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UNCOVERING THE POTENTIAL OF ETHNOSCIENCE IN SCIENCE LEARNING TO IMPROVE STUDENTS' LITERACY: A SYSTEMATIC-LITERATURE REVIEW (2014–2024)

N. Hikmah[1], Yohandri*[2], F. Arsih[2], M. Azhar[2], A. Razak[2]

[1]Student of Doctoral Program of Science Education, Faculty of Mathematics and Natural Science, Universitas Negeri Padang, Indonesia
[2]Departement of Science Education Doctoral Program, Faculty of Mathematics and Natural Science, Universitas Negeri Padang, Indonesia

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ABSTRACT

Literacy is a crucial 21st-century skill aligned with SDG 4 (Quality Education), yet Indonesian students continue to face challenges, as reflected in PISA 2022 results. Ethnoscience, which integrates local wisdom into science education, offers a promising approach to address this issue. This study presents a systematic literature review of research published between 2014 to 2024 on the use of ethnoscience in science learning and its impact on student literacy. The findings indicate that ethnoscience has been widely applied, particularly at the high school level, through strategies such as project-based learning, inquiry, and STEAM. Ethnoscience contributes to improving scientific, environmental, and cultural literacy by contextualizing science learning and fostering engagement, critical thinking, and cultural awareness. This research synthesizes a decade of empirical evidence on ethnoscience integration in science education, maps the strategies employed, and examines their relationship with students' literacy outcomes. The results suggest that ethnoscience provides a culturally grounded approach that can effectively support the development of science literacy.

Keywords: ethnoscience; literacy; science learning

INTRODUCTION

Literacy is among the 21st-century skills that students must acquire. These skills are essential for preparing students to face today's real world challenges (Shiddiqi, 2024) reflected in the Sustainable Development Goals (SDGs). SDG Goal 4 (Quality Education) aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (Hanemann & Robinson, 2022). Literacy is a fundamental skill for all individuals (Imjai et al., 2025). It defined as the ability to read, write, and comprehend information in order to communicate with others in everyday settings (Leasa et al., 2024; Shiddiqi, 2024).

Effective science learning requires literacy skills, often referred to as science literacy, are necessary. These skills play an important role in enabling students to actively participate in science learning (Jang et al., 2024). Paul deHart Hurd coined the term "science literacy" in 1958, defining it as the purpose of science education (Rudolph, 2023). Science literacy is the ability to understand phenomena, apply scientific knowledge, identify questions, draw conclusions based on genuine evidence, and make judgments (Effendi et al., 2021). It helps students not only grasp scientific concepts but also apply them in everyday situations, as well as improve their problem-solving

***Correspondence Address**
E-mail: yohandri@fmipa.unp.ac.id

ability (Syofyan et al., 2025). Science literacy is necessary for identifying various challenges and difficulties related to science and technology (Putri et al., 2025).

Science literacy involves understanding the relationship between people and their surroundings, and is one of the goals of modern science education (Guerrero & Sjöström, 2024). However, the 2022 PISA (Program for International Student Assessment) results reveal that Indonesia remains ranked 66th, with an average literacy score of 359, 366 in numeracy, and 383 in science (OECD, 2023). These results indicate that Indonesian students' literacy skills remain relatively poor. This is partly due to the fact that the science learning process relies on memorization, is teacher-centered method, and utilizes non-contextualized approaches (Putri et al., 2025). Students with limited literacy skills may encounter challenges in learning, which may limit their participation in science learning (Jang et al., 2024). Therefore, an appropriate solution is required to address students' insufficient literacy skills during the learning process in Indonesia.

Indonesia is a culturally diverse country with a variety of customs and local wisdom. Culture-based learning, such as ethnoscience, is a methodology that can help overcome literacy challenges. Culturally integrated learning has the potential to significantly enhance students' literacy in the context of science education (Tan et al., 2025). Ethnoscience is applied by combining culture, circumstances, and science learning. This is closely linked to the concept of science literacy, where students are encouraged to apply scientific concepts to real-world situations through direct observation, identification of scientific problems, and making conclusions based on actual conditions. (Uslan et al., 2024).

The application of ethnoscience can enhance not only students' literacy skills in learning but also the global literacy of society (Arianingrum et al., 2024). Although students are often engaged in cultural practices in their daily lives, their literacy levels remain limited (Zulirfan et al., 2023), Therefore, to improve student literacy, ethnoscience must be incorporated into the learning process. With this approach, it is hoped that students will improve their literacy skills and while also developing appreciation and concern for the culture around them.

This study is a systematic literature review (SLR). Many scholars have carried out a number of studies on the use of ethnoscience in science learning to enhance students' literacy skills; however, the applications, methodologies, target populations, and reported outcomes vary significantly. As a result, an SLR is necessary to identify patterns and research gaps, as well as examine the diversity of approaches in incorporating ethnoscience into science learning. Beyond mapping existing studies, this review also aims to provide a solid theoretical foundation for future implementations of ethnoscience in enhancing students' literacy skills. To achieve this, the SLR was guided by four central research questions: (1) how research on ethnoscience in science learning has contributed to the improvement of students' literacy skills over the past decade (2014–2024); (2) how ethnoscience has been integrated or implemented within science learning; (3) at what levels of education ethnoscience is most commonly applied; and (4) what roles ethnoscience plays in supporting the development of students' literacy skills within science education.

METHODS

This study is a systematic literature review (SLR) that examines the findings from previous research on the impact of ethnoscience on student literacy. This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria (see Figure 1). PRISMA is used to ensure that the results of a systematic review are reliable, as it initiates a systematic review through the processes of identification, screening or selection, eligibility testing, data inclusion, and ultimately data analysis and presentation (Page et al., 2021).

Table 1. SLR Research Scope based on the PICO Element

Element	Description
Population	Students at different stages of education who participate in the formal science learning (physics, biology, and chemistry) at school.
Intervention	The use of teaching materials or the integration of ethnoscience in the science learning process.
Comparison	Comparing student literacy without using ethnoscience in science learning.
Outcome	Identifying the impact of ethnoscience on science learning and the progress of students' literacy following the learning process.

On identification, each relevant article was collected through a systematic search using PICO (Population, Intervention, Comparison, Outcome) elements to break down the SLR objectives into searchable keywords, thus facilitating the process of formulating research questions (Carrera-rivera et al., 2022). The application of PICO to the research is as follows:

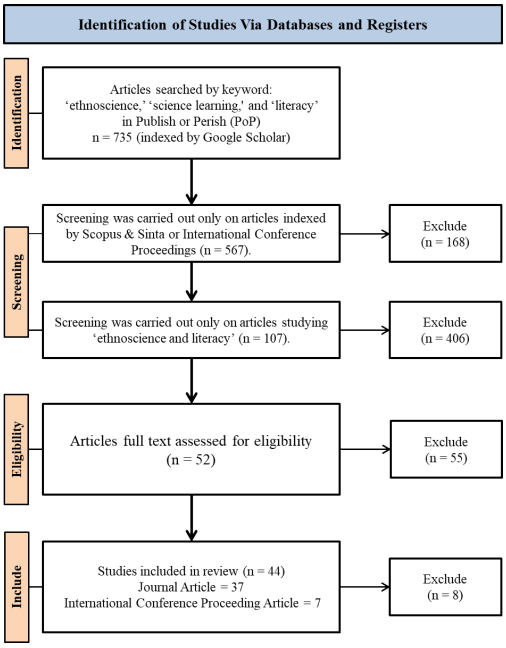

Figure 1. Flow Diagram of PRISMA

Based on the PICO framework, specific keywords were selected to align the search process with the objectives of this SLR, namely *"ethnoscience"*, *"literacy"*, and *"science learning"*. The searches were conducted using the Publish or Perish application across databases including Google Scholar, Semantic Scholar, Scopus, and ERIC. Boolean operators were applied to refine the results, using the following search string:

("ethnoscience") AND ("literacy") AND ("science learning")

("ethnoscience") AND ("literacy")

This process yielded a total of 735 articles in the identification stage before applying the inclusion and exclusion criteria.

The second stage was screening, which ensured that the final analysis contained only relevant and high-quality material. For this reason, the review process required the application of inclusion and exclusion criteria, as well as systematic sorting of material for analysis (Page et al., 2021). These criteria were used to screen the literature collected using the Publish or Perish (PoP) software (see Table 2). After screening, the number of articles that passed the screening was 567 articles remained from the initial stage. Next, each article was evaluated, and 107 articles that met the inclusion criteria were included in the eligibility stage.

In the eligibility stage, articles that passed the initial screening stage were further evaluated by the authors. This stage was conducted to ensure that only the most relevant and high-quality articles were included in the final analysis. The criteria for this stage were: 1) The article discusses the effect of the application of ethnoscience in science learning and its relationship with student literacy; 2) the article is empirical, with data supporting the analysis of the relationship between ethnoscience and student literacy; 3) the article implements the approach or integrates ethnoscience into the learning process or teaching materials in a science education context; 4) the article reports results relevant to the improvement or influence of student literacy; and finally 5) the article has a clear, valid, and reliable methodology for measuring the effect of ethnoscience on student literacy.

By applying the eligibility criteria, 52 articles were found to meet the criteria. After reanalysis, only 44 articles that best meet the eligibility criteria. These consisted of 37 Sinta or Scopus-indexed articles and 7 International conference proceeding articles.

The extracted data were analyzed using content analysis, which enabled the identification of themes and patterns across the selected studies. The analysis focused on several key aspects,

including the distribution of studies by publication year, types of ethnoscience integration, the educational levels where the approaches were applied, and the reported effects on various forms of literacy, such as scientific, environmental, and cultural literacy. To organize and summarize the findings, a frequency and thematic matrix was constructed, supported by visual representations such as bar charts and tables.

Table 2. The Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Publication Timeline	2014-2024	2013 and before
Document Type	Scopus or Sinta-indexed journal articles and conference proceedings articles	Books, book series, chapters in a book, and articles that are not indexed by Scopus or Sinta.
Source Type	Peer-reviewed, open-access journals or conference proceedings	Non-Journal and non-conference proceeding
Nature of the Study	Discusses ethnoscience and literacy	Does not address ethnoscience and literacy

Modification of (Idris et al., 2022)

RESULTS AND DISCUSSION

The review procedure was successfully completed by assessing 44 articles that met the stated criteria using a systematic literature review approach. The articles were examined using research based on the integration of ethnoscience in science learning, the levels of education where ethnoscience has been applied, and the role of ethnoscience in science learning to promote student literacy. Several types of researches have been conducted to evaluate the use of ethnoscience in ehancing student literacy. The collected articles were published between 2014 and 2024. An overview of the distribution of ethnoscience-related research on student literacy during the last decade is presented in Figure 2.

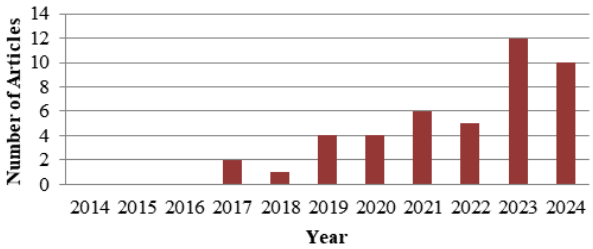

Figure 2. Distribution of Articles by Year (2014-2024)

This figure indicates that there has been an increase in research on the integration of ethnoscience in the science learning process to enchance student literacy. The current science learning process aims to equip students with the skills to apply their knowledge in real-life settings and to understand the phenomena in their environment (Risdianto et al., 2021). Such knowledge can be developed through student engagement with cultural values, which creates opportunities for students to gain authentic, meaningful, and collaborative learning experiences (Patras et al., 2023; Jong et al., 2024).

Ethnoscience is a learning approach that integrates indigenous knowledge and scientific knowledge (Nurcahyani et al., 2021; Perez-Rodríguez et al., 2023). It reconstructs culture and local wisdom into scientific knowledge by describing them through experience, verification, and data reduction (Asiyah et al., 2021; Prabowo et al., 2024). The application of local wisdom in science learning can positively impact on students by enhancing their thinking skills and appreciation of the surrounding culture, ensuring that these cultural values continue to be preserved (Tiro et al., 2024). Thus the application of ethnoscience-based science learning is considered essential in the current educational context (Arjaya et al., 2024).

An overview of 44 studies on the integration of ethnoscience in science education to enhance students' literacy is presented in Table 3.

Table 3. Results of Article Review from Scopus- and Sinta-Indexed Journals

No	Journal Identity	Integrating Ethnoscience in Science Learning	School Level	Role of Ethnoscience in Student Literacy
1	(Dewi et al., 2019)	Learning approach in chemistry	College	Helping students understand learning concepts by connecting them to culture and everyday life.
2	(Solheri et al., 2022)	Learning approach	Junior High School	Creating an environment and activities that align with students' culture as part of the learning process.
3	(Wati et al., 2021)	Science teaching materials based on guided inquiry	Junior High School	Providing students with new experiences in the learning process, allowing them to participate actively.
4	(Sumarni et al., 2017)	Learning approach	College	Improving the quality of learning so that students can analyze and explain chemistry concepts effectively.
5	(Syahmani et al., 2024)	E-module based on problem-based learning	College	Providing instructional materials relevant to the local context, allowing students to understand chemistry in everyday life.
6	(Amalia et al., 2024)	Science literacy assessment	Junior High School	Introducing a new way to incorporate cultural values into science lessons, making science literacy more relevant and engaging.
7	(Setiawan et al., 2023)	E-module based STEM	Junior High School	Building students' teamwork and social skills by promoting mutual respect and understanding.
8	(Pebrianti et al., 2024)	E-module based on problem-based learning	Senior High School	Increasing students' science literacy through the implementation of an integrated ethnochemistry e-module.
9	(Wardani et al., 2024)	Learning approach in chemistry	Senior High School	Making the learning process more contextual, meaningful, and appropriate for students' learning preparedness.
10	(Heliawati et al., 2022)	Learning media in chemistry	College	Connecting learning content to local opportunities to make the learning process more engaging and meaningful.
11	(Aprilia & Lutfi, 2023)	Interactive multimedia	Senior High School	Enhancing students' science literacy through ethnoscience-based multimedia.
12	(Yasir et al., 2022)	Learning approach based on mind-mapping video	Junior High School	Encouraging students to appreciate nature by applying their knowledge and experience from everyday life, while also developing technology.
13	(Nabilah et al., 2022)	Learning approach	Junior High School	Making the learning process more exciting and enjoyable by implementing a systematic and transparent learning method.
14	(Wulansari & Admoko, 2021)	Learning approach	Senior High School	Assisting students in strengthening their scientific knowledge through real-world experiences.
15	(Alim et al., 2020)	Learning approach based on guided inquiry	Elementary School	Encouraging students to actively pursue knowledge.
16	(Hidayah et al., 2024)	Learning approach based on project-based learning	Elementary School	Developing students' science literacy by fostering thinking skills, scientific inquiry, communication abilities, and social awareness.
17	(Rusmansyah et al., 2023)	Learning approach based on project-based learning	Senior High School	Encouraging students to broaden their knowledge, relate scientific concepts to cultural knowledge, and deepen their understanding.

No	Journal Identity	Integrating Ethnoscience in Science Learning	School Level	Role of Ethnoscience in Student Literacy
18	(Sasmita et al., 2024)	Inquiry and STEM integrated e-module	College	Improving students' environmental literacy, as demonstrated by gains in knowledge, attitudes, and skills throughout the learning process.
19	(Amanah et al., 2023)	E-module based STEAM	Senior High School	Addressing students' lack of science literacy in the learning process.
20	(Parmin & Fibriana, 2019)	Learning approach	College	Improving both students' science literacy skills and educators' scientific skills.
21	(Sulistri et al., 2020)	Science pocketbooks	Elementary School	Increasing students' science literacy through the integration of ethnoscience in pocketbooks.
22	(Jihannita et al., 2024)	E-module	Junior High School	Integrating culture relevant to students' daily lives so they can comprehend the information provided.
23	(Citra Ayu Dewi et al., 2021)	Learning approach based on contextual collaborative	College	Assisting students in integrating their knowledge and cultural competency across various fields.
24	(Yuliana et al., 2021)	Learning approach based on contextual	Elementary School	Allowing students to learn more and take an active role in learning.
25	(Hidayanti & Wulandari, 2023)	Learning approach based on problem-based learning	Elementary School	Encouraging students to learn concepts and actively seek solutions to the difficulties they confront, while also gaining new experiences to students.
26	(Bramastia et al., 2023)	Learning approach, along with STEM	Junior High School	Developing students' science literacy across three aspects: science as knowledge, inquiry processes, and the connections between technology and society.
27	(Sanova et al., 2023)	Learning approach based on problem-based learning	Senior High School	Giving students opportunities to be active and think creatively, critically, logically, and openly, making it easier for them to understand the learning material.
28	(Sumarni, 2018)	Learning approach based on inquiry learning	College	Motivating students to solve problems, connect their knowledge, and apply it in relevant situations, while developing critical thinking skills.
29	(Lestari et al., 2024)	Etnobotany, learning approach berbasis model Inquiry learning	Senior High School	Helping students deepen their understanding of natural resources, local wisdom, and environmental protection, thereby allowing them to comprehend the complex relationship between humans and nature.
30	(Socrates et al., 2023)	Learning approach based games	Senior High School	Increasing student participation and facilitating their understanding of learning materials, making physics learning more meaningful.
31	(Muhlis et al., 2023)	Science worksheet	Junior High School	Providing new knowledge and experience through activities that reconstruct community knowledge into scientific knowledge
32	(Mulyono et al., 2024)	Learning approach based on inquiry learning	Senior High School	Maximizing the potential of inquiry-based learning and providing a strong foundation for evidence-based and critical thinking.
33	(Yulyanti et al., 2022)	Physics e-module	Senior High School	Demonstrating the use of an ethnoscience-integrated physics e-module can increase students' science literacy.
34	(Jufrida et al., 2024)	Learning approach based on discovery learning	Junior High School	Connecting students with real-world and everyday events connected to science, and encouraging them to construct and link knowledge with environment reality.

No	Journal Identity	Integrating Ethnoscience in Science Learning	School Level	Role of Ethnoscience in Student Literacy
35	(Andayani, 2020)	Learning approach based on guided inquiry	Senior High School	Improving students chemical literacy, particularly in integrating data and providing scientific evidences.
36	(Muyassaroh & Mukhlis, 2023)	A fairy tale book based on the guided inquiry	Junior High School	Making learning more contextual using scientific methodologies by incorporating local cultural knowledge relevant to students' daily lives.
37	(Hadi et al., 2020)	Learning approach based on discovery learning	Junior High School	Engaging students in scientific activities rooted in local wisdom, helping them recall concepts, understand the material, and connect scientific knowledge with everyday life.
38	(Novitasari et al., 2017)	Learning approach	Junior High School	Transforming science into real-life applications as an effective way to stimulate critical thinking and foster students' curiosity.
39	(Y. R. K. Wardani et al., 2023)	E-worksheet	Junior High School	Enhancing students problem-solving abilities and providing a sense of achievement satisfaction in the learning process.
40	(Rusilowatil et al., 2021)	Science leraning materials	Junior High School	Making it easier for students to comprehend science.
41	(Atmojo et al., 2021)	Learning approach	Elementary School	Using culture to inspire students, expand their imagination and creativity, and deepen their understanding of the subject matter.
42	(Hastuti et al., 2019)	Learning approach based in Inquiry-based learning	Junior High School	Helping students learn and receive indigenous knowledge from communities by conducting scientific research to uncover scientific truths.
43	(Atmojo et al., 2019)	Learning approach	College	Assisting students in recognizing scientific aspects withinin culture that they were previously unaware of.
44	(Juwita et al., 2023)	E-module	Junior High School	Improving students' abilities to comprehend scientific phenomena, interpret scientific data and evidence, and form and evaluate conclusions.

According to the findings of the article review, ethnoscience in the science learning process is primarily used as a learning strategy. Etymologically, ethnoscience is derived from the terms 'ethnos,' meaning nation, and scientia,' meaning knowledge. Thus, the ethnoscience method can be defined as a culture or knowledge possessed by a nation, tribe, or social group that can be integrated into science education (Khusniati et al., 2023; Chibuye & Singh, 2024). Applying the ethnoscience approach in learning allows students to develop a deeper appreciation for their culture enhance their 21st-century skills. (Mulyono et al., 2024). In the context of science education, ethnoscience can be used as ethnophysics, ethnochemistry, and ethnobiology, or culture-based learning combined with physics, chemistry, and biology materials (Gumbo et al., 2021; Chibuye & Singh, 2024; Albuquerque et al., 2024).

In addition to its use as a learning technique, ethnoscience can be incorporated in teaching materials, evaluations, and learning media and used in conjunction with learning models. The development of ethnoscience-based teaching materials helps students to adhere to societal norms or culture (Khusniati et al., 2023). Integrating ethnoscience-based eaching materials can facilitate student comprehension on the subject matter (Bachri et al., 2024), as well enhance students' motivation to learn, since the material presented is closely related to their daily lives, providing meaningful learning (Nisa et al., 2024).

Integrating ethnoscience into assessments can benefit students by developing the cognitive skills they need in the 21st century (Winarto et al., 2022; Quiñonez & Mendoza, 2024). Ethnoscience integrated into learning media is also highly feasible to use (Manurung et al., 2024).

This integration provides an enjoyable learning experience for students as it contains actual and relevant problems through an interactive learning process (Antrakusuma et al., 2023).

Ethnoscience can also be used in science education alongside learning models and STEM. Integrating ethnoscience into learning models, especially in contemporary learning models such as project-based learning, problem-based learning, and inquiry learning, helps students grasp and process material while developing 21st-century skills. Through participation in knowledge building, project creation, problem solving, discovery, and investigation, all of which integrates cultural values in the learning process (Dewi et al., 2021; Hidayah et al., 2024; Sasmita et al., 2024; Jufrida et al., 2024; Syahmani et al., 2024). The combination of ethnoscience and STEM provides a meaningful learning experience by incorporating local knowledge into STEM, which has significant implications for adapting the science curriculum in the learning process, particularly in Indonesia (Sumarni et al., 2022; Izzah et al., 2023). In addition, this integration can foster positive character development and strengthen students' 21st-century skills (Sudarmin et al., 2023).

Ethnoscience is applied across educational levels, from elementary school to college. At the primary level, ethnoscience is taught in an exploratory and experience-based manner, aiming to introduce basic scientific principles through cultural understanding that is relevant to daily lives (Akmal et al., 2021; Patras et al., 2023; Yuliyanti et al., 2024). At the junior high school level, ethnoscience applications require more study and critical reflection, encouraging students to think complexly about the relationship between science and culture (Kasi et al., 2021; Nurhasnah et al., 2022; Jufrida et al., 2024).

The application of ethnoscience in senior high school is similar to that in junior high school. Students are expected to connect scientific theory with real-world practice and analyze the social and ethical consequences of scientific knowledge (Jannah et al., 2022). At the college level, the application of ethnoscience becomes more academic and research-oriented, with students conducting in-depth analysis and contributing to ethnoscience knowledge and its application in a broader context (Parmin et al., 2017; Heliawati et al., 2022; Fitri et al., 2024).

According to the studied publications, ethnoscience is most commonly used in high school settings. This is because at this level, students are encouraged to develop their own areas of expertise. Furthermore, students at this level can understand and analyze the relationship between science and culture. They can also participate in community-based projects, demonstrating that ethnoscience not only improves students' understanding of science but also teaches them to value cultural diversity and local knowledge.

The findings of the 44 analyzed articles suggest that using ethnoscience in science education can boost student literacy. Ethnoscience can help students enhance their literacy in subjects such as science, chemistry, biology, physics, and environmental studies. This occurs because applying ethnoscience to the learning process contextualizes science education. Contextual learning can boost student literacy by connecting science concepts to real-world circumstances, making learning more relevant, and positively impacting students (Suryawati & Osman, 2018; Dewi et al., 2021; Khoudi et al., 2024; Xiao, 2024).

Ethnoscience-integrated science learning combines science material and concepts with local culture and culture around students. This helps students understand the presented material or information because they realize it is relevant and close to their daily lives. Culture-based science learning is another innovation in the science learning process, which enhances students' learning experiences and makes the learning process more meaningful. Students may see that science, physics, chemistry, and biology are very relevant to their daily lives. This learning method can also help children develop a greater awareness of and appreciation for the customs and culture that surround them.

Taken together, the findings suggest that ethnoscience has substantial potential to enhance science literacy by bridging global competencies with local knowledge. Yet, the literature also reveals significant gaps: reliance on descriptive case studies, limited quantitative validation, and insufficient exploration of challenges and limitations. Future research should therefore move beyond documenting positive outcomes to critically evaluating the depth, sustainability, and scalability of ethnoscience integration across diverse educational contexts.

CONCLUSION

This systematic literature review reveals that the integrating ethnoscience in science learning plays a significant role in enhancing students' literacy skills across educational levels. Based on the analysis of 44 empirical studies published between 2014 and 2024, ethnoscience has been widely implemented through teaching models such as inquiry, project-based learning

(PjBL), and STEAM, as well as through culturally relevant teaching materials, multimedia, and assessments.

The findings suggest that ethnoscience is most widely applied at the secondary school level, where students are cognitively prepared to connect scientific concepts with local culture. Its integration supports the development of scientific, environmental, and cultural literacy by fostering contextualized and meaningful learning, increasing student engagement, and promoting critical thinking, cultural awareness, and interdisciplinary understanding.

Results further show that ethnoscience consistently improves literacy outcomes, particularly when combined with student-centered and problem-based learning approaches. The strongest effects are seen at the junior and senior high school levels, although positive effects have also been documented in elementary and tertiary levels. When applied in classrooms, ethnoscience enhances students' understanding of science, makes learning more relevant to their lived experiences, encourages appreciation of local wisdom, and cultivates 21st-century skills.

In conclusion, ethnoscience offers a culturally grounded pedagogical approach that aligns with the goals of SDG 4 (Quality Education) and holds great potential for transforming science education. This review contributes to the field by synthesizing current research, identifying integration patterns, and proposing a framework for future applications of ethnoscience-based science learning.

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