Ethnoscience in the Digital Age: A Systematic Review of Pedagogical Strategies for Scientific and Digital Literacy Development

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Abstract: In the 21st century, achieving proficiency in both scientific and digital literacies is crucial for effective societal participation and addressing complex global challenges. However, a significant cultural disconnect often persists in formal science education, marginalizing students' indigenous knowledge. This systematic literature review aims to investigate the efficacy of ethnoscience-based instruction in bridging this gap and enhancing students' scientific and digital literacies within the Indonesian educational context. Following PRISMA guidelines, a systematic search was conducted in Google Scholar, Scopus, Dimensions, and ERIC. This process identified 28 eligible studies published between 2016 and 2025. Data were analyzed and compared using reported gain scores to evaluate the impact of various instructional interventions. The findings reveal that research in this field is predominantly characterized by Research and Development (R&D) designs (60%), with a primary focus on the secondary school level. The analysis demonstrates that ethnoscience serves as a powerful pedagogical bridge, linking students' local cultural backgrounds to modern scientific concepts. While publications are increasing, a significant disparity exists between the widespread focus on scientific literacy and the emerging, yet underdeveloped, area of digital literacy. Interventions that integrate ethnoscience with digital modalities are effective for general knowledge acquisition but are limited in fostering higher-level scientific attitudes and inquiry when used without a robust pedagogical framework. The results indicate that integrating ethnoscience into established learning models, particularly Project-Based Learning (PjBL) and Problem-Based Learning (PBL), yields significantly more holistic outcomes compared to media-only interventions. These models are uniquely effective in promoting complex competencies, including scientific inquiry, citizenship literacy, and cultural awareness. This study concludes that future pedagogical practices should prioritize structured, model-based integration to fully harness the potential of ethnoscience for comprehensive 21st-century skill development.

Keywords: ethnoscience, scientific literacy, digital literacy, systematic review.

■ INTRODUCTION

Advances in information technology in the 21st century place new demands on society to possess strong scientific and digital literacy. Scientific literacy is crucial for informed decision-making, effective civic discourse, and addressing global challenges such as climate change and public health. International assessments, such as PISA, consistently highlight the need to improve young people's scientific competencies worldwide. (OECD, 2017). However, formal science education, which often focuses on modern science, presents challenges: cultural disconnects and barriers that marginalize students' local and indigenous knowledge (Koehler, 2017). This disconnect prevents students from diverse backgrounds from learning and understanding scientific principles embedded in traditional

practices and cultural contexts, thus hindering the development of their scientific literacy. If science education fails to connect students' perspectives, it will reduce its relevance and effectiveness (Quigley, 2009).

This problem is compounded by the need to integrate digital literacy skills into all modern learning environments. In the educational landscape, knowledge acquisition is inseparable from technology; students must possess the competencies to efficiently and ethically access, evaluate, manage, and use scientific information available in digital environments. (Feerrar, 2019). Therefore, the most effective strategy for improving scientific literacy must simultaneously address cultural gaps by integrating ethnoscience and leveraging digital tools to develop both scientific understanding and technological skills (Sudarmin et al., 2024, 2020).

The urgency of integrating ethnoscience into the digital-age curriculum stems from the increasing phenomenon of "scientism," which often portrays Western modern science as the sole authoritative knowledge system (Nurfaizah et al., 2025; Snively & Corsiglia, 2001). This perspective frequently leads to a cognitive dissonance among students from indigenous or traditional backgrounds, who find their community's centuries-old wisdom dismissed as non-scientific (Handayani et al., 2018). Research suggests that when students perceive a conflict between their cultural identity and classroom content, their motivation for STEM subjects declines significantly (Aikenhead & Michell, 2011). In this context, ethnoscience serves not merely as a cultural flavoring for lessons but as a critical framework that validates students' prior knowledge (Sudarmin et al., 2024). By repositioning indigenous practices, such as traditional fermentation, medicinal herb processing, or local established irrigation systems, as valid subjects of scientific inquiry, educators can foster a more inclusive and contextualized

science classroom. Furthermore, the integration of ethnoscience and digital literacy creates opportunities for digital preservation and cultural revitalization. Students can use digital platforms to document, simulate, and share their local wisdom with a global audience, thereby transforming them from passive consumers of Western digital content into active creators of culturally relevant scientific knowledge.

This systematic literature review aims to answer the question: How does the integration of ethnoscience into science learning affect student achievement, particularly in improving scientific and digital literacy? For a clear and focused literature review, core concepts must first be clearly explained in an educational context. Ethnoscience, sometimes known as indigenous knowledge or traditional ecological knowledge, refers to a body of knowledge, beliefs, and practices that accumulate and evolve through adaptation and are passed down from generation to generation (Kipfer, 2021; Okechukwu et al., 2014). Ethnoscience is a system of indigenous knowledge developed by a particular cultural group to navigate and understand its environment (Sudarmin, 2014). Its primary educational value lies in its ability to make formal science learning relevant and contextual (Zidny & Eilks, 2018). By connecting scientific principles to familiar, real-world phenomena found in local cultures, ethnoscience acts as a bridge that increases student engagement and fosters deeper conceptual understanding (Sudarmin et al., 2025; Zidny et al., 2020).

Here, scientific literacy is defined as the ability to use scientific knowledge, formulate questions, and draw evidence-based conclusions to understand and inform decision-making about the world and the changes it undergoes as a result of human activity (Bybee et al., 2009; OECD, 2023). Following an international framework, scientific literacy encompasses more than mere factual recall; it involves understanding scientific

concepts, interpreting data, engaging in scientific reasoning, and critically evaluating scientific information encountered in everyday life. Scientific literacy is a set of skills necessary for people to function effectively in a technologically and scientifically complex world (Kumar & Choudhary, 2025). Finally, in the context of this review, digital literacy is the ability to use digital technologies, communication devices, and networks to access, manage, integrate, evaluate, and create information (Feerrar, 2019; Reddy et al., 2023). For students, digital literacy encompasses not only the operation of hardware and software but also the critical assessment of the validity and credibility of digital sources, the effective communication of scientific ideas through multimedia, and the safe and ethical participation in online learning communities. When applied to science education, digital literacy enables students to document ethnoscience, analyze global scientific data, and utilize virtual devices for experiments, transforming the learning process.

Despite the recognition of the relevance of culture and digital competency in contemporary education, critical gaps remain in the existing literature. In a review by Fahrudin et al. (2023), 151 publications on ethnoscience research in education from 2013 to 2022 were examined to examine the field's development and trends. It found that literacy, specifically scientific literacy, was cited as a factor influencing the implementation of ethnoscience in science classrooms. The review, however, did not further explore studies that measured the impact of ethnoscience on scientific literacy; it only noted the rationale for this focus, namely Indonesia's low PISA scores on the global stage. Another comprehensive review was reported by Jannah et al. (2023), who examined 153 publications from 2008 to 2023 retrieved from the Scopus database. In the discussion section, it was noted that ethnoscience is a trend that teachers must facilitate to enhance students' scientific literacy

and conceptual understanding of social issues. The latest bibliometric analysis by Yuliana et al. (2025) identified scientific literacy in thematic development and keyword trends and noted that it was enriched by ethnoscience.

The wealth of literature reviews indicates that ethnoscience is of high interest to researchers in Indonesia, but few examine its specific impact on scientific and digital literacy. Several studies have investigated the positive relationship between the inclusion of ethnoscience and improved student scientific literacy. Similarly, substantial research exists on how digital tools enhance scientific understanding and develop independent digital skills. However, there is a significant lack of a systematic, synthesized body of knowledge that explicitly addresses the interaction among these concepts.

Research Questions

For a focused review and analysis, research questions are devised. The research questions for this review are:

RQ1. What are the general trends and characteristics of the literature on ethnoscience research in scientific and digital literacy, based on publication metrics from 2016 to 2025?

RQ2. What specific pedagogical models and digital modalities are most frequently employed and reported as effective in concurrently developing both scientific literacy and digital literacy through an ethnoscience approach?

RQ3. What are the prominent keywords and topics in the literature concerning the impact of ethnoscience-based learning on scientific and digital literacies?

RQ4. What is the reported impact of an ethnoscience-based learning context on the development of students' scientific and digital literacy skills?

RQ5. To what extent has the integration of ethnoscience in science education been shown to improve students' scientific and digital literacy outcomes, specifically focusing on gains in core conceptual understanding and competencies?

■ **METHOD**

Research Design

This research employs a systematic literature review (SLR) to address the research questions. SLR is chosen for its rigorous methods for searching, narrowing, and selecting studies from the available records using predetermined inclusion and exclusion criteria (Littell et al., 2008). For a more concise SLR workflow, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement was used. The PRISMA statement provides a 27-item checklist for reporting systematic reviews and a comprehensive four-stage workflow for the selection process (Page et al., 2021). Meanwhile, the selection process comprises identification, screening, eligibility assessment, and inclusion. In identification, a strategic search in several academic databases is done using a set of keywords. Later, in the screening stage, records are judged based on the title or abstract. Invalid records (e.g., empty queries, duplicates) are removed prior to screening; this also includes records that are outside the preferred timeframe, language, or publication type. Records that pass screening are sought for retrieval and evaluation as full-text reports; not all records may be retrievable. Lastly, the retrieved full-text reports are assessed for eligibility according to the inclusion and exclusion criteria. Reports that satisfied all of the criteria are included for subsequent analysis.

Search Strategy

The databases used in this review were Google Scholar, Scopus, Dimensions, and ERIC (Education Research Information Center). Boolean operators (OR and AND) were employed with the following keywords: ("ethnoscience" OR "ethno-science") AND ("science literacy" OR "scientific literacy" OR "digital literacy"). Of these, only the Google Scholar search was conducted using Harzing's Publish or Perish, while the rest were conducted directly on the site. The resulting dataset was exported as a Comma-Separated Values (.csv) file for subsequent selection.

Inclusion and Exclusion Criteria

The primary aim of this review is to examine the impact of ethnoscience-based learning or modalities on scientific and digital literacies. Therefore, it is paramount that ethnoscience be the primary focus of the intervention under study, although it may be integrated with various learning strategies or media. Studies that do not utilize ethnoscience as the focus are excluded. Furthermore, all included papers must measure scientific literacy and/or digital literacy as primary or among the learning outcomes (Table 1).

Regarding the type of publication, peer-reviewed original research papers or proceedings are preferred. Review papers (including book reviews, systematic literature reviews, or meta-analyses) are excluded to avoid the regurgitation of secondary data. Non-peer-reviewed publications, such as unpublished theses or grey papers, are also excluded. Included studies are required to be published in English for ease of access and synthesis by the research team and must have appeared within the last decade. Regarding the research approach, any approach (e.g., quantitative, qualitative, mixed methods) is included.

All datasets were pooled into a single spreadsheet for the selection process. The steps follow the PRISMA four-stage workflow: starting with eliminating duplicates and empty queries, and then identifying unfit records based on criteria.

Table 1. Descriptions of the inclusion-exclusion criteria

Criteria	Inclusion	Exclusion
Research aims	Must investigate the use, integration, or application of ethnoscience in a formal or non-formal learning setting.	Does not contain ethnoscience-based learning
Outcomes or measurements	The study must explicitly measure or discuss an outcome related to either scientific literacy (e.g., conceptual understanding, scientific skills) OR digital literacy (e.g., technological fluency, information evaluation skills).	Does not measure scientific or digital literacy
Type of publications	Original research articles, proceedings	Review articles, theoretical papers, grey papers, opinion pieces, editorials, book reviews, or (e.g., other SLRs, meta-analyses).
Research approach	Quantitative, qualitative, mixed-methods, R&D	Not applicable
Time period	Published between 2016 and 2025	Older than 2016
Language	English	Other than English
Accessibility	Open access or can be retrieved by institution access	Paywalled with no possible institution access

Papers that can be retrieved and are eligible after careful assessment are imported into the reference manager.

Data Extraction and Analysis

Data extraction was conducted using a detailed spreadsheet to capture relevant metadata and results from each study. The fields included: first author name; year of publication; journal name and index value (e.g., Scopus quartile or SINTA accreditation); affiliated region; research approach and design; data collection methods; and participants' level of education. Additionally, the table records, if applicable, the learning models & modalities used, the selected ethnoscience topics and science-adjacent topics, the sample size, the reported score (mean and standard deviation), and the normalized gain (g).

Studies included in this review were primarily based on two criteria to ensure the reliability of the source material. First, only papers published in peer-reviewed journals (national journals included) were eligible. Second, to balance reliability with comprehensiveness, the review included papers from both Scopus-indexed journals and journals indexed by other major institutions (e.g., Dimensions, DOAJ, ERIC). These criteria were imposed to prevent worthy studies from national authors that are not published in Scopus-indexed journals.

Limitations and Bias

This review considered only peer-reviewed studies published in English that appeared within the last ten years. This approach introduces a limitation, as it likely excludes valuable, insightful studies that were unpublished, written in another language, or published prior to the search cutoff. Furthermore, limiting the search to only four databases may have resulted in missing relevant studies indexed in other databases, therefore contributing to index bias and potentially biasing the representation of the current scholarly landscape on the topic.

■ RESULT AND DISCUSSION

RQ1. General Trends and Characteristics

The identification process was conducted on October 13, 2025, yielding 399 records from Google Scholar (315), Dimensions (70), Scopus (8), and ERIC (6). Records were then screened to remove duplicates, empty queries, and non-English records, reducing the total to 325. A screening based on title and abstract eliminated 283 and 3 records, respectively. A total of 39 records were checked to retrieve the full documents; however, 2 reports could not be retrieved due to either a broken link or paywalling. Among the retrieved 37 papers, 7 we considered not relevant to the topics, 1 was an unpublished thesis, and 1 was published in a discontinued journal. Thus, 28 studies were deemed eligible and included in the analysis and review.
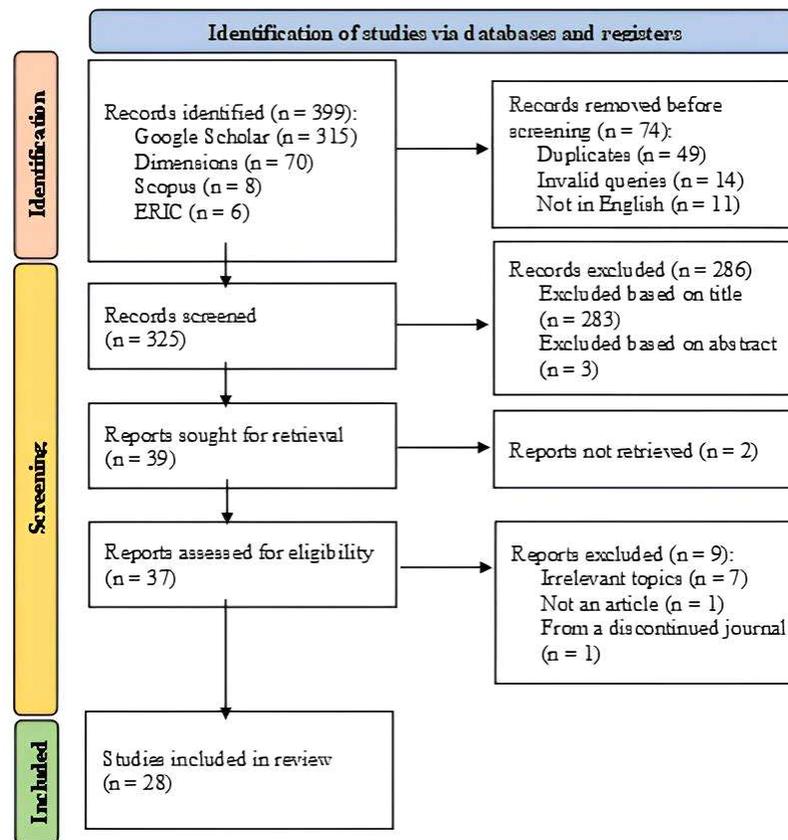

Figure 1. PRISMA flow diagram for the search and selection process

Table 2. Overview of the studies included in the review

ID	Author	Journal and Index Value	Approach	Design	Data Collection	Level of Education
1	Herayanti et al. (2025)	*Jurnal Kependidikan* (SINTA 2)	R&D	4D model	Test, questionnaires	Higher education
2	Imron et al., 2025	*Jurnal Inovasi Pendidikan IPA* (SINTA 2)	Quantitative	Quasi experiment	Test	Secondary school (Middle)

| 3	Kholifah, Yulina, & Gusman (2025)	Engineering Headway (Indexed)	Quantitative	Quasi experiment	Test, questionnaires	Secondary school (High)
4	Nurkhasyanah, Khafid, & Nuswowati (2025)	International Journal of Research and Review (Indexed)	R&D	4D model	Test, questionnaires	Elementary schools
5	Putri, Sudarmin, & Prasetya (2025)	International Journal of Active Learning (SINTA 4)	R&D	4D model	Test, questionnaires	Secondary school (Middle)
6	Rahmalia, Sudarmin, & Ellianawati (2025)	Unnes Science Education Journal (SINTA 3)	R&D	4D model	Test, questionnaires	Secondary school (Middle)
7	Safitriani et al. (2025).	Journal of Physics Education and Science (Indexed)	R&D	ADDIE	Test, questionnaires	Secondary school (Middle)
8	Amalia, Ilhami, Fuadiyah, & Kusumanegara (2024)	*Pedagogik Jurnal Pendidikan* (SINTA 4)	R&D	Educational Design Research	Test, questionnaires, interview	Secondary school (Middle)
9	Arianingrum, Wahyuni, & Rusdianto (2024)	International Journal of Social Learning (SINTA 2)	R&D	ADDIE	Test, questionnaire	Non-formal
10	Bahari, Zurweni, & Hariyadi (2024)	Formatif Jurnal Ilmiah Pendidikan MIPA (SINTA 2)	R&D	Lee & Owens model	Test, questionnaires, interview	Secondary school (Middle)
11	Jihannita, Fadly, Ekapti, Luthfiana, & Widowati (2024)	Journal of Innovation in Educational and Cultural Research (SINTA 1)	R&D	Borg & Gall method	Test, questionnaire	Secondary school (Middle)
12	Jufrida, Kurniawan, & Basuki, 2024)	International Journal of Evaluation and Research in Education (Q3)	Mixed-methods	Exploratory sequential mixed methods	Interviews	Secondary school (Middle)
13	Jumanto et al., (2024)	International Journal of Research and Review (Indexed)	R&D	4D model	Question-naire	Elementary schools

14	Mufrihah et al. (2024).	Unnes Science Education Journal (SINTA 3)	R&D	ADDIE	Test, questionnaire	Secondary school (Middle)
15	Umrotin, Listyorini, Gofur, & Sumberartha (2024)	AIP Conference Proceedings (Indexed)	R&D	Lee & Owens model	Test, questionnaire	Higher education
16	Yasir, Annuria Auliya Rahma, Mubarok, & Zakaria (2024)	Indonesian Journal of Science and Education (SINTA 2)	Quan-titative	Quasi-experiment (Pre-experimental)	Test	Secondary school (Middle)
17	Munawaroh, Sunandar, & Qurbaniah (2023)	Jurnal Pendidikan Biologi Indonesia (SINTA 2)	R&D	4D model	Questionnaire, interview	Secondary school (Middle)
18	Rusmansyah, Leny, & Sofia (2023)	Journal of Innovation in Educational and Cultural Research (SINTA 1)	Quan-titative	Quasi experimental	Test, questionnaire	Secondary school (High)
19	Wardani, Sunyono, & Viyanti (2023)	Advances in Social Science, Education and Humanities Research (Indexed)	R&D	4D model	Test, questionnaire	Secondary school (Middle)
20	Mahyuny, Nursamsu, Hasruddin, & Muslim (2022)	*Jurnal Penelitian Pendidikan IPA* (SINTA 2)	R&D	Unspecified	Question-naire	Secondary school (High)
21	Yasir, Aushia, & Parmin (2022)	*Jurnal Penelitian Pendidikan Sains* (SINTA 3)	Quan-titative	Quasi-experiment (Pre-experimental)	Test, questionnaire	Secondary school (Middle)
22	Atmojo, Lukitoaji, & Muhtarom (2021)	Journal of Physics: Conference Series (Q4)	Quan-titative	Quasi experiment	Test	Elementary schools
23	Dewi, Erna, Martini, Haris, & Kundera (2021)	Journal of Turkish Science Education (Q2)	Quan-titative	Quasi-experiment (Pre-experimental)	Test	Higher education
24	Rusilowati, Sundari, & Marwoto (2021)	Journal of Physics: Conference Series (Q4)	R&D	Borg & Gall method	Question-naire	Secondary school (Middle)

25	Ariyatun, Sudarmin, & Triastuti (2020)	Proceedings of the 5th International Conference on Science, Education and Technology, ISET 2019 (Indexed)	Quan-titative	Descriptive	Test	Secondary school (High)
26	Sulistri, Sunarsih, Utama, & Moseki (2020)	Journal of Education, Teaching, and Learning (SINTA 3)	R&D	ADDIE	Test, questionnaires, interview	Elementary schools
27	Atmojo, Kurniawati, & Muhtarom (2019)	Journal of Physics: Conference Series (Q4)	Quan-titative	Quasi experiment	Test, questionnaire	Higher education
28	Fitria & Wisudawati, (2018)	International Journal of Chemistry Education Research (SINTA 4)	R&D	Borg & Gall method	Question-naire	Secondary school (High)

Research Publications by Year

Figure 2 illustrates the temporal trend in published papers concerning the impact of ethnoscience-based learning on scientific and digital literacies. The data reveal a clear upward trend in publications over the observed period, despite minor annual fluctuations. The first publication appeared in 2018 (Fitria & Wisudawati, 2018), marking the beginning of this research interest. A period of considerable growth continued until 2021, followed by a slight decrease in 2022. The most significant expansion occurred from 2023 to 2024, peaking in 2024 with eight published papers. The small decline observed in 2025 is likely attributable to the fact that 2025 current, ongoing year of data collection.
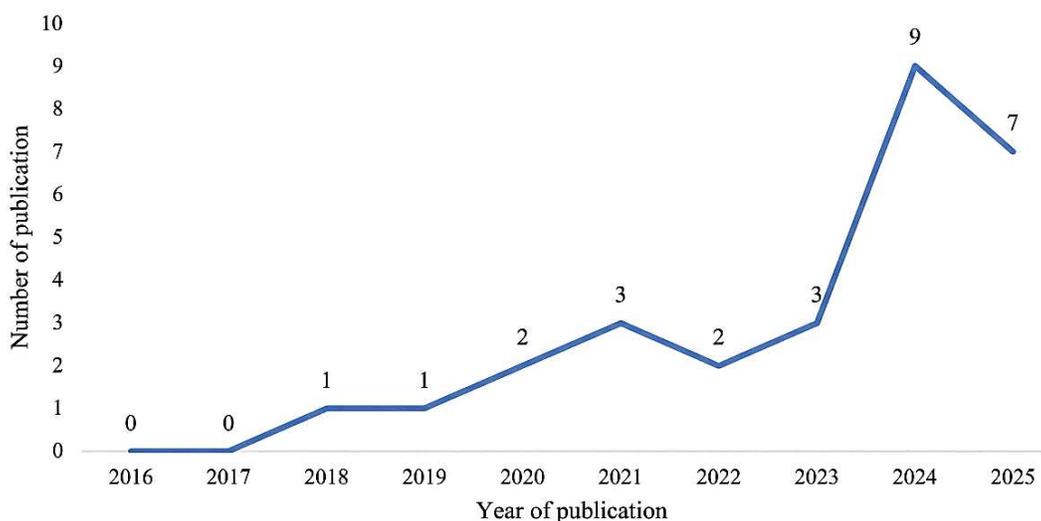
Figure 2. Number of publications by year (2016-2025)

Geographical Distribution and Implications for External Validity

All of the included studies originated from Indonesia (Figure 3). The research exhibits a strong regional concentration, with over one-third (9 publications) of the ethnoscience and literacy research originating from Central Java. Universitas Negeri Semarang is the most prominent institution in this region. Yogyakarta and East Java each contributed 4 publications, which were led by Universitas Negeri Surabaya and Universitas Negeri Yogyakarta, respectively. Following this, West Kalimantan, East Nusa Tenggara, and Jambi each contributed 2 publications. The remaining regions, Riau, Aceh, South Kalimantan, Lampung, and another publication from East Java, accounted for one publication each.

This finding reveals a large geographical concentration. While this highlights the popularity of ethnoscience research interest in Indonesia, primarily due to its cultural diversity, it questions the generalizability of the results. Ethnoscience, by definition, is deeply rooted in local wisdom and specific sociocultural contexts (Snively & Corsiglia, 2001). Therefore, the high efficacy reported in these studies regarding scientific and digital literacies must be interpreted within the Indonesian educational framework. The efficacy of integrating batik motifs or local agricultural practices into science curricula, for instance, may not yield identical outcomes in different cultural settings (e.g., in Africa or Latin America) without significant contextual adaptation.

Furthermore, the homogeneity of the data source affects the external validity of the conclusions. While the synthesis provides a robust model for "Indigenous Ethnoscience" in Southeast Asian contexts, it cannot yet be claimed as a universal global standard. Future research should prioritize cross-country collaborations or comparative studies to investigate whether the ethnoscience-literacy nexus holds true across diverse geographical and educational systems. Acknowledging this limitation is crucial to prevent "contextual overgeneralization" and to encourage broader international exploration of ethnoscience.

Figure 3. Distribution of authors' affiliation region by province

Distribution

The quality assessment and index data reveal a diverse distribution among the 28 studies (Figure 4). A small but significant portion of the literature, four papers (16%), was published by reputable international publishers and were indexed by Scopus (ranging from Q2 to Q4). Two of these papers are published as proceedings, which are from the Journal of Physics: Conference Series. The majority of the research, 16 papers (60%), was published in nationally-accredited journals by the Science and

Technology Index (SINTA). The highest share in this group was at the SINTA 2 level, accounting for almost half of the category, whereas the lowest-level papers were at the SINTA 4 level. The remaining papers are all peer-reviewed but indexed by non-ranked bibliographic databases, such as DOAJ, Scilit, or CrossRef.

The included studies primarily focused on participants from the secondary education level (Figure 4), underscoring a concentration of ethnoscience-based learning research at this stage. Specifically, middle school participants accounted for the largest segment of the literature, featuring in 14 of the 28 papers. High school participants followed with 5 papers, reinforcing the strong emphasis on secondary schooling. Research involving elementary school students was addressed in 4 publications, indicating a moderate level of focus at the foundational level. Studies conducted at the higher education level (college/university) were limited to 4 papers, and only 1 involved participants from a non-formal educational setting.

All included studies were empirical; no conceptual or theoretical research was identified. The Sankey diagram (Figure 6) presents the exact
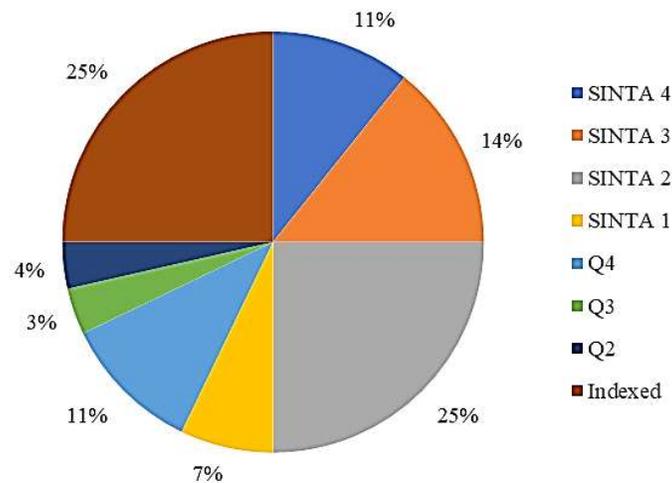

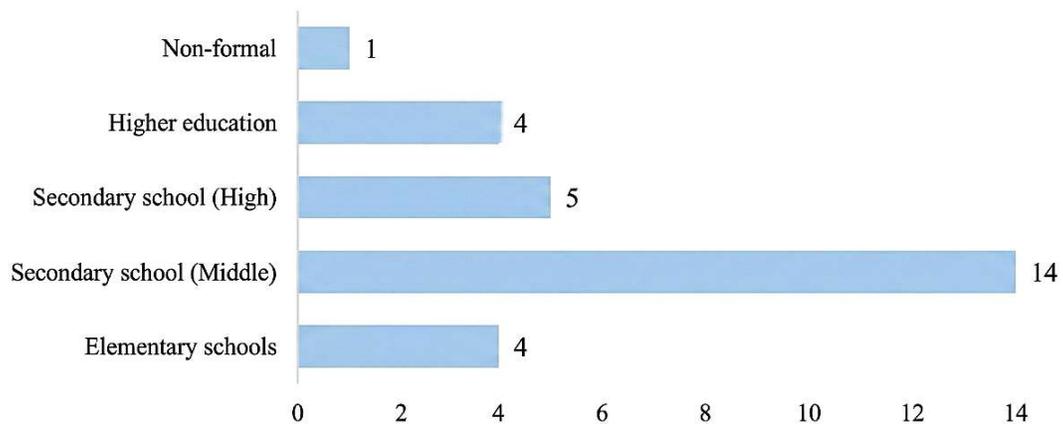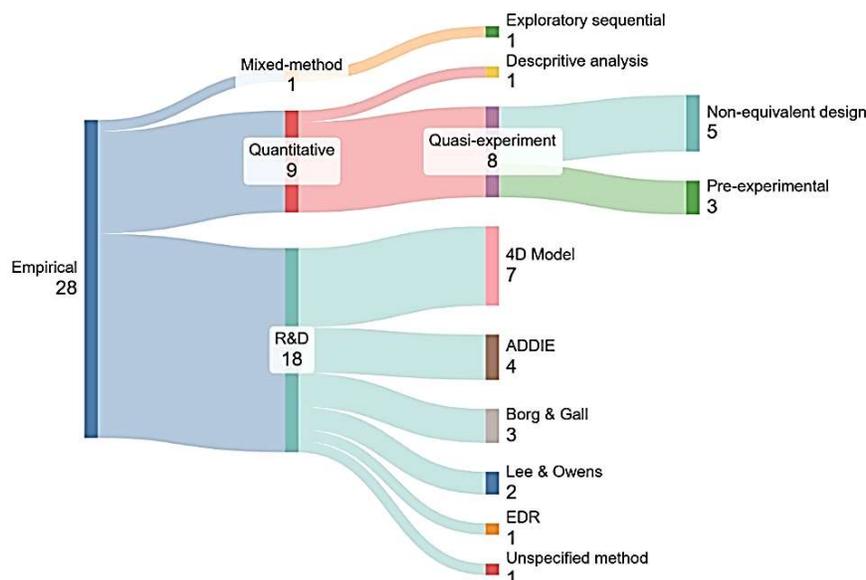**Figure 4.** Distribution of journals by index

Figure 5. Distribution of publications based on the target participants' level of education

distribution. The papers primarily utilized a Research and Development (R&D) approach, which accounted for the largest share of the literature with 17 papers. In the R&D studies, a variety of models were employed, with Thiagarajan's 4D model being the most frequently used (6 papers), followed by the ADDIE model (5) and the Borg & Gall model (3). The remaining R&D studies employed the Lee & Owens model and Educational Design Research; one study did not specify its exact model. The second largest share was quantitative research (9 papers). Of these, seven employed an experimental or quasi-experimental design. Specifically, four studies utilized a non-equivalent control group design, and three used a pre-experimental design. Only one paper utilized descriptive quantitative analysis. Lastly, one paper employed a mixed-methods approach, specifically an exploratory sequential design in which qualitative data collection preceded quantitative data collection.

The dominance of R&D approaches gives insight into the current landscape of ethnoscience research in Indonesia. This trend suggests that the field is currently leaning toward a 'product-oriented' phase, in which researchers' primary objective is to bridge the gap between abstract indigenous knowledge and formal classroom

instruction by producing teaching materials, modules, or digital tools (Wang et al., 2023). However, this pragmatic focus comes with certain exchanges. This reliance on R&D models indicates a preference for 'pedagogical engineering' over in-depth theoretical exploration on why ethnoscience-based instruction can improve scientific and digital literacies among learners on cognitive levels (Ramli et al., 2025). While these studies are important for providing teachers with ethnoscience-based learning resources, there is a noticeable gap in understanding how ethnoscience fundamentally alters students' cognitive structures and how it interacts with sociocultural backgrounds. For example, one might explore: to what extent does ethnoscience-based learning reduce cognitive load by providing cultural scaffolding for scientific phenomena, or how does the efficacy of ethnoscience-based learning differ between homogenous and heterogeneous classrooms? One review also stated a similar recommendation for cross-cultural studies to validate the transferability of the findings in ethnoscience studies (Ali et al., 2025)

Regarding data collection methods, a combination of two or three instruments was frequently used in the literature. The most common

Figure 6. Sankey diagram of research type, approach, and design

Figure 7. Distribution of articles by data collection methods

combination, appearing in 14 papers, was the use of a test alongside a questionnaire. This trend is largely attributable to the high number of Research and Development (R&D) studies identified, which typically comprise two distinct stages: validation (assessed using validity or practicality questionnaires) and effectiveness (assessed using pre- and post-tests). Additionally, interviews were employed in three studies to complement the main instruments, primarily to obtain in-depth insights and feedback on the developed end product. All papers that conducted a formal effectiveness study, thereby measuring learning outcomes, utilized a test (as noted in the analysis of quantitative papers). Studies that did not incorporate a test generally focused only on the design and validation stages of the development process. The only mixed-methods study used a specific combination of interviews and tests as its core data-collection instruments.

RQ2. Keywords and Topics Analysis

Identifiers from the selected studies are entered into VOSviewer to identify keyword co-occurrences in the titles and abstracts. The network visualization map (Figure 8a) depicts the interconnection of the identified terms. In contrast, the density visualization map (Figure 8b) reveals the structure and concentration of the literature, with color intensity (from deep purple to bright yellow) indicating the frequency of co-occurring keywords. The map is anchored by a prominent, highly dense hotspot (yellow) at the center, confirming that the central theme of the research centers on the core concepts of 'ethnoscience,' 'student,' 'research,' and 'study'. This indicates that the body of work is heavily focused on empirical investigations into the application or impact of ethnoscience content and methods, with the student serving as the primary subject of these studies. Terms such as 'test' and 'scientific

a   b

Figure 8. Co-occurrences of keywords in (a) network and (b) density visualization maps

literacy' are closely embedded within this core, establishing them as key outcome variables linked to the central ethnoscience research agenda.

The map identifies two major adjacent clusters extending from the central core, representing specific stages of the research process and the intended outcomes. The cluster extending toward the right-center is dominated by terms related to educational design and effectiveness assessment, including 'development,' 'teaching material,' 'R&D,' 'effectiveness,' 'validity,' and 'questionnaire'. The proximity of these terms suggests a strong methodological focus on the creation and evaluation of new educational products. This cluster confirms that the primary goal of the studies is the development of materials and the subsequent measurement of their effectiveness using validation instruments such as questionnaires, aligning closely with the dominance of the R&D approach noted in the methodological section. Simultaneously, this cluster implies theoretical stagnation. The dominance of 'effectiveness' and 'R&D' suggests that researchers continue to prioritize the usability of their ethnoscience products over the fundamental theory of how these products improve students' literacy (Ali et al., 2025).

Conversely, the cluster located in the upper-left quadrant features terms related to specific inputs, contexts, and supporting actors. This cluster includes concepts like 'problem,' 'learning,' 'science,' 'medium,' 'product,' 'teacher,' and 'characteristic'. Although less dense than the core, this grouping highlights the surrounding elements necessary for implementing the research: identifying a problem in learning science, using specific instructional media or products, and involving the teacher and various experts (e.g., a materials expert and a media expert). Overall, the density visualization strongly demonstrates that the literature is not only focused on the 'ethnoscience' concept but is defined by an intervention-based research strategy centered on student outcomes and the development of learning tools.

RQ3. Models and Modalities

The models and modalities used in teaching ethnoscience are presented in a sunburst chart (Figure 9). Analysis of the chart indicates a strong preference for digital modalities in implementing ethnoscience-based learning, which accounts for the largest proportion of the reviewed studies. This prevalence implies a significant effort to modernize instruction and directly address the development of digital literacy as a key outcome. The use of digital tools is varied but centers on content delivery and activities. Digital reading materials constitute the largest share, indicating a high reliance on digital texts. Furthermore, the extensive use of electronic worksheets and electronic modules highlights the conversion of traditional resources into digital formats. Finally, the inclusion of modern tools such as learning videos and augmented reality (AR) suggests that researchers are exploring interactive and immersive experiences to integrate ethnoscience concepts.

Regarding models, ethnoscience content is typically embedded within established, student-centered pedagogical frameworks. Project-based learning (PjBL) was the most frequently identified model, followed closely by problem-based learning (PBL). The preference for these models aligns well with the experiential nature of ethnoscience, which often draws on local culture and knowledge to address authentic, real-world tasks. Furthermore, one study employed thematic learning as its strategy, organizing instruction around a central theme to integrate ethnoscience concepts. Another distinct approach identified was contextual collaborative learning, which specifically leveraged ethnoscience as the educational context while emphasizing social and group effort in the learning process.

**Figure 9.** Sunburst chart of the identified models and modalities

Despite widespread digital integration, traditional modalities and general teaching materials still have, albeit smaller, a presence, confirming that conventional resources remain essential. Within this category, books and modules form the core of the traditional instructional materials. This ongoing focus on creating and adapting various teaching materials reinforces the finding that the production of physical resources remains a key activity in ethnoscience research, often directly linked to the R&D approach prevalent in the literature.

RQ4. Reported Impacts

The measured impacts on literacies are presented quantitatively as normalized gains, which indicate the average learning effectiveness across studies. These results are visually summarized in a bar graph (Fig. 10) and a heatmap (Fig. 11). Based on aggregate value, the majority of the studies reported gains in the high category: both studies in digital literacy and nine studies in science literacy. The remaining studies reported medium gains. The study designs used to measure these impacts varied, necessitating different interpretations of the gains. When analyzing the outcomes, a clear division emerged between studies that used control groups and those that employed single-sample designs. Studies employing quasi-experimental designs (or micro-research in R&D) provided the most reliable evidence of the efficacy of ethnoscience. In these controlled environments, where ethnoscience instruction was compared against traditional methods, the reported gains remained significant. For instance, Atmojo et al. (2019) reported high (0.81) and low (0.15) gains in the experimental and control groups, respectively, suggesting that the ethnoscience intervention was specifically the driver of literacy improvement.

Some studies focused solely on the effectiveness of the intervention, using a single sample group (pre-experimental design or small-group trial). Conversely, studies utilizing pre-experimental designs or small-group trials (n = 12), while reporting impressive results, must be interpreted with caution. These single-group designs lack a baseline for comparison, making
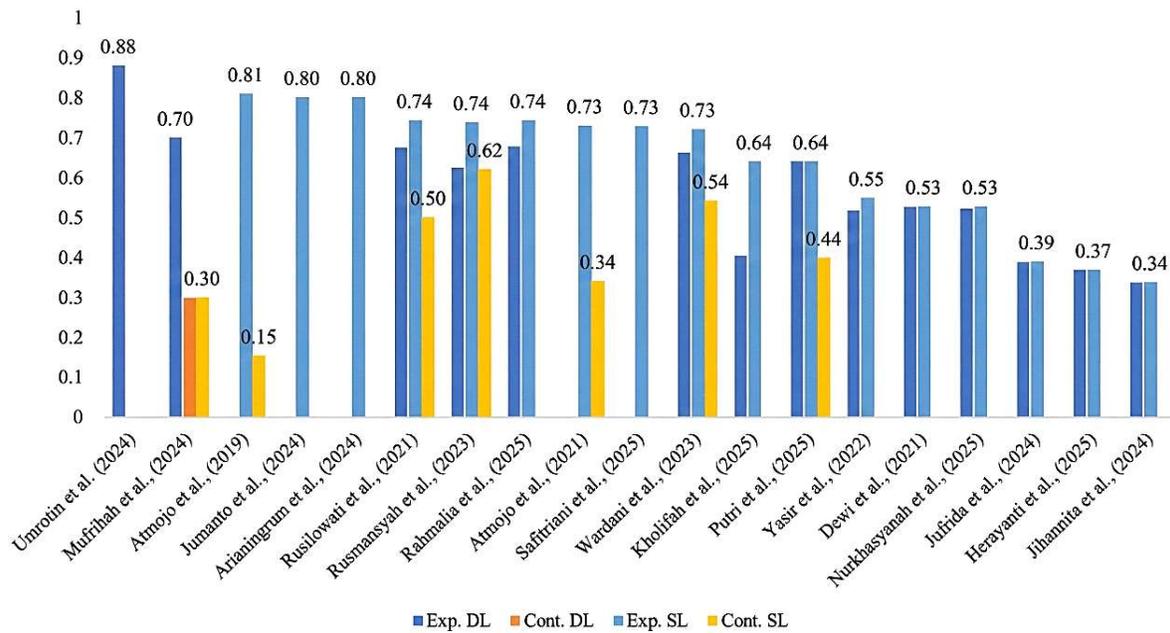
Figure 10. Reported gain in each study

Study	Overall	Category 1	Category 2	Category 3
Rusilowati et al., (2021)	High	High	Medium-High	High
Rusmansyah et al., (2023)*	High	High	Medium-High	High
Safitriani et al., (2025)	High	Medium-High	High	High
Putri et al., (2025)	Medium-High	Medium-High	Medium-High	High
Yasir et al., (2022)	Medium-High	Medium-High	Medium-Low	Medium-Low
Wardani et al. (2023)**	High	Medium-Low	Medium-Low	Medium-Low
Dewi et al., (2021)	Medium-High	Medium-Low	Medium-Low	Medium-High
Herayanti et al. (2025)*	Medium-Low	Medium-Low	Medium-Low	Medium-Low
Atmojo et al., (2019)	High			
Atmojo et al., (2021)	High			
Rahmalia et al., (2025)	High			
Jumanto et al., (2024)	High			
Arianingrum et al., (2024)	High			
Nurkhasyanah et al., (2025)	Medium-High			
Kholifah et al., (2025)	Medium-High			
Jihannita et al., (2024)	Medium-Low			
Jufrida et al., (2024)	Medium-Low			

*) Data were interpolated based on bar chart

**) Results for each indicator were reported in average value, not gain. Relative scale was used

Figure 11. Heatmap of reported gain in each indicator

it difficult to isolate the ethnoscience effect from other pedagogical variables. Nine studies reported high gains (g e" 0.70), with the highest values of 0.88 and 0.81 (Atmojo et al., 2019; Umrotin et al., 2024). Meanwhile, seven studies reported a medium gain (0.3 d" g < 0.70) in literacies, with the lowest value in this category being 0.34 (Jihannita et al., 2024).

Meanwhile, the heatmap provides more detail on each indicator of science literacy for studies for which data are available. However, not all studies provide clear gain values for each indicator; for instance, Rusilowati et al. (2021) report a total N-gain value but only average scores for the indicator, whereas Rusmansyah et al. (2023) present a complete breakdown of scores for each group but present them in a bar chart. Thus, data interpolation and relative comparison are used for the sake of the analysis. The categories for N-gains and average scores are high (> 0.70 or > 75), medium-high (0.50-0.69 or 51-75), medium-low (0.30-0.49 or 26-50), and low (< 0.30 or < 25). The indicators were grouped for easier visualization and comparison: Category 1 comprises indicators related to scientific phenomena, Category 2 comprises indicators for evaluating and designing scientific inquiry, and Category 3 comprises indicators for interpreting data and evidence. The results are shown in Figure 10.

Several key trends emerge regarding the effectiveness of ethnoscience-based learning on students' scientific literacy. Most notably, there is a dominant trend toward success in Categories 1 and 3, with the majority of studies, such as those by Rusilowati et al. (2021), Rusmansyah et al. (2023), and Safitriani et al. (2025), achieving "High" performance levels. This suggests that integrating local wisdom effectively bridges abstract scientific concepts with students' cultural familiarity, particularly in identifying ideas and drawing fact-based conclusions. However, a consistent performance gap is observed in Category 2, which consistently receives "Medium-High" to "Medium-Low" ratings across studies, including those by Yasir et al. (2022) and Dewi et al. (2021). This indicates that, while ethnoscience is effective for conceptual and data-driven understanding, students still struggle with higher-order tasks such as designing scientific procedures and evaluating investigations.

Gaps in ethnoscience impact on digital literacy

Scientific literacy has been a primary concern in ethnoscience research in Indonesia for the past decade, whereas digital literacy is relatively recent. Of the 28 included studies, only two explicitly attempted to design an ethnoscience-based intervention to improve digital literacy. A 2024 study developed and evaluated mobile teaching materials to increase middle school students' digital literacy (Mufrihah et al., 2024). Ten competencies were measured: accessing digital media; selecting, understanding, analyzing, verifying, and distributing digital information; producing digital media in various formats; participating in digital communities; and collaborating in online forums. The developed intervention includes numerous features that support the aforementioned competencies, including a login page, case studies and quizzes, bookmark management, simple language and icons, discussion forums, and learning modules. Meanwhile, in another study in the same year, Umrotin et al. (2024) developed an electronic ethnobotany encyclopedia using Project-Based Learning (PBL). They found that it effectively increased digital literacy among Biology undergraduate students. The material featured Augmented Reality (AR) for 3D object visualization and QR Codes for quick access to supplementary information. The PjBL approach, by requiring students to address an "essential question," develops their digital literacy by guiding them to locate and use diverse digital resources to produce scientific work. This intervention successfully helped students demonstrate strong digital technology usage in producing simple articles from multiple sources, highlighting the role of these tools in effective blended learning.

Here, ethnoscience elements are integrated into the content to contextualize students' cultural backgrounds. However, the strength of the evidence regarding the impact on digital literacy

must be interpreted with caution due to the disparity in study designs. In the first study, which used a quasi-experimental approach, the control class received conventional instruction rather than digitally based instruction without ethnoscience content. This creates a confounding variable, making it difficult to isolate the cause, whether the gain was driven by the ethnoscience context or simply by the introduction of digital tools. Furthermore, the second study employed a pre-experimental design without a control group, which significantly weakens the reliability of its findings because it cannot account for external factors or other confounding variables.

Consequently, given these methodological limitations, it cannot be conclusively determined whether the content plays a more significant role in students' digital literacy than the digital modality itself (Kocakaya, 2011). The current literature thus offers preliminary rather than confirmatory evidence. Nonetheless, these studies represent an important first step, as they are among the few to formally measure digital literacy outcomes in an ethnoscience intervention; the apparent gaps warrant further exploration. This formal inclusion highlights a general gap in the wider literature. This is despite the numerous studies that incorporate digital modalities into their intervention design. Given the widespread integration of digital modalities into current ethnoscience-based interventions, digital literacy is the logical next competency to address. The reliance on digital tools, whether for information access, content creation, or communication, already necessitates a foundational level of digital skill, making the formal inclusion of digital literacy a natural progression for the field of research.

Effectiveness in contextualizing learning

Various studies that implemented ethnoscience in digital modalities have shown positive effects on science literacy by contextualizing science with students' prior knowledge and backgrounds. Almost all studies explicitly note that integrating local wisdom makes learning more contextual and connects scientific concepts to real-life experiences (Hikmah et al., 2025; Sihombing et al., 2025).

In some cases, ethnoscience-approach repeatedly cited as "more easily learned and accepted" (Atmojo et al., 2021) and helps students recognize that science is "closer to their daily lives" (Wardani et al., 2023). These findings may be related to students' acceptance and motivation for learning science, thereby fostering a more positive attitude towards science. Most importantly, the use of local wisdom in developing learning interventions helped students "appreciate nature" (Yasir et al., 2022) and "preserve and develop their local wisdom" (Nurkhasyanah et al., 2025). It is evident that learning about and understanding one's culture from a scientific perspective can foster significant appreciation among students, thereby increasing their willingness to engage in preservation activities.

Effectiveness in knowledge acquisition

The combination of digital media and ethnoscience appears highly effective in increasing students' understanding of scientific facts and concepts. As in a study using a digital pocketbook, the most significant gains in scientific literacy indicators were in "science as a body of knowledge" (Sulistri et al., 2020). Another study reported an increase in post-test scores when an electronic magazine on traditional foods was used to enhance students' conceptual understanding (Safitriani et al., 2025).

However, some studies report low gains in specific domains, such as scientific inquiry, due to limited involvement in investigative activities (Herayanti et al., 2025; Rusilowati et al., 2021; Sulistri et al., 2020). In a more recent study, the researchers specifically targeted procedural skills by including practical, hands-on components, for example, experiments in producing biotechnology

products using local techniques and ingredients (Rahmalia et al., 2025). Accordingly, these could be considerations for future work focused on procedural knowledge acquisition.

Integration with learning models

Ethnoscience has been integrated into various learning models to enhance science literacy. Atmojo et al. (2019) achieved substantial gains in scientific literacy through ethnoscience-based thematic learning at the elementary school level. Similar results were also achieved from studies that combined ethnoscience with project-based learning (Ariyatun et al., 2020; Rusmansyah et al., 2023) and ethno-STEM PjBL (Imron et al., 2025); whereas one that used contextual collaborative learning-based ethnoscience (CCLBE) only resulted in medium gain (Dewi et al., 2021).

These studies, compared with media-based studies, reported stronger performance on high-level scientific literacy competencies. Ariyatun et al. (2020) reported high percentages in evaluating and designing scientific investigations (86.08%) and explaining scientific phenomena (82.43%). Furthermore, Imron et al. (2025) found that the Ethno-STEM PjBL approach promotes critical thinking and creativity by encouraging students to solve problems in innovative ways. Furthermore, Dewi et al. (2021) reported that CCLBE improves students' attitudes toward scientific literacy, indicating an enhancement of competence beyond knowledge acquisition. Other competencies were also reported to be achieved simultaneously with SL in other study such as citizenship literacy (Atmojo et al., 2020) and cultural awareness and preservation (Imron et al., 2025).

The analysis shows that ethnoscience-based learning models are more effective for achieving holistic, broader outcomes. These results could be due to learning models often being more structured and systematic. In contrast, studies that focus only on media often rely entirely on modalities; therefore, they lack the essential learning process for developing higher-level skills, such as scientific inquiry or attitude. Nevertheless, these results can still inform future research that seeks to complement the benefits of digital media with the pedagogical advantages of learning models.

The synthesis of the reviewed studies highlights a nuanced distinction between the efficacy of pedagogical models and that of digital media. While ethnoscience-based media, such as the e-LKPD developed by Wardani et al. (2023), showed high effectiveness with an N-gain of 0.72 and a large effect size (0.98), the impact was primarily concentrated on basic literacy indicators like 'explaining phenomena.' In contrast, the study noted that indicators requiring greater analytical skills, such as 'interpreting scientific data and evidence,' showed the lowest increase. These data confirm that media-based interventions are more effective at increasing student motivation and engagement through engaging visuals and familiar cultural contexts (e.g., Nyeruit ethnoscience). However, the high outcomes of model-based interventions, for instance, the PjBL model in Rusmansyah (2023) with an N-gain of 0.74 or the integrated activities in Atmojo et al. (2019) with an N-gain of 0.81, stem from their structured pedagogical syntax. These models require students not only to observe but also to actively participate in project completion and evidence-based decision-making. Therefore, while the media serve as an excellent teaching aid, a structured learning model is essential to enhance higher-level inquiry and the interpretation of complex scientific evidence.

■ CONCLUSION

Based on an analysis of 28 articles, the study of ethnoscience's impact on science and digital literacy reveals a growing field, as evidenced by a rise in publications over the past decade. While

numerous studies affirm its role in enhancing science literacy, a clear research gap exists regarding its influence on digital literacy. Keyword analysis highlights a strong focus on educational design and assessment, reflecting the predominantly practical nature of the research. The integration of various models and digital modalities with ethnoscience has demonstrated varying effectiveness, with reported effects ranging from substantial to moderate. Specifically, studies that focused on the implementation of conventional or digital media primarily succeed in contextualizing learning and enhancing knowledge acquisition. In contrast, those employing comprehensive learning models achieve broader educational outcomes, including fostering scientific attitudes and cultural awareness.

The analysis also reveals that ethnoscience serves as both a cultural bridge and a pedagogical catalyst, operating through two distinct pathways. First, this review identifies a relationship between scientific and digital literacy. When ethnoscience bridges scientific literacy by contextualizing abstract concepts, its integration with digital modalities creates a symbiotic relationship that enhances digital literacy. However, the evidence suggests that this is only fully realized when embedded within structured pedagogical models (such as PjBL or PBL) rather than through isolated digital media. While digital media primarily enhances knowledge acquisition and the explanation of phenomena, pedagogical models provide the necessary scaffolding to develop higher-order skills such as scientific inquiry, data interpretation, and cultural awareness. Second, this review proposes a framework in which ethnoscience serves as the contextual anchor, while digital tools serve as transformative aids for documentation and communication. The study concludes that the conceptual gap in current research, specifically the low gains in data interpretation, must be addressed by shifting from product-oriented R&D toward fundamental studies that explore the cognitive mechanisms of how students tackle traditional and modern scientific worldviews. Therefore, the future of ethnoscience research must move beyond validation studies toward establishing a more comprehensive scientific theory that empowers students as both culturally and digitally literate citizens.

■ DECLARATION OF GENERATIVE AI IN WRITING PROCESS

During the writing of this manuscript, the author(s) employed Gemini and Grammarly to assist with language refinement and proofreading. The author(s) have reviewed and edited the content generated by this tool and assume full responsibility for the content of the published article.

■ REFERENCES

Ali, L. U., Suranto, S., Indrowati, M., Zaini, M., Bariroh, U., Afifah, M., & Taher, T. (2025). Exploring ethnoscience in science education: A systematic literature review from 2020-2025. *Konstan - Jurnal Fisika Dan Pendidikan Fisika*, *10*(01), 59–67. https://doi.org/10.20414/konstan.v10i01.692

Amalia, D. V., Ilhami, A., Fuadiyah, S., & Kusumanegara, A. (2024). Development of a scientific literacy instrument based on Riau Malay ethnoscience in science subjects. *PEDAGOGIK: Jurnal Pendidikan*, *11*(1), 1–18. https://doi.org/10.33650/pjp.v11i1.6382

Arianingrum, D., Wahyuni, S., & Rusdianto, R. (2024). Development of an ethnoscience module on the environmental pollution theme to improve community early literacy. *International Journal of Social Learning (IJSL)*, *4*(3), 387–403. https://doi.org/10.47134/ijsl.v4i3.289

Ariyatun, A., Sudarmin, S., & Triastuti, S. (2020). Analysis science literacy competency of high school student through chemistry learning based on projects integrated ethnoscience. *Proceedings of the 5th International Conference on Science, Education and Technology, ISET 2019, 29th June 2019, Semarang, Central Java, Indonesia*. Proceedings of the 5th International Conference on Science, Education and Technology, ISET 2019, 29th June 2019, Semarang, Central Java, Indonesia, Semarang, Indonesia. https://doi.org/10.4108/eai.29-6-2019.2290321

Atmojo, S. E., Kurniawati, W., & Muhtarom, T. (2019). Science learning integrated ethnoscience to increase scientific literacy and scientific character. *Journal of Physics: Conference Series*, *1254*(1), 012033. https://doi.org/10.1088/1742-6596/1254/1/012033

Atmojo, S. E., Lukitoaji, B. D., & Muhtarom, T. (2021). Improving science literation and citizen literation through thematic learning based on ethnoscience. *Journal of Physics: Conference Series*, *1823*(1), 012001. https://doi.org/10.1088/1742-6596/1823/1/012001

Bahari, S., Zurweni, Z., & Hariyadi, B. (2024). Development of interactive learning media based on Android integrated with ethnoscience towards the development of students' soft skills and science literacy abilities in science learning at junior high school. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *14*(2). https://doi.org/10.30998/formatif.v14i2.28125

Bybee, R., McCrae, B., & Laurie, R. (2009). PISA 2006: An assessment of scientific literacy. *Journal of Research in Science Teaching*, *46*(8), 865–883. https://doi.org/10.1002/tea.20333

Dewi, C. C. A., Erna, M., Martini, Haris, I., &

Kundera, I. N. (2021). The effect of contextual collaborative learning based ethnoscience to ýncrease student's scientific literacy ability. *Journal of Turkish Science Education*, *18*(3), 525–541. https://doi.org/10.36681/tused.2021.88

Fahrudin, D., Saputro, S., & Sarwanto. (2023). Ethnoscience in science learning research trend: A systematic literature review from 2013-2022. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 458–467. https://doi.org/10.29303/jppipa.v9i8.3813

Feerrar, J. (2019). Development of a framework for digital literacy. *Reference Services Review*, *47*(2), 91–105. https://doi.org/10.1108/RSR-01-2019-0002

Fitria, M., & Wisudawati, A. W. (2018). The development of ethnoscience-based chemical enrichment book as a science literacy. *International Journal of Chemistry Education Research*, *2*(1), 50–59. https://doi.org/10.20885/ijcer.v2i1.10083

Handayani, R. D., Wilujeng, I., & Prasetyo, Z. K. (2018). Elaborating indigenous knowledge in the science curriculum for the cultural sustainability. *Journal of Teacher Education for Sustainability*, *20*(2), 74–88. https://doi.org/10.2478/jtes-2018-0016

Herayanti, L., Fuaddunnazmi, F., & Sukroyanti, B. A. (2025). Development of ethnoscience-based teaching materials to improve students' scientific literacy. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, *11*(1), 365. https://doi.org/10.33394/jk.v11i1.13429

Hikmah, N., Yohandri, Arsih, F., Azhar, M., & Razak, A. (2025). Uncovering the potential of ethnoscience in science learning to improve students' literacy: A systematic-

literature review (2014–2024). *Jurnal Pendidikan IPA Indonesia*, *14*(3). https://doi.org/10.15294/jpii.v14i3.19591

Imron, E. M., Nugraheni, F. S. A., Utami, B., Nursalsabila, Z., Mahardiani, L., Bramastia, & Tanghal, A. B. (2025). Effectiveness of ethno-STEM-based science teaching with the project-based learning model on students' scientific literacy. *Jurnal Inovasi Pendidikan IPA*, *11*(2), 435–453. https://doi.org/10.21831/jipi.v11i2.78952

Jannah, M., Noris, M., & Indriyani, I. (2023). Trends and issues of ethnoscience research from 2008 to 2023: A bibliometric analysis. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 621–633. https://doi.org/10.29303/jppipa.v9i9.4771

Jihannita, J., Fadly, W., Ekapti, R. F., Luthfiana, D., & Widowati, A. (2024). The development of science module integrated with ethnoscience of singo barong mask to improve scientific literacy and cultural preservation attitudes. *Journal of Innovation in Educational and Cultural Research*, *5*(2), 356–363. https://doi.org/10.46843/jiecr.v5i2.790

Jufrida, J., Kurniawan, W., & Basuki, F. R. (2024). Ethnoscience learning: How do teacher implementing to increase scientific literacy in junior high school. *International Journal of Evaluation and Research in Education (IJERE)*, *13*(3), 1719. https://doi.org/10.11591/ijere.v13i3.26180

Jumanto, L., . F., & . H. (2024). Development of ethnoscience-laden IPA teaching materials on material on the form of substances and their changes to improve science literacy skills of elementary school students. *International Journal of Research and Review*, *11*(11), 379–386. https://doi.org/10.52403/ijrr.20241135

Kholifah, R. N., Yulina, I. K., & Gusman, T. A. (2025). *Implementation of problem-based learning modules integrated ethnoscience to improve science literacy in redox material*. 139–146. https://doi.org/10.4028/p-l4rSR1

Kipfer, B. A. (2021). Ethnoscience. In *Encyclopedic Dictionary of Archaeology* (pp. 453–454). Springer International Publishing. https://doi.org/10.1007/978-3-030-58292-0_50367

Kocakaya, S. (2011). An educational dilemma: are educational experiments working? *Educational Research and Reviews*, *6*(1), 110–123.

Koehler, C. (2017). Crucial role of indigenous knowledge in formal education systems. In *Handbook of Research on Social, Cultural, and Educational Considerations of Indigenous Knowledge in Developing Countries* (pp. 60–79). IGI Global Scientific Publishing. https://doi.org/10.4018/978-1-5225-0838-0.ch004

Kumar, V., & Choudhary, S. K. (2025). Reimagining scientific literacy: A textbook framework for future-focused science education. *Research in Science Education*, *55*(4), 1109–1127. https://doi.org/10.1007/s11165-025-10269-7

Littell, J. H., Corcoran, J., Pillai, V. K., & Corcoran, J. (2008). *Systematic Reviews and Meta-Analysis*. Oxford Univ. Press.

Mahyuny, S. R., Nursamsu, N., Hasruddin, H., & Muslim, M. (2022). Development of students' worksheet learning tools made by ethnoscience based on science literacy. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 2294–2301. https://doi.org/10.29303/jppipa.v8i4.1949

Mufrihah, F., Ellianawati, E., & Rusilowati, A. (2024). Effectiveness of digital teaching materials with content ethnoscience in increase digital literacy. *Unnes Science Education Journal*, *13*(3), 196–204.

https://doi.org/10.15294/usej.v13i3.13886

Munawaroh, S., Sunandar, A., & Qurbaniah, M. (2023). Developing e-modules based on scientific literacy in bamboo ethno-taxonomy. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(2). https://doi.org/10.22219/jpbi.v9i2.24057

Nurfaizah, D. A., Sarawati, T., & Aminatun, T. (2025). Exploring two decades of indigenous knowledge integration in science education: A bibliometric and systematic literature review. *Proceedings International Conference on Religion, Science and Education*, *4*, 315–326.

Nurkhasyanah, E., Khafid, M., & Nuswowati, M. (2025). Development of 3D augmented reality assemblers edu media with a project based learning model based on local wisdom of cirebon region to improve students' science literacy. *International Journal of Research and Review*, *12*(8), 396–412. https://doi.org/10.52403/ijrr.20250847

OECD. (2017). *PISA 2015 assessment and analytical framework: Science, reading, mathematic, financial literacy and collaborative problem solving*. OECD. https://doi.org/10.1787/9789264281820-en

OECD. (2023). *PISA 2022 assessment and analytical framework*. OECD. https://doi.org/10.1787/dfe0bf9c-en

Okechukwu, A., Achimugu, L., & Njoku, M. (2014). Innovations in science and technology education: A case for ethnoscience based science classrooms. *International Journal of Scientific and Engineering Research*, *5*, 52–56.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, n71. https://doi.org/10.1136/bmj.n71

Putri, E. D., Sudarmin, S., & Prasetya, A. T. (2025). Development of ethno-CRT learning model to improve critical thinking skills and science literacy in ecology and biodiversity materials. *International Journal of Active Learning*, *10*(2), 35–44. https://doi.org/10.15294/ijal.v10i2.29886

Quigley, C. (2009). Globalization and science education: The implications for indigenous knowledge systems. *International Education Studies*, *2*. https://doi.org/10.5539/ies.v2n1p76

Rahmalia, U. C., Sudarmin, S., & Ellianawati, E. (2025). Development of biotechnology E-module loaded with ethnoscience to equip students with science process skills & science literacy. *Unnes Science Education Journal*, *14*(2), 341–351. https://doi.org/10.15294/usej.v14i2.25221

Ramli, R., Razali, R., Gadeng, A. N., Diana, N., & Hariadi, J. (2025). Integrating local knowledge into higher education: A qualitative study of curriculum innovation in Aceh, Indonesia. *Education Sciences*, *15*(9), 1214. https://doi.org/10.3390/educsci15091214

Reddy, P., Chaudhary, K., & Hussein, S. (2023). A digital literacy model to narrow the digital literacy skills gap. *Heliyon*, *9*(4), e14878. https://doi.org/10.1016/j.heliyon.2023.e14878

Rusilowati, A., Sundari, & Marwoto, P. (2021). Development of integrated teaching materials vibration, wave and sound with

ethnoscience of bundengan for optimization of students' scientific literation. *Journal of Physics: Conference Series*, *1918*(5), 052057. https://doi.org/10.1088/1742-6596/1918/5/052057

Rusmansyah, R., Leny, L., & Sofia, H. N. (2023). Improving students' scientific literacy and cognitive learning outcomes through ethnoscience-based PjBL model. *Journal of Innovation in Educational and Cultural Research*, *4*(1), 1–9. https://doi.org/10.46843/jiecr.v4i1.382

Safitriani, I., Sudarmin, Febriyanto, H., Naufal, M., Eralita, N., Budoyo, J., & Anisah, S. (2025). Development of an E-magazine based on ethnoscience of semarang's traditional food in the topic of temperature and heat to train students' scientific literacy skills. *Journal of Physics Education and Science*, *2*(4), 19. https://doi.org/10.47134/physics.v2i4.1959

Sihombing, R. A., Anwar, S., Liu, S.-Y., Muslim, M., Winarno, N., & Sihombing, P. J. (2025). Integrating local wisdom into environmental education: A systematic review of ethnoscience research in Indonesia. *Journal of Natural Science and Integration*, *8*(1), 57. https://doi.org/10.24014/jnsi.v8i1.35762

Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science Education*, *85*(1), 6–34. https://doi.org/10.1002/1098-237X(200101)85:1%253C6::AID-SCE3%253E3.0.CO;2-R

Sudarmin. (2014). *Pendidikan Karakter, Etnosains, dan Kearifan Lokal (Konsep dan Penerapannya dalam Penelitian dan Pembelajaran Sains)*. Swadaya Manunggal.

Sudarmin, Ariyatun, Rahayu, S., Yamtinah, S., Pujiastuti, S. E., Munzil, & Winarto. (2025). How to increase student sustainable attitudes: A study effect of the education for sustainable development ethno-pedagogy learning model (EP-ESD). *Multidisciplinary Science Journal*, *7*(5). https://doi.org/10.31893/multiscience.2025252

Sudarmin, S., Sumarni, W., Azizah, S. N., Yusof, M. H. H., & Listiaji, P. (2020). Scientific reconstruction of indigenous knowledge of batik natural dyes using ethno-STEM approach. *Journal of Physics: Conference Series*, *1567*(4), 042046. https://doi.org/10.1088/1742-6596/1567/4/042046

Sudarmin, Savitri, E. N., Pujiastuti, Rr. S. E., Yamtinah, S., Hanim Binti Mohd Zaim, H., & Ariyatun. (2024). Reconstruction of ethno-stem integrated project learning models for explanation of scientific knowledge regarding aroma compounds of indonesian and world herbal teas. *Jurnal Pendidikan IPA Indonesia*, *13*(2), 195–208. https://doi.org/10.15294/wknw8m59

Sulistri, E., Sunarsih, E., Utama, E., & Moseki, U. (2020). The development of digital pocketbook based on the ethnoscience of the singkawang city to increase students' scientific literacy on heat matter and its transfer. *Journal of Education, Teaching and Learning*, *5*(2), 263–268.

Umrotin, E., Listyorini, D., Gofur, A., & Sumberartha, I. W. (2024). *Validity and effectiveness of project-based learning-based ethno-botany electronic encyclopedia of students' digital literacy*. 030046. https://doi.org/10.1063/5.0214871

Wang, C., Zhang, M., Sesunan, A., & Yolanda, L. (2023). *Technology-driven education reform in Indonesia: A look into the current status of the Merdeka Belajar program*.

Wardani, Y. R. K., Sunyono, & Viyanti. (2023). Development of e-LKPD based on nyeruit ethnoscience to train science literacy on additives and addictive substances. In R. Perdana, Sunyono, G. E. Putrawan, T. Y. Septiawan, & B. Saputra (Eds.), *Proceedings of the 4th International Conference on Progressive Education 2022 (ICOPE 2022)* (Vol. 746, pp. 159–166). Atlantis Press SARL. https://doi.org/10.2991/978-2-38476-060-2_16

Yasir, M., Annuria Auliya Rahma, Mubarok, H., & Zakaria, N. S. (2024). Scientific literacy skill in science learning based on ethnoscience. *Indonesian Journal of Science and Education*, *8*(2), 157–166. https://doi.org/10.31002/ijose.v8i2.1643

Yasir, M., Aushia, A. T. A. H., & Parmin, P. (2022). Ethnoscience-based mind mapping video using indigenous knowledge to practice student's science literacy ability. *JPPS (Jurnal Penelitian Pendidikan Sains)*, *12*(1), 26–39. https://doi.org/10.26740/jpps.v12n1.p26-39

Yuliana, I., Jatmiko, B., Widodo, W., & Suryanti. (2025). Mapping ethnoscience in multidisciplinary research over the last two decades: A bibliometric analysis. *Multidisciplinary Reviews*, *8*(11), 2025343. https://doi.org/10.31893/multirev.2025343

Zidny, R., & Eilks, I. (2018). Indigenous knowledge as a socio-cultural context of science to promote transformative education for sustainable development: A case study on the Baduy community (Indonesia). In S. Markic (Ed.), *Building bridges across disciplines for transformative education and a sustainable future: A collection of invited papers inspired by the 24th Symposium on Chemistry and Science Education held at the University of Bremen, June 1-3, 2018* (1. Auflage). Symposium on Chemistry and Science Education, Aachen. Shaker Verlag.

Zidny, R., Sjöström, J., & Eilks, I. (2020). A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Science & Education*, *29*(1), 145–185. https://doi.org/10.1007/s11191-019-00100-x