concepts through fish processing), and joyful learning (engaging with interactive technology), can be simultaneously activated through ethnoscience-based, technology-enhanced instruction (Dipayana et al., 2026; Rizal et al., 2025). This differs from previous deep learning integrations that focused on STEAM or edutainment approaches (Sudirman et al., 2025), thereby offering a culturally grounded alternative for science literacy development in underserved coastal communities (Muyassaroh et al., 2025).

Practically, the results of this research can serve as a reference for teachers and curriculum developers in designing contextual and meaningful IPAS learning for coastal elementary school students. Teachers are encouraged to explore local wisdom in the surrounding environment, especially related to marine product processing, and then reconstruct it into learning materials integrated with formal scientific concepts. The use of digital interactive boards needs to be designed systematically by utilizing interactive features such as visualization, simulation, and collaboration to facilitate deep learning. For school principals and policymakers, this research provides recommendations to provide adequate technological infrastructure, conduct continuous teacher training, and develop curriculum policies that provide space for integrating local wisdom. For coastal communities, implementing this learning model can serve as a means of preserving and appreciating ancestral cultural heritage while enhancing the ecological awareness of the younger generation.

Conclusion

This literature study concludes that the integration of traditional fish processing ethnoscience and digital interactive boards within a deep learning framework demonstrates conceptual potential to support the improvement of science literacy among coastal elementary school students. However, these conclusions must be interpreted cautiously, as this study synthesizes existing evidence rather than directly measuring effectiveness in coastal student populations.

First, the literature consistently indicates that traditional fish processing practices-salting, drying, smoking, and fermentation-contain scientific concepts that can be reconstructed into contextual learning materials. However, direct evidence specifically demonstrating this effectiveness among coastal elementary school students remains limited, as most studies have been conducted at the secondary level or in non-coastal settings. Therefore, while the conceptual foundation for ethnoscience integration is well-established, its transferability to coastal elementary contexts requires further empirical validation. Second, the literature suggests that digital interactive boards possess pedagogical affordances, visualization, simulation, and collaboration features, that can conceptually support deep learning principles. However, this research has predominantly been conducted in general classroom settings without specific focus on ethnoscience content or coastal student populations. The synergistic potential between IFP features and ethnoscience-based content remains conceptually plausible but empirically unverified in coastal elementary schools. Third, the integration of ethnoscience, digital interactive boards, and deep learning principles, mindful, meaningful, and joyful learning, offers a conceptually coherent framework that aligns with contextual and culturally responsive pedagogy. Nevertheless, the simultaneous integration of all three components has not been empirically tested in any single study; rather, these elements have been examined separately. Thus, the conceptual model proposed in this study represents a synthesis of existing evidence that requires empirical testing.

In conclusion, this literature study provides a conceptually supportive foundation for integrating traditional fish processing ethnoscience and digital interactive boards within a deep learning framework to enhance science literacy among coastal elementary school students. However, the proposed integration model should be viewed as a conceptual proposition rather than a proven intervention. The effectiveness of this model in coastal elementary settings remains an open empirical question that warrants investigation through future quasi-experimental or developmental research.

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