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A Systematic Review of the Effectiveness of Ethnoscience-Based Learning in Improving Science Literacy in Primary and Secondary Education

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Abstract: Conventional science learning often feels abstract and distant from students' realities, especially at the elementary and secondary levels. This can hinder the development of deep understanding and the relevance of the material to everyday life. Ethnoscience-based learning integrates local knowledge with modern scientific concepts to create contextual and meaningful learning. This study aims to: Assess the effectiveness of ethnoscience-based learning in improving students' scientific literacy at the elementary and secondary education levels; Identify learning models and media used in ethnoscience-based learning; Find challenges and supporting factors in implementing ethnoscience-based learning in schools. This study is a systematic review examining the effectiveness of ethnoscience-based learning in improving students' scientific literacy at the elementary and secondary levels. By analyzing 20 empirical studies published between 2020 and 2025, this review evaluated various learning models, teaching materials, and learning media that use ethnoscience as a foundation. The results show that ethnoscience-based learning consistently improves scientific literacy, critical thinking skills, learning motivation, and appreciation for local culture. Challenges such as limited teacher training and curriculum adjustments need to be addressed for optimal implementation. This study provides recommendations for developing more contextual curricula and learning practices, as well as strengthening teacher training. The findings are expected to serve as a reference for educators, researchers, and policymakers in strengthening scientific literacy through an ethnoscience approach.

Keywords: Ethnoscience-based learning; Learning model; Primary and secondary education; Scientific literacy; Systematic review

Introduction

Scientific literacy is a crucial skill for students to understand, apply, and evaluate scientific knowledge in everyday life. However, surveys on scientific literacy in Indonesia indicate low achievement, driven by science learning methods that tend to emphasize memorization without linking it to the cultural context and the surrounding environment. One approach considered effective in addressing this issue is ethnoscience-based learning, which integrates local knowledge and cultural wisdom into science learning (Rizki et al., 2025). Ethnoscience, as a cultural discipline that connects indigenous knowledge with science, can make learning more contextual and meaningful, and increase student motivation (Winarto et al., 2022; Sari et al., 2023). Science education plays a crucial role in preparing young people to face increasingly complex global challenges. The ability to think critically, solve problems, and make decisions based on scientific evidence, all of which

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constitute scientific literacy, are essential competencies in the 21st century (Hu & Bi, 2025; García-Carmona, 2025). However, the reality on the ground shows that the level of scientific literacy of students in Indonesia remains a serious concern (Ardiyanti et al., 2019).

Various reports, including the results of the Programme for International Student Assessment (PISA) study, consistently rank Indonesia at the bottom in terms of scientific literacy (Eminita et al., 2020). This situation indicates a mismatch between curriculum objectives and learning outcomes, one of which may stem from a science learning approach that lacks relevance and context for students (Jones et al., 2025; Wu & Wang, 2025; EL-Deghaidy et al., 2017). Science learning is often presented in isolation from students' daily lives, making it abstract and less meaningful (Permanasari et al., 2021; Dah et al., 2024; Syafril et al., 2021). Yet, science not only grows in modern laboratories but is also deeply embedded in the practices and wisdom of local communities. Here, ethnoscience offers a new perspective (Shongwe, 2024). Ethnoscience is the study of how different cultural groups understand, classify, and use knowledge about their natural environment (Murwitaningsih & Maesaroh, 2023). By integrating ethnoscience into learning, students are encouraged to explore the connections between modern scientific concepts and traditional knowledge, local practices, and their own cultural worldviews. For example, physics concepts can be found in the principles of traditional shipbuilding, or biology principles in traditional agricultural methods.

An ethnoscience-based approach has great potential to overcome boredom and difficulties students face in understanding science (Christiana & Rohaeti, 2024). By connecting subject matter to students' cultural contexts and life experiences, learning becomes more relevant, engaging, and understandable (Pantiwati et al., 2022). This not only increases students' motivation to learn but also enables them to see science as an integral part of their cultural heritage and identity. It is anticipated that through this strategy, students will not only master scientific concepts but also be able to apply them in broader contexts, and appreciate the diversity of local knowledge and wisdom. Various studies have shown that integrating ethnoscience into science learning can improve students' conceptual understanding, science process skills, character, and scientific literacy (Telussa & Tamaela, 2023).

Therefore, a systematic review of the effectiveness of ethnoscience-based learning is essential to summarize empirical evidence and provide recommendations for developing science learning at the elementary and secondary levels. Based on this background, the research questions are as follows: How effective is ethnoscience-based learning in improving scientific literacy in elementary and secondary education? What learning models and media are used in ethnoscience-based learning?. What are the challenges and supporting factors in implementing ethnoscience-based learning?. This research aims to: Assess the effectiveness of ethnoscience-based learning in improving students' scientific literacy in elementary and secondary education; Identify the learning models and media used in ethnoscience-based learning; Identify the challenges and supporting factors in implementing ethnoscience-based learning in schools.

The results of this systematic review are expected to provide the following benefits: For educators, it can serve as a reference in developing and implementing learning models that integrate local wisdom to improve students' scientific literacy; For curriculum developers and policymakers, it can serve as a basis for designing educational policies that support culturally based contextual learning; For researchers, as a reference for further research that explores aspects of implementation and development of ethnoscience-based learning.

Method

This research used a Systematic Literature Review (SLR) approach. SLR is a systematic, explicit, and reproducible research method for identifying, evaluating, and synthesizing primary research findings relevant to a specific research question (Mengist et al., 2020; Nurkhin et al., 2024). This approach was chosen because it provides a comprehensive and objective overview of the effectiveness of ethnoscience-based learning in improving scientific literacy in elementary and secondary education. To ensure that the literature search, selection, and analysis process were carried out systematically and transparently, a research protocol was first developed. This protocol included the research question formulation, inclusion and exclusion criteria, search strategy, selection process, data extraction, and data synthesis methods. The article selection process was conducted independently. Researchers screened the titles, abstracts, and content of articles according to established inclusion and exclusion criteria.

Inclusion Criteria

Empirical research articles discussing ethnoscience-based learning and scientific literacy; Articles published in national or international peer-reviewed journals; Articles in Indonesian or English; Articles published between 2020 and 2025; Focus on elementary and secondary education levels (elementary, junior high, and senior high).

Exclusion Criteria

Non-empirical articles such as opinion pieces, reviews without primary data, and editorials; Articles that do not focus on ethnoscience-based learning or scientific literacy; Articles that are not fully available or not available in Indonesian or English.

Search Strategy

A literature search was conducted in several relevant electronic databases, including Google Scholar, Crossref, and the national digital library. The keywords used included: "ethnoscience AND scientific literacy AND elementary/middle/high school"; "ethnoscience-based learning AND scientific literacy AND elementary/junior high school"; "ethnoscience-based learning AND science literacy". The search was limited to articles that met the inclusion criteria above.

Article Selection Process

The selection process follows these stages: Initial identification: Collecting articles based on keywords from databases; Screening: Selecting articles based on titles and abstracts to eliminate irrelevant ones; Full content evaluation: Examining the full text of articles to ensure compliance with the inclusion criteria; Final selection: Selecting 20 articles that meet all criteria for further analysis. This selection process follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standard. The stages and number of articles at each stage are recorded to ensure transparency and reproducibility of the research. The PRISMA diagram can be illustrated as follows.

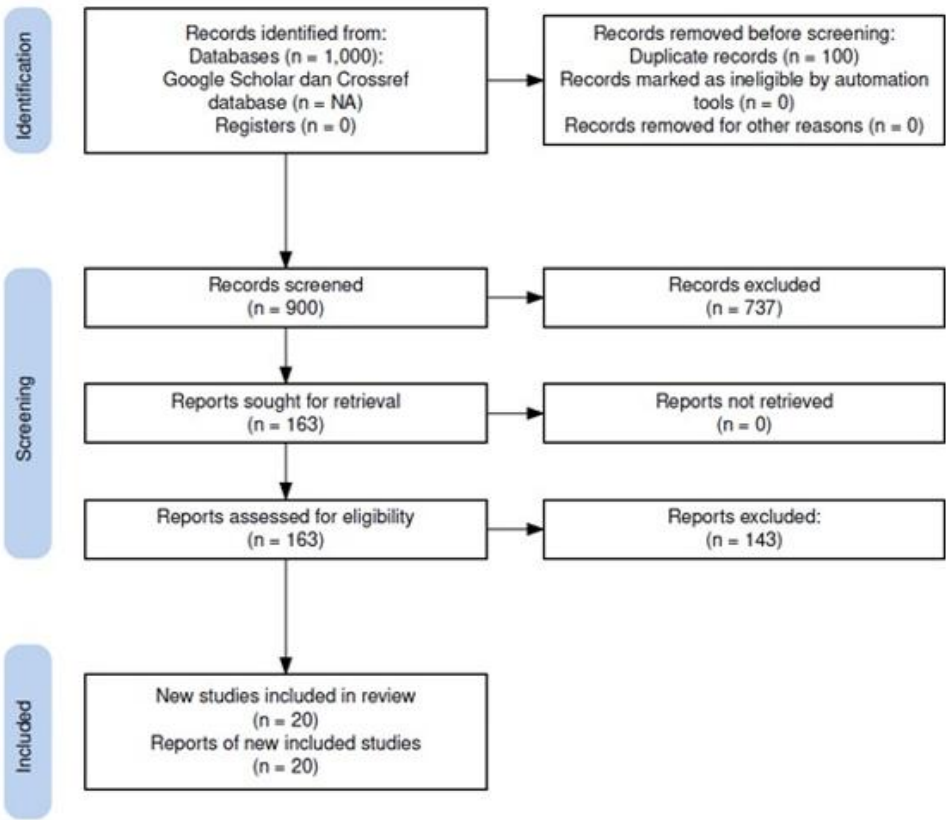

Figure 1. PRISMA Diagram

Data from the selected articles were extracted using a coding sheet that included key information such as: author, year of publication, article title, research objectives, methods used, scientific literacy measurement instruments, main results, and recommendations provided by the study authors. This extraction process aimed to systematically organize the data to facilitate analysis and synthesis of findings. Data analysis was conducted narratively and thematically to synthesize findings related to the characteristics of ethnoscience-based learning models, the scientific literacy measurement methods used, and to identify research gaps and recommendations for future learning development. The narrative approach allowed for an in-depth explanation of the context and results of each study, while thematic analysis helped group findings based on key themes emerging from the literature.

To minimize bias in the selection and analysis process, the authors cross-checked the data with the original sources (primary articles) to ensure the accuracy of data extraction and interpretation. This step ensured that the article selection and analysis process was objective, transparent, and free from bias. Each selected article was also evaluated for methodological quality using criteria from the Critical Appraisal Skills Programme (CASP) specifically for quasi-experimental and experimental studies. The evaluation included clarity of the research objectives, appropriateness of the research design, validity and reliability of the scientific literacy measurement instruments, and reporting of the research results. Only articles with good methodological quality were included in the final synthesis to ensure the validity of the findings. Most of the primary studies in this review used a quasi-experimental design with control and experimental groups to test the effectiveness of ethnoscience-based learning on students' scientific literacy. This design is commonly used in educational research because it allows for direct comparison between groups receiving and without intervention. However, there are several critical notes regarding the methodology used, including:

Design Variation and Internal Validity

Not all studies employed randomization in sample selection, thus the potential for selection bias remains. Many studies used purposive or convenience sampling, which can limit internal validity and the generalizability of the results. Some studies also lacked transparency in reporting the group allocation process.

Scientific Literacy Measurement Instruments

Most studies adapted existing scientific literacy measurement instruments, but the validity and reliability testing of the instruments was not always detailed. This potentially led to variations in measurement accuracy between studies and affected the consistency of the results.

Data Analysis and Reporting

Nearly all studies used t-tests or simple parametric statistical analyses. However, reporting of effect sizes and further analyses such as ANCOVA or mixed-methods analyses was limited, even though these are crucial for strengthening claims of intervention effectiveness.

Duration and Scope of the Intervention

The duration of ethnoscience-based learning in most studies was relatively short (one to two learning cycles), so the long-term impact on students' scientific literacy has not been adequately tested. Furthermore, most research is still limited to science subjects at the junior high school level, resulting in a homogenous scope of material and context. From this selection and quality evaluation process, 20 articles were selected for further analysis. The following table summarizes these articles, including title, author, year, research type, educational level, and main findings.

Table 1. Summary of research results (2020–2025)

References (Author, Year)	Article Title	Types of research	Educational level	Research Focus	Key Findings	Link/DOI
Dewi et al. (2021)	Effect of Contextual Collaborative Learning Based Ethnoscience to Increase Student's Scientific Literacy Ability	Experiment	SMP/S MA	Ethnoscience-based Contextual Collaborative Learning	Significantly improving students' scientific literacy	https://doi.org/10.36681/tused.2021.88
Wati et al. (2021)	Analysis of student scientific literacy: study on learning using ethnoscience integrated science teaching materials based on guided inquiry	Analysis Study	SD/SM P	Integration of Ethnoscience in Guided Inquiry-Based Teaching Materials	Improving students' scientific literacy skills	https://doi.org/10.29303/jpm.v16i5.2292
Jufrida et al. (2024)	Ethnoscience learning: how do teacher implementing to increase scientific literacy in junior high school	Mixed Method	SMP	Implementation of Ethnoscience Learning by Teachers	Effectively improving junior high school students' scientific literacy	https://doi.org/10.11591/ijere.v13i3.26180
Kotimah et al. (2024)	The Effectiveness of Ethnoscience- Based Electronic Student Worksheet to Improve Critical Thinking and Scientific Literacy in Middle School Students	Experiment	SMP	Use of Ethnoscience-Based E-LKPD	Improving critical thinking and scientific literacy skills of junior high school students	https://doi.org/10.29303/jppipa.v10i11.8729

References (Author, Year)	Article Title	Types of research	Educational level	Research Focus	Key Findings	Link/DOI
Hidayah et al. (2024)	Implementation of Ethnoscience- Based PjBL on Science Literacy Learning Outcomes	Quasi Experiment	SMA	Ethnoscience-Based PjBL Model	Improving high school students' scientific literacy outcomes	https://doi.org/10.46843/jiecr.v5i3.1278
Bramastia et al. (2023)	Effectiveness of EthnoSTEM-Based Science Learning to Improve Junior High School Students' Science Literacy Ability	Experiment	SMP	EthnoSTEM Learning	Effectively improving junior high school students' scientific literacy	https://doi.org/10.29303/jppipa.v9ispecialissue.5710
Dewi et al. (2020)	The Development of Ethnoscience Based Acid-Base Modules to Improve Students' Scientific Literacy Ability	R&D	SMP	Development of an Ethnoscience-Based Acid-Base Module	Valid and effective module for improving scientific literacy	https://www.ijicc.net/images/Vol_14/Iss_1/14191_Dewi_2020_E_R.pdf
Fridayanti & Khusniati (2023)	The effectiveness of pop-up books containing ethnoscience on increasing students' scientific literacy on the material of the solar system	Experiment	SD/SM P	Ethnoscience-Themed Pop-Up Book	Effectively improving scientific literacy on solar system material	https://doi.org/10.1063/5.0127038
Yuliana et al. (2021)	The effect of ethnoscience-themed picture books embedded within context-based learning on students' scientific literacy	Experiment	SD/SM P	Ethnoscience Picture Book in Contextual Learning	Improving students' scientific literacy	https://doi.org/10.14689/ejer.2021.92.16
Herayanti et al. (2025)	Development of Ethnoscience-Based Teaching Materials to Improve Students' Scientific Literacy	R&D	SD/SM P	Development of Ethnoscience-Based Teaching Materials	Valid and effective module for improving students' scientific literacy	https://doi.org/10.33394/jk.v11i1.13429
Verawati & Wahyudi (2024)	Raising the Issue of Local Wisdom in Science Learning and Its Impact on Increasing Students' Scientific Literacy	Experiment	SMA	Integration of Local Wisdom in Science Learning	Improving students' scientific literacy	https://doi.org/10.33394/ijete.v1i1.10881
Hastuti et al. (2022)	Assessment Instrument Scientific Literacy on Addictive Substances Topic in Inquiry Based Learning Integrated Ethnoscience	R&D	SMA	Development of Science Literacy Instruments for Addictive Substances	Valid and reliable instrument	https://doi.org/10.21831/jser.v6i1.48343
Rusmansyah et al. (2023)	Improving Students' Scientific Literacy and Cognitive Learning Outcomes through Ethnoscience-Based PjBL Model	Quasi Experiment	SMA	Ethnoscience-Based PjBL Model	Improving scientific literacy and cognitive learning outcomes	https://doi.org/10.46843/jiecr.v4i1.382
Wiratama et al. (2025)	The Development of Ethnoscience-Based E-Student Worksheets to Enhance Students Scientific Literacy at Madrasah Ibtidaiyah	R&D	SD	Development of Ethnoscience-Based E-LKPD	Valid, practical, and effective in practicing scientific literacy	https://doi.org/10.46963/mpgmi.v11i1.2380
Yasir et al. (2024)	Scientific Literacy Skill in Science Learning based on Ethnoscience	Pre-Experiment	SMP	Ethnoscience-Based Learning	Improving junior high school students' scientific literacy	https://doi.org/10.31002/ijose.v8i2.1643
Amalia et al. (2024)	Development of a Scientific Literacy Instrument Based on	R&D	SMP/S MA	Development of Riau Malay Ethnoscience-	Valid, practical, and effective instrument	https://doi.org/10.33650/pjp.v11i1.6382

References (Author, Year)	Article Title	Types of research	Educational level	Research Focus	Key Findings	Link/DOI
	Riau Malay Ethnoscience in Science Subjects			Based Science Literacy Instruments		
Aprilia & Lutfi (2023)	Ethnoscience- Based Interactive Multimedia to Improve Scientific Literacy in Chemical Equilibrium Materials	R&D	SMA	Ethnoscience-Based Interactive Multimedia	Valid, practical, and effective in improving scientific literacy	https://doi.org/10.33394/hjkk.v11i3.7942
Yasir et al. (2022)	Ethnoscience- Based Mind Mapping Video Using Indigenous Knowledge to Practice Students' Science Literacy Ability	Experiment	SMP	Ethnoscience-Based Mind Mapping Videos	Improving students' scientific literacy abilities	https://doi.org/10.26740/jpps.v12n1.p26-39
Putri et al. (2025)	Analysis of the Practicality of Ethnoscience- Based Science Learning Modules to Improve Scientific Literacy of Students at SMP Negeri 1 Sendana	R&D	SMP	Analysis of the Practicality of Ethnoscience-Based Learning Modules	Practical and effective module for scientific literacy	https://twistjournal.net/twist/article/view/665

Results and Discussion

Results

Effectiveness of Ethnoscience-Based Learning in Improving Scientific Literacy

Based on various studies summarized in tables and findings supported by additional sources, several key findings related to the influence of ethnoscience-based learning on students' scientific literacy can be outlined as follows (Table 2).

Numerous experimental and quasi-experimental studies have shown that the use of teaching materials, modules, or learning models that integrate ethnoscience significantly improves students' scientific literacy skills compared to conventional learning. For example, Sarini et al. (2024), and other studies using ethnoscience-integrated science modules or teaching materials showed a significant increase in students' scientific literacy, with N-gain values in the moderate to high category. The use of media such as electronic student worksheets (LKPD), pop-up books, interactive multimedia, mind-mapping videos, and ethnoscience-based modules has proven effective in improving students' scientific literacy and critical thinking skills. This is also supported by research by Munawarah et al. (2024), which shows that ethnoscience-based learning media can increase student engagement and understanding.

Table 2. Effectiveness of ethnoscience-based learning on scientific literacy

Author and Year	Variabel that ismeasured	Key Results	Conclusion of Effectiveness
Dewi et al. (2021)	Science Literacy	Significant improvement in students' scientific literacy skills after the intervention	Effectively improve scientific literacy
Kotimah et al. (2024)	Scientific Literacy and Critical Thinking	Improving scientific literacy and critical thinking skills of junior high school students	Effective and significant
Hidayah et al. (2024)	Science Learning Outcomes	Science learning outcomes increase with the ethnoscience-based PjBL model	Effectively improve learning outcomes
Fridayanti & Khusniati (2023)	Science Literature	Improving scientific literacy on solar system material using pop-up books	Effective and engaging for students
Bramastia et al. (2023)	Science Literacy	Increasing scientific literacy through EthnoSTEM learning	Effective for junior high school level

The research, covering elementary, middle, and high school levels, consistently demonstrates that integrating ethnoscience into science learning is effective in improving scientific literacy at all levels. For example, Atmojo et al. (2019) at the elementary, as well as at the high school level, all reported improvements in students' scientific literacy through an ethnoscience approach. In addition to improving scientific literacy, the development of ethnoscience-based assessment instruments and teaching materials has also proven valid, reliable, and practical for use in learning. Examples include the development of an acid-base module by Rasmawan (2020) literacy instrument based on Riau Malay ethnoscience by Purnamasari et al. (2024)

and other teaching materials and modules whose effectiveness has been tested. The integration of local wisdom and cultural context into science learning helps students understand scientific concepts in a more meaningful and relevant way to everyday life. This increase learning interest and overall scientific literacy skills, as demonstrated by research by Wazni et al. (2023) and several other studies that emphasize the importance of ethnoscience as a bridge between science and local culture. With local culture so that learning becomes more meaningful and interesting for students (Ratri et al., 2025).

Learning Models and Media Used

Various ethnoscience-based learning models used in these studies include Project-Based Learning (PjBL), STEAM, guided inquiry, discovery learning, and contextual collaborative learning. These models integrate local wisdom and cultural phenomena into the learning process, making the material more relevant and easier for students to understand. The learning media used varied, ranging from printed and electronic modules (E-LKPD), picture books, interactive multimedia, and pop-up books on ethnoscience. These media have proven effective in supporting conceptual understanding and increasing student learning motivation.

Table 3. Effectiveness of ethnoscience-based learning on scientific literacy

Author and Year	Types of research	Educational level	Learning model	Instructional Media
Dewi et al. (2021)	Experiment	SMP	Contextual Collaborative	Ethnoscience-Based Module
Kotimah et al. (2024)	Experiment	SMP	Ethnoscience Based on E-LKPD	Electronic Worksheet (E-LKPD)
Hidayah et al. (2024)	Quasi-Experiment	SMA	Project Based Learning (PjBL)	Electronic Module
Fridayanti & Khusniati (2023)	Experiment	SD/S MP	Guided Inquiry	Pop-up Book on Ethnoscience
Bramastia et al. (2023)	Experiment	SMP	Ethno STEM	Interactive Multimedia

Challenges and Supporting Factors for Implementation

Although ethnoscience-based learning is generally effective, several challenges have been identified in its implementation. The main challenges are limited teacher training in comprehensively understanding and applying ethnoscience concepts, a lack of contextual and accessible teaching materials, and the need to adapt the curriculum to better support the integration of local wisdom (Jamilah et al., 2024). Supporting factors for successful implementation include school management support, ongoing teacher training, and the involvement of the local community as a learning resource.

Table 4. Challenges and supporting factors for the implementation of ethnoscience-based learning

Author and Year	Main Challenges	Supporting Factors
Yasir et al. (2022)	Limited teacher training	School management support
Jufrida et al. (2024)	Lack of contextual teaching materials	Ongoing teacher training
Verawati & Wahyudi (2024)	Suboptimal curriculum adjustments	Local community involvement
Dewi et al. (2021)	Limited intervention time	Engaging interactive learning media
Kotimah et al. (2024)	Lack of ethnoscience-based learning resources	Teacher and local community collaboration

Discussion

The results of this review confirm that ethnoscience-based learning can significantly improve students' scientific literacy. This aligns with constructivist learning theory, which emphasizes the importance of context and real-world experiences in constructing knowledge. By linking scientific concepts to local culture and environments, students not only understand the theory but are also able to apply it in their daily lives. This approach also improves critical thinking and problem-solving skills, which are key components of scientific literacy (Virtič, 2022; Lestari & Setyarsih, 2021). Learning models such as PjBL and STEAM that integrate ethnoscience provide opportunities for students to explore and collaborate within their own cultural contexts (Kamila et al., 2024). Interactive and contextual learning media, such as e-modules and ethnoscience-based picture books, have also been shown to increase interest and motivation in learning (Afnan et al., 2023; Hayandi et al., 2025). This suggests that successful learning depends not only on the model but also on the media used to deliver the material in an engaging and relevant manner (Haleem et al., 2022; Ardiyanti et al., 2019).

The main obstacles identified are the lack of teacher training and the availability of appropriate teaching materials. Teachers unfamiliar with the concept of ethnoscience tend to struggle to integrate local materials into science learning (Afnan et al., 2023). Therefore, ongoing professional training and the development of

accessible ethnoscience-based teaching materials are crucial. Furthermore, curriculum adjustments that allow for the integration of local wisdom will strengthen the implementation of this learning. Involving local communities as learning resources can also enrich students' experiences and strengthen the relationship between schools and their communities (Sakti et al., 2024). The integration of ethnoscience-based learning not only improves scientific literacy but also strengthens cultural identity and national values. This approach aligns with the national education goal of producing a generation that is not only academically intelligent but also possesses a love and appreciation for local culture. Therefore, developing educational policies that support the use of ethnoscience in science learning is crucial to improving the quality of education in Indonesia.

Conclusion

A systematic review of 20 research articles shows that ethnoscience-based learning has been proven effective in improving students' scientific literacy at the elementary and secondary levels. The integration of local wisdom and culture into the science learning process not only improves conceptual understanding and critical thinking skills but also motivates students to be more active and engaged in learning. Learning models such as Project Based Learning (PjBL), STEAM, guided inquiry, and discovery learning that integrate ethnoscience, supported by interactive and contextual learning media, have a significant positive impact on students' learning outcomes and cultural appreciation. Furthermore, this approach is also aligned with the values of Pancasila, strengthening character education and national identity. However, the implementation of ethnoscience-based learning faces several challenges, particularly related to limited teacher training, a lack of contextualized teaching materials, and the need for curriculum adjustments. The relatively short duration of interventions in many studies also indicates the need for further research to examine long-term impacts.

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Conceptualization, resources, writing—original draft preparation, M.K.S.; methodology, visualization, I.W.S.; validation, formal analysis, data curation, writing—review and editing, I.N.T.; investigation, I.W.R. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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