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Ethnoscience as a Science Phenomenon in Science Learning to Increase Student Science Competency: A Literature Review

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Abstract: Students' science competencies are challenged in science education. It is caused by the fact that science concepts are commonly presented abstractly and not contextually. This study aimed to systematically map the use of ethnoscience phenomena in science education and their contribution to enhancing students' science competencies. The method employed was a systematic literature review with a quantitative bibliometric approach, based on the PRISMA guidelines, utilizing published articles from Scopus, Google Scholar, Semantic Scholar, and SINTA (2019 – 2024). Forty-four articles met the inclusion criteria. The study results show that the ethnoscience phenomenon in science education can be classified into four main themes, namely traditional food processing, ecology and local environment, traditional technology and tools, and material culture and chemical processes, which are consistently related to three aspects of PISA science competency: explaining scientific phenomena, designing and evaluating investigations, and interpreting scientific data and evidence. It can be concluded that ethnoscience is an effective contextual bridge between science concepts - students' cultural experiences, and offering a novelty as thematic mapping of ethnoscience phenomena and theoretical mechanisms for improving science competency, which serves as a basis in science learning development based local culture in the future.

Keywords: Ethnoscience; Science competence; Science phenomena

Introduction

Scientific competence is very important due to its function as a basis for individuals to understand natural phenomena and solve various life problems through solutions based on data, concepts, and relevant scientific laws. This competency encompasses three main aspects, namely the ability to explain phenomena scientifically, design and evaluate investigations, and interpret scientific data and evidence (Latip et al., 2022). To master these competencies, individuals need adequate conceptual, procedural, and epistemic knowledge so they can assess information, make appropriate decisions, and behave rationally to respond to phenomena and/or changes in the world (Latip et al., 2022).

In schools, science education plays an important role in training and increasing students' science competencies (Bybee, 2013; OECD, 2019). In reality, teaching practices are commonly stuck in cognitive aspects only and rarely connect the science to scientific phenomena and local cultural context or local wisdom of students (Syaflita et al., 2021). These cause students face difficulty in connecting abstract science concepts to real-life experiences (Aikenhead, 2006). In addition, students have difficulty connecting scientific concepts to real-life situations, which leads to the perception that science learning is meaningless for them (Dinata et al., 2024).

The ethnoscience approach can be used as an alternative to bridge the gap, as it integrates modern scientific knowledge with local community wisdom (Al-

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Fialistyani et al., 2020; Aprilia & Lutfi, 2023; Wardani et al., 2023). Through ethnoscience, students learn scientific concepts from culture, thereby increasing their understanding and motivation for learning science (Atmojo et al., 2019; Dinata et al., 2024; Rapsanjani et al., 2023). Thus, ethnoscience has the potential to develop students' critical thinking, creativity, and science literacy skills (Dinata et al., 2024).

Several studies show that integration of ethnoscience into science education improves learning outcomes, scientific process skills, and students' positive attitudes toward science (Fitri et al., 2024; Suciyati et al., 2021). Furthermore, ethnoscience also supports 21st-century educational goals that emphasize the mastery of global competencies based on cultural and scientific literacy. However, research on ethnoscience is still partial, fragmented, and has not been systematically mapped (Syaflita et al., 2021). Therefore, a Systematic Literature Review (SLR) is needed to integrate previous research findings, identify trends and research gaps, and provide recommendations for the development of ethnoscience-based science learning in the future (Fahrudin et al., 2023).

Method

A systematic literature review using a quantitative bibliometric approach is used to evaluate scientific publications in order to identify trends, patterns, and key research entities in a scientific field. By applying the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, this approach enables a comprehensive and replicable literature review process, resulting in a clear, transparent, and systematic presentation of the research topic (Chotisarn & Phuthong, 2025). The used inclusion criteria included articles published between 2019 and 2024; publications in Indonesian and English; and research focusing on the topic of ethnoscience in efforts to improve students' science competencies. The integration of ethnoscience in science education was evaluated to identify the integration of ethnoscience in science education in elementary, junior high school, senior high school, and university subjects. Bibliometric analysis was conducted using VOSviewer software to visualize bibliographic data, including citation network analysis, collaboration between authors, and keyword correlations, thereby revealing the intellectual structure and dynamics of developments in the field of research. The combination of bibliometric analysis and systematic review facilitates researchers in synthesizing empirical findings and mapping the landscape of research activities, including identifying key contributors and emerging trends (Azarian et al., 2023). The integration of these two approaches provides a comprehensive understanding of the development, historical flow, and future direction of research, which is highly relevant in interdisciplinary studies to gain deeper insights (Marzi et al., 2025).

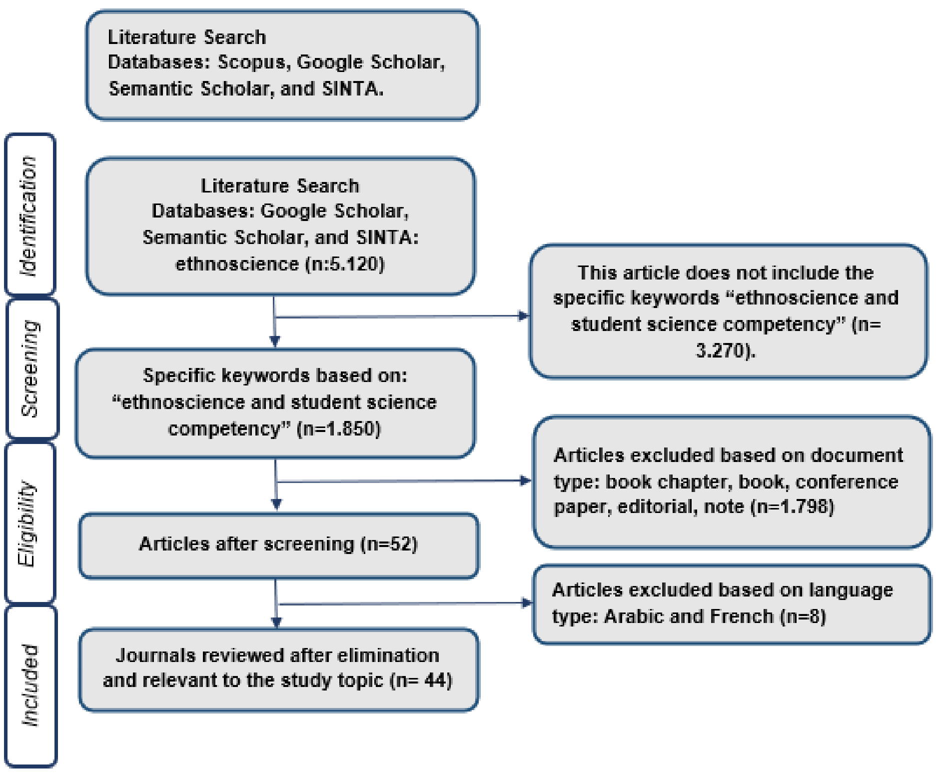

Figure 1. Flow process literature search based on PRISMA guidelines

The initial stage of this study began with the determination of keywords through a macro (top-down) methodological approach, starting from a broad search scope and narrowing down to more specific topics and studies. Based on an evaluation of the limitations of previous studies and the lack of studies that specifically discuss ethnoscience and student science competency, this study established the keywords "ethnoscience and student science competency" as the main focus listed in the article title, abstract, and keywords section. Furthermore, the Scopus, Google Scholar, Semantic Scholar, and SINTA databases were utilized to support various research needs, including conducting literature reviews, identifying experts in related fields, and monitoring research developments and trends.

Based on prospecting results that is taken from 2019 to 2024 from the Google Scholar, Semantic Scholar, and SINTA databases using article titles, abstracts, and keywords: "ethnoscience and student science competence" in various disciplines, from the earliest publication in 2019 to the latest in 2024, the total number of articles on ethnoscience was 5,120 documents (see Figure 1). Following this finding, the screening process filtered the documents based on their classification. Articles were eliminated based on document type: book chapter, book, conference paper, editorial, and note (1,798). The screening results, categorized by document type, yielded 44 articles. These documents were then further analyzed in this study to answer: RQ1: What is the publication trend of ethnoscience in science education? RQ2: What types of ethnoscience phenomena appear in studies related to science learning in Indonesia in the period 2019–2024? RQ3: How are these ethnoscience phenomena mapped and related to science concepts (biology, physics, chemistry) taught in schools? RQ4: How are science competencies defined, measured, and explained in the reviewed studies? RQ5: How can the integration of ethnoscience phenomena in science learning improve students' science competencies based on the findings of the study?

Result and Discussions

An analysis of the distribution of ethnoscience research in 87 articles (see figure 5) was conducted by grouping publications based on country, region, and publication source categories, with a restriction to the top ten articles in each category. This approach aims to obtain a more comprehensive picture of the distribution patterns of ethnoscience studies in various geographical and institutional contexts. Understanding this distribution is expected to provide conceptual contributions to academics and practitioners in formulating the direction of future research agendas, especially in efforts to strengthen the development of a sustainable ethnoscience paradigm.

First, the allocation of scientific research related to ethnoscience, categorized by country or geographical region, is dominated by Indonesia with 37 articles, Brazil with 5 articles, the United States with 5 articles, Taiwan with 4 articles, Germany with 2 articles, Malaysia with 3 articles, and Sweden with 2 articles (see Figure 2).

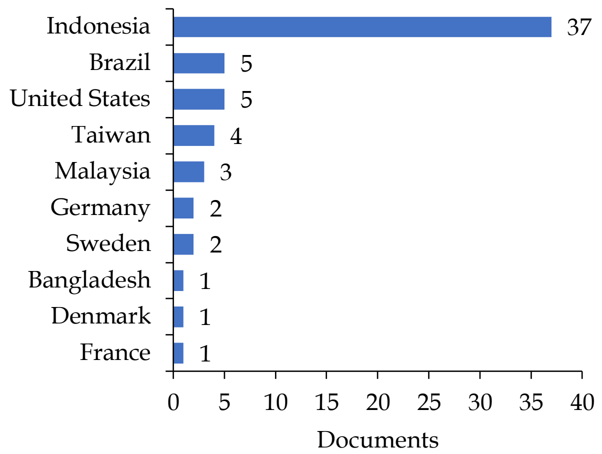

Figure 2. Number of articles by country or region (top 10 countries)

Second, the distribution of universities conducting research and publications related to ethnoscience shows dominance by Semarang State University with 10 articles, Surabaya State University with 6 articles, Mataram University with 4 articles, Padang State University with 4 articles, Jambi University with 4 articles, National University of Malaysia with 3 articles, Sebelas Maret University with 3 articles, Sultan Ageng Tirtayasa University with 3 articles, and the Federal Rural University of Pernambuco with 2 articles (see Figure 3).

The distribution of ethnoscience studies in 10 major publications based on affiliation shows that this field of study not only attracts academic interest in academic institutions located in countries with diverse cultures and local wisdom (such as Papua New Guinea and Indonesia), but also attracts attention in educational institutions with a cultural majority.

Third, the trend of ethnoscience research publications based on year of publication during the period 2016–2024 shows a peak in publications in 2023 with a total of 13 publications, followed by a decline in 2024. This data was obtained from 87 published articles (see Figure 4).

Keyword correlation analysis was performed on 87 published articles using VOSviewer software. The results of the analysis provide an overview of the research map related to ethnoscience. Based on the visualization, it can be seen that ethnoscience has a strong correlation with the field of education. Keywords are visualized in the form of colored circles, where the size of the circle reflects the frequency of the keyword's appearance; the more frequently it appears, the larger the circle will appear. The keywords most frequently used by researchers include "ethnoscience," "culture," "traditional knowledge," "education," "teaching," and "metacognitive skill," with a publication range from 2014 to 2024. Meanwhile, keywords such as "science project" are still rarely used, indicating that this topic has great potential for development in future ethnoscience research (see Figure 5).

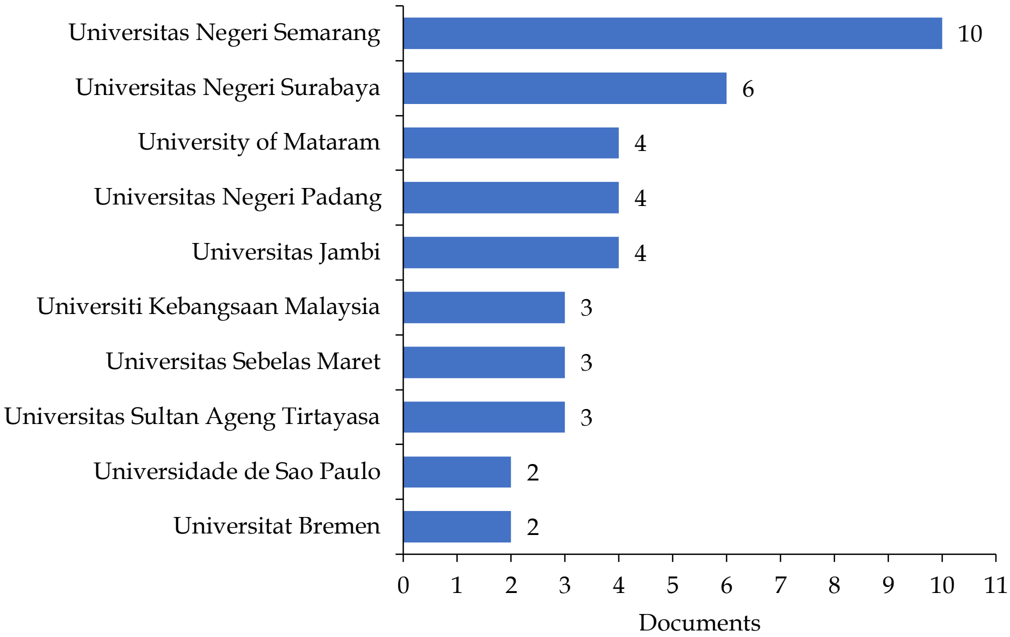

Figure 3. Number of articles by university (top 10 countries)

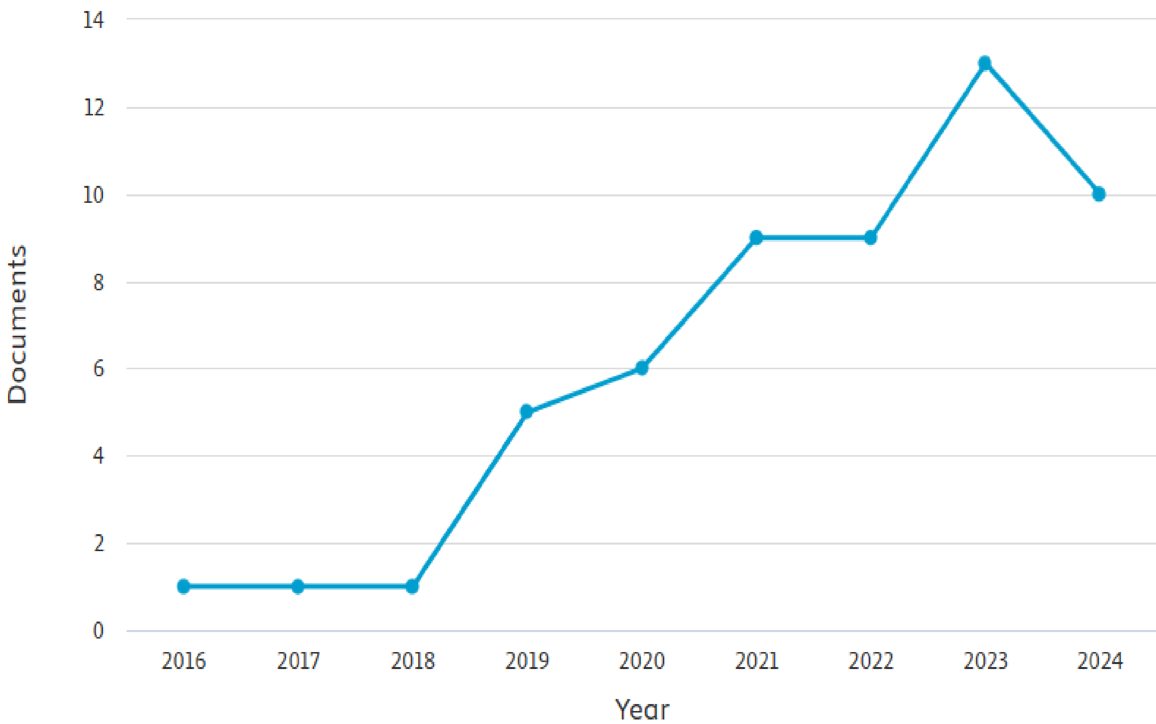

Figure 4. Number of ethnoscience publications in the period (2016-2024)

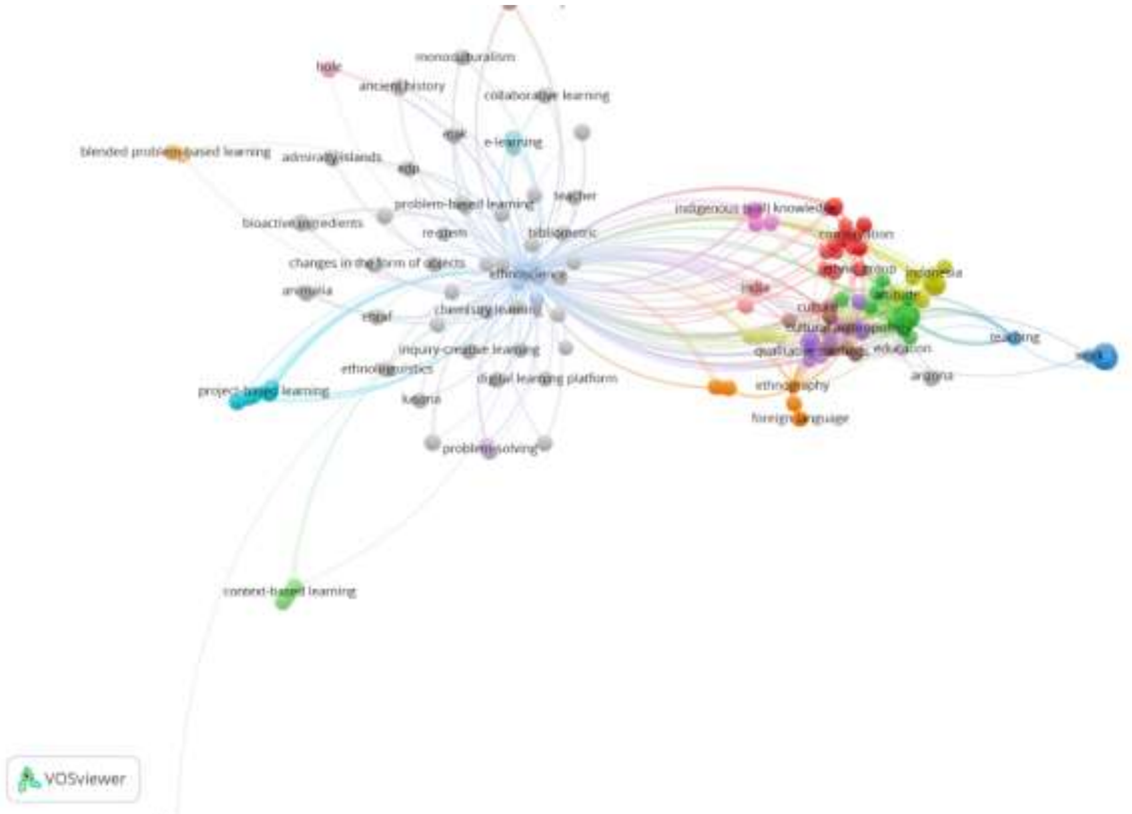

Figure 5. Network visualization based on keyword relevance (87 published articles)

The visualization of keywords in Figure 5 shows strong interrelationships between topics of ethnoscience research in science education, despite the diversity of contexts and research focuses. These findings indicate a relatively consistent pattern of research that utilizes cultural phenomena as a context for science education. Based on this, the next section will outline the general characteristics of the reviewed studies to provide an overview of the research context, the approaches used, and the ethnoscience phenomena integrated into science education.

Characteristics of the Included Studies

A total of 44 articles that met the inclusion criteria were analyzed. These studies came from various local contexts in Indonesia and contained ethnoscience phenomena used as sources for science learning, especially in biology, physics, and chemistry. The majority of studies used a descriptive qualitative approach, the development of ethnoscience-based learning tools, and quasi-experiments to see their impact on students' science competencies.

Table 1. Ethnoscience phenomena related to science learning

Culture	Ethnoscience Phenomenon	Science Phenomena in Science Learning	Citation
Making smoked fish and smoking fish	The process of making salai fish involves burning and smoking fish using firewood, coconut shells, and coconut husks.	Learning about the classification of living things, knowing the changes in energy, heat, and the effect of temperature and time on the quality of fish, as well as the process of reducing water content when burning.	Sakti et al. (2024)
Tain Lale	Preparation of coconut oil pulp as coconut flour used as a raw material for coconut cake.	Learn about food biotechnology, classification of living things related to coconut plants, and body metabolism related to energy sources such as fat and protein, amino acid content in coconut oil.	Wardani & Sarjan (2024)
Wogi	It is a speciality of the Paga Lio region that comes from. Small anchovies are fermented with salt and left for a few days.	Studying conventional biotechnology by fermentation.	Bogar et al. (2024)
Hydrangea Flower Cultivation	People usually utilise the flowers as ornamental plants and flowers thrown at weddings, and the cyanide poison.	Part of the ethnobotanical material that discusses the classification and taxonomy of plants.	Firdiana et al. (2024)

Culture	Ethnoscience Phenomenon	Science Phenomena in Science Learning	Citation
Jeungki	Used by the community to pound coffee, chips, rice, sago, flour, or pound spices, etc.	Studying the magnitude and units of measurement concepts of length, volume, area, mass, and time in Aceh culture, and the application of simple aircraft. Aceh culture and the application of simple aeroplanes.	Safarati et al. (2024)
Batik Sekar Jagad	Batik from Gemeksekti Village, Tanuraksan Kebumen, which is characterised by its diversity of flowers and plants.	Learn about the molecular structure and compounds of Dyes.	Wirasti (2024)
Chanos-chanos	A speciality of milkfish satay from Serang city, using banana leaves for wrapping and grilling.	Learning about the classification of living things, temperature, heat, and the constituents of atoms.	Kholidah et al. (2023)
Palm sugar	It is the making of brown sugar by using local wisdom.	Learn about the chemical and physical properties, properties of solutions, and separation of Mixtures.	Indriani et al. (2023)
Making Salted Fish	Masyarakat wilayah Deli memanfaatkan energi matahari untuk penjemuran ikan asin.	Adanya fenomena pemanfaatan sumber energi terbaharui yakni matahari yang berkaitan dengan materi sumber energi.	Siagian & Tamba (2023)
Smong	A poem about the signs of a tsunami was taught to the people of Aceh based on the past experiences of the people of Simeulue with the earthquake and Tsunami.	The phenomenon of the signs of tsunamis and earthquakes is related to the geography of the Earth, which serves as a warning of these disasters.	Walidah et al. (2023)
Bed House	A local wisdom that comes from the Lebong - Bengkulu area, namely earthquake-resistant traditional houses.	Learning about the balance of the forces that occur.	Sartika et al. (2023)
Tamain	An archery activity using a bow and arrow on game animals.	Learning the concept of spring force in physics material, when the crossbow is pulled and released.	Rapsanjani et al. (2023)
Kahos/kahu	It is an activity of eating areca nut with a concoction of betel leaves or fruits, gambier, lime, and tobacco, then chewed until smooth.	Studying steroid compounds, glycosides, flavonoids, triterpenoids, anthraquinones, tannins, essential oils, catechins, and studying the additives and addictive substances contained in betel leaves.	
Sagu sep	It is the making of sago sep by heating stones and then covering them with leaves in which there is sago, tuber meat, and above the leaves coated with tree bark bus.	Learning about heat transfer by conduction.	
Sal	It is a sign of prohibition to cultivate and take (plants and animals) within a predetermined period of time as a customary event for residents who passed away.	Preservation of natural resources and environmental balance.	
Konda	Malind people who live on the coast can know the tides when the moon rises, when the moon enters, and when the moon is in the middle of the tide.	Studying the gravitational force and ocean waves from tidal events.	
Awe Kelemeh and Manenggop	Community activities in fishing using pounded tuba roots.	Tuba roots contain rotenone. The rotenone compound that enters the gills of fish will cause the fish to be unable to respire and then faint or die, floating to the surface of the water.	
Tifa (Kandara)	A distinctive musical instrument of the Malin people that comes from Kangaroo leather and is played by beating and drumming.	The sound energy generated from the membrane beaten from the kangaroo skin will vibrate and produce a sound that will experience resonance, and the tube shape of the Tifa allows it to become a resonator in the form of an air chamber that serves to amplify the sound. This is in accordance with the	

Culture	Ethnoscience Phenomenon	Science Phenomena in Science Learning	Citation
		material of sound sources and sound properties in Physics learning.	
Sasak Traditional Hall	The community builds houses made of wood on the poles, walls with woven bamboo, and roofs with reeds.	Studying the concept of structure and function of tissues in leaves and stems, as well as the concept of properties of substances and their relationship with constituent particles and their structure.	Muliadi et al. (2022)
Salted egg	Salted egg making with salt soaking.	Membrane transport material in diffusion and osmosis events. When eggs are salted, there is a process of salt diffusion into the egg, accompanied by the release of water from the egg (osmosis).	Junita & Yuliani (2022)
Krayan Mountain Salt	The process of making salt by separating the water and salt for the utilisation of mountain salt for cooking vegetables or other soupy dishes. Other uses besides as a food preservative, Krayan mountain salt is believed to be able to treat various diseases such as high blood pressure, skin diseases, and other diseases.	The process of separating water and salt refers to chemical separation by crystallisation with precipitation at high temperatures and heat transfer without intermediaries (Radiation), heat transfer events and changes in temperature and form of objects, as well as preservation and salting events.	Kantina et al. (2022)
Nyale smell	Worm catching, worm storage, and worm processing by the people of Lombok.	Learn about the content, morphology, and habitat of worms.	Rahmayanti et al. (2021)
Bekasam	Processed fresh fish by fermentation and characterized by a sour and salty flavour.	Study the process of preservation properties, the process of protein hydrolysis into amino acids.	Siregar (2021).
Ashar flower plant	A typical Lampung plant.	Identifying environmental balance issues, observing and identifying Plant parts and their functions, and recognise plant parts that can produce oxygen.	Fiteriani et al. (2021)
Lampung's signature coffee plant	People take care of coffee plants as one of the superior commodities from Lampung province.	Maintaining the balance of nature, the benefits of coffee plants for humans, and the preservation of natural resources.	
Floating Market	The community utilises the waters as a stall for selling with small boats called jukungs and as a tourist attraction.	Entering into the material of environmental ecosystems, environmental components, and nature conservation.	Rahmawati & Atmojo (2021)
Salt Production	Salt-making process with drying.	Studying salt hydrolysis, temperature changes, changes in the form of objects, and crystallisation.	Utari et al. (2020)
Repelling birds using tin cans	Villagers use old tin cans to keep birds away from rice fields.	Learning about vibrations and sound waves in physics using cans and the utilisation of waves in technology.	Masfufah & Ellianawati (2020)
Soil diversity of Dukun sub-district, Gresik	Differences in the texture and nature of the soil in several villages, for the majority of the community utilise the land for farming or farming.	The event of differences in soil structure and properties is the subject of learning material about soil organisms and their role in life.	Nihwan & Widodo (2020)
Lembak fishing tradition and Pempek making	Lembak people catch fish during the harvest season in April, where the fish will be processed as pempek, a speciality of South Sumatra.	Fishing events in the dry season utilise the phenomenon of seasonal changes in biology learning, and pempek-making practice.	Intika (2020)
Tape Making	The process of making tape by fermentation (fermenting and curing) is done by the Javanese people.	Studying the process of energy production in cells under anaerobic conditions (without oxygen).	Puspasari et al. (2019)
Making Serabi	The process of making traditional serabi (market snacks), originating from Indonesia, uses liquid wax.	Learning about the process of heat transfer and the effect of temperature on shape change.	
Tumpengan, Gethuk Lindri, Cenilan, Klepon, Es Loli, and	Natural coloring processes, natural preservation, and the habit of drinking coffee as a source of addictive substances.	Studying physical and chemical changes, health impacts, and scientific analysis through activities such as identifying additives, conducting simple experiments using detergents, and analyzing the effects of addictive substances.	Aninnas et al. (2023)

Culture	Ethnoscience Phenomenon	Science Phenomena in Science Learning	Citation
Coffee Culture in East Java			
Makanan Tradisional Lampung	The preparation and consumption of traditional Lampung foods involve local knowledge about ingredients, processing methods, and the utilization of nutrients that are relevant to the digestive system.	Studying the concepts of the digestive system, organ functions, mechanical-chemical digestion processes, and the relationship between traditional foods and health.	Zelviana et al. (2023)
Potato Dodol, Lemang Kantong Semar, Kawo Powder Drink, Nur Kerinci Coffee, and Bantik Incung	The process of making Kerinci specialties involves traditional knowledge about the properties of substances, changes in substances, heat, and traditional processing techniques.	concepts of substance properties, physical and chemical changes, heat, scientific observation, problem solving, and connecting science concepts.	Agustia et al. (2023)
Local environment of the Madrasah (plants, school gardens, school grounds, Batanghari River, community gardens)	traditional knowledge used by students to observe natural phenomena, ecosystems, and the use of natural resources by communities	ecological concepts, observation of living and non-living objects, scientific processes (observation, classification, inference), and contextual problem solving.	Maysarah et al. (2025)
Traditional food of West Sumatra: Lamang Tapai	The process of making lamang tapai reflects local knowledge related to tapai fermentation (chemical changes caused by yeast) and heating glutinous rice in bamboo until cooked.	Cultural phenomena are used to teach biotechnology (fermentation), chemical-physical changes, heat & heat transfer, and the structure & function of living things.	Hayandi et al. (2025)

Types of Ethnoscience Phenomena Identified

A systematic synthesis of the reviewed articles shows that ethnoscience phenomena in science education do not stand as separate cultural examples, but rather form consistent thematic patterns. Based on similarities in cultural context and their relevance to science concepts, the identified ethnoscience phenomena can be grouped into four main themes. This grouping helps clarify the role of ethnoscience as a structured scientific context in science education.

Food Processing and Fermentation

The first theme is the most frequently found category in the reviewed studies, namely the ethnoscience phenomenon related to traditional food processing and fermentation processes, as reported in various ethnoscience studies of science learning (Bogar et al., 2024; Dinata et al., 2024). The phenomena in this theme include the making of tape (Puspasari et al., 2019), bekasam (Siregar, 2021), salted eggs (Junita & Yuliani, 2022), serabi (Aninnas et al., 2023), wogi (Bogar et al., 2024), smoked fish or salai fish (Dinata et al., 2024), and the use of coconut oil residue as food (Wardani & Sarjan, 2024). These practices are part of the daily activities of the community and are passed down as local knowledge based on empirical experience (Puspasari et al., 2019; Siregar, 2021).

The phenomenon of traditional food processing has a strong connection with the concept of science, especially in the fields of biology and chemistry (Bogar et al., 2024; Dinata et al., 2024). The fermentation process represents the application of conventional biotechnology involving the role of microorganisms in specific environmental conditions (Puspasari et al., 2019; Siregar, 2021). In addition, changes in the taste, texture, and aroma of food products indicate chemical changes and enzymatic reactions (Bogar et al., 2024; Junita & Yuliani, 2022). Several practices are also related to the concepts of heat and heat transfer, mixture separation, reaction kinetics, and energy transformation during the heating, drying, and preservation processes (Dinata et al., 2024; Indriani et al., 2023; Lantabura et al., 2024).

The use of traditional food contexts in science education makes scientific concepts easier to understand because they are close to students' experiences (Junita & Yuliani, 2022). Based on the synthesis results, this theme was found in 15 articles, indicating that traditional food processing is the most dominant and potential source of ethnoscience in science education (Bogar et al., 2024; Dinata et al., 2024).

Local Ecology, Natural Resources, and Environmental Practices

The second theme covers ethnoscience phenomena related to local ecology, natural resource utilization, and community environmental practices. Phenomena included in this category include the tradition of manongkah kerang, which is used as a source of ethnoscience-based science learning (Ilhami et al., 2021); Bau Nyale, which represents the relationship between community culture and marine ecology (Rahmayanti et al., 2021); soil diversity in the Dukun Gresik District, which is utilized by the community for agricultural activities and serves as a context for learning about soil organisms (Nihwan & Widodo, 2020). The tradition of sal is a customary prohibition on the extraction of natural resources that serves to maintain environmental balance (Kantina et al., 2022). The knowledge of sea tides among the Malind community is based on observations of the moon phases and sea conditions (Rapsanjani et al., 2023), and the economic activities of the community in floating markets that utilize aquatic ecosystems as living spaces and sources of livelihood (Lantabura et al., 2024; Rahmawati & Atmojo, 2021).

These phenomena are closely related to science concepts in the fields of ecology and geoscience, such as ecosystems, environmental balance, adaptation of living things, and conservation of natural resources, as shown in studies of soil diversity and floating markets as contexts for science learning (Nihwan & Widodo, 2020; Rahmawati & Atmojo, 2021). Local knowledge about sea tides reflects the community's understanding of the influence of the moon's gravitational force and ocean wave dynamics, which can be scientifically explained through the concepts of gravitational force and wave motion (Rapsanjani et al., 2023). Meanwhile, customary prohibitions such as sal indicate the existence of socio-cultural mechanisms that serve to maintain environmental sustainability, in line with the principles of natural resource conservation in modern science (Kantina et al., 2022).

The integration of local ecological phenomena into science education not only strengthens conceptual understanding but also encourages the development of environmental awareness and scientific literacy among students through direct engagement with environmental phenomena in their surroundings (Ilhami et al., 2021; Rahmayanti et al., 2021). This theme was identified in 11 articles, demonstrating the significant contribution of ethnoscience in linking science education with environmental and sustainability issues (Nihwan & Widodo, 2020; Rahmawati & Atmojo, 2021; Rapsanjani et al., 2023).

Traditional Technology and Tools

The third theme relates to the use of traditional technology and tools in community life. Phenomena included in this category include the use of jeungki as a pestle used by communities in their daily activities (Safarati et al., 2024), tifa is a traditional musical instrument that is played by striking it to produce sound (Rapsanjani et al., 2023), the process of drying salted fish by utilizing solar energy as a renewable energy source (Siagian & Tamba, 2023), and the use of sounds from used cans to scare birds away from rice fields as a form of simple technology based on local wisdom (Masfufah & Ellianawati, 2020).

This phenomenon is highly relevant to the concept of science, particularly in the field of physics. The use of traditional tools can be linked to the concepts of force, simple machines, and mechanical energy, as demonstrated in the use of jeungki in pounding food ingredients (Safarati et al., 2024). Traditional musical instruments such as the tifa provide a real-world context for studying vibrations, sound waves, resonance, and sound sources through membrane vibrations and air resonance in tubes (Rapsanjani et al., 2023). Meanwhile, the use of sound to repel birds demonstrates the application of wave and energy principles in simple technology based on local knowledge, which can be linked to the concept of sound waves in physics learning (Masfufah & Ellianawati, 2020).

Science education that utilizes traditional technology helps students understand that the principles of physics are not only found in modern technology, but have also long been applied in local culture. Based on the synthesis results, this theme was found in 8 articles, which confirmed the role of traditional tools and technology as a source of contextual science learning.

Material Culture and Chemical Processes

Table 2. The synthesis results show that the phenomenon of ethnoscience is consistently related to three aspects of PISA science competency, namely

Science Competency Aspects	Evidence from Studies
Explaining scientific phenomena	Analyzing the fermentation process (tape, wogi), mixture separation (Krayan salt), tidal phenomena (Malind), and heat (serabi).
Evaluating and designing scientific inquiry	Identify variables (fermentation time, smoking temperature), design observations (floating market ecosystem).
Interpreting data and evidence scientifically	Interpreting physical/chemical changes, reading observation data (quality of smoked fish, batik colors))

The fourth theme covers ethnoscience phenomena related to material culture and traditional chemical processes. Phenomena in this category include the production of Krayan mountain salt, which utilizes traditional methods of separating water and salt (Kantina et al., 2022), Sekar Jagad Batik, which uses natural dyes in its production process (Wirasti, 2024). The production of palm sugar is part of the local community's wisdom in processing natural materials (Indriani et al., 2023), and various traditional separation practices commonly found in community activities (Utari et al., 2020).

These phenomena are closely related to the concepts of science in the fields of chemistry and physics, such as crystallization, changes in form and substance, diffusion and osmosis, the properties of solutions, and the physical and chemical properties of materials, as described in studies on the production of salt and palm sugar based on ethnoscience (Indriani et al., 2023; Kantina et al., 2022). In the practice of batik making, the use of natural dyes can be linked to the molecular structure of pigments and their interaction with fabric fibers in chemistry learning (Wirasti, 2024). The process of making salt and palm sugar also reflects the application of the principles of mixture separation and heat transfer, which are carried out traditionally and contextually in science learning (Kantina et al., 2022; Utari et al., 2020).

The use of local material culture in science education helps students understand abstract chemical concepts through observable, real processes. This theme was identified in 9 articles, indicating that material culture has great potential as a context for ethnoscience-based chemistry education.

Ethnoscience Provides a Strong Contextual Bridge for Science Learning

The synthesis results show that ethnoscience phenomena serve as a strong contextual bridge in science learning. Phenomena that originate from local culture and wisdom present authentic learning situations because they are close to students' daily lives. This context helps students understand that science concepts are not separate from reality, but are present in the practices they encounter in their surroundings. These findings indicate that ethnoscience plays a significant role in contextualizing scientific concepts and integrating science concepts with students' daily experiences (Tsaniyah & Fadly, 2024).

Through ethnoscience, students find it easier to explain scientific phenomena because the concepts in scientific phenomena are learned through real events, such as cultural activities or traditional practices. The connection between abstract science concepts and concrete experiences makes students' understanding more meaningful. In addition, the use of local contexts also increases student engagement and motivation to learn because the material being studied is relevant to their lives.

These findings are in line with the approaches of “contextual learning” and “situated cognition,” which emphasize that learning is more effective when concepts are developed in meaningful contexts. Thus, ethnoscience plays an important role in bridging science concepts with students' real-life experiences, thereby supporting more contextual and understandable science learning.

Why Ethnoscience Improves Science Competence: A Theoretical Interpretation

The improvement of science competence through ethnoscience-based learning does not occur by chance, but can be explained through a number of theoretically sound learning mechanisms. A synthesis of research results shows that ethnoscience works through concrete experiences, increased cognitive demands, and cultural relevance that impact student learning motivation (Atmojo et al., 2019; Rusmansyah et al., 2023). These three mechanisms are interrelated and contribute directly to the development of students' science competence.

Concrete Experience → Better Conceptualization

Ethnoscience phenomena such as tape fermentation, the process of baking serabi, or the separation of Krayan mountain salt provide concrete learning experiences that can be observed directly by students. These experiences play an important role in helping students build clearer mental representations of the science concepts learned in class. Through direct observation of these cultural practices, students can relate the concepts of heat and heat transfer to the baking process, understand the chemical reactions and changes in food fermentation, and recognize the principles of mixture separation and crystallization in salt making. In addition, phenomena involving biological materials also support understanding of the classification of living things and biological processes, while the use of traditional tools reinforces understanding of the concepts of force and motion.

Concrete experiences make it easier for students to develop conceptual understanding. This is because science concepts are not studied abstractly, but through real events that are meaningful to them. Therefore, ethnoscience acts as a bridge that connects empirical experiences with conceptual understanding in science learning.

Increasing Cognitive Demand

In addition to providing concrete experiences, ethnoscience-based learning also increases students' cognitive demands. Analysis of cultural phenomena does not stop at the observation stage, but requires students to engage in higher-order thinking processes (Cahyaningrum et al., 2025; Zidny et al., 2021). In many studies, students are asked to identify the variables that influence a cultural practice, explain the scientific mechanisms behind the process, and compare local knowledge with modern scientific explanations.

This activity encourages students to develop analytical, evaluative, and reflective thinking skills. For example, when students compare traditional fermentation processes with modern biotechnology concepts, they learn to interpret evidence, draw conclusions, and explain cause-and-effect relationships scientifically (Aljunaedi et al., 2025; Sumarni et al., 2022). This process is directly related to higher-order thinking skills, such as the ability to explain scientific phenomena and use scientific knowledge to solve contextual problems (Cahyani & Wahyudiati, 2023). With increased cognitive demands, students can understand science concepts in depth, enabling them to use them flexibly in various contexts (Cahyaningrum et al., 2025). This makes ethnoscience an effective approach for developing deeper science competencies.

Cultural Relevance Promotes Motivation

Another mechanism that explains the success of ethnoscience in improving science competency is the high cultural relevance felt by students, as demonstrated in science learning that integrates local phenomena as a learning context (Muliadi et al., 2022; Rahmawati & Atmojo, 2021). Phenomena such as floating markets, which have long been part of the economic activities of coastal communities (Rahmawati & Atmojo, 2021), Bale Adat Sasak as a representation of the material culture and local wisdom of the Sasak community (Muliadi et al., 2022), or the Bau Nyale tradition related to marine ecology and cultural practices of the Lombok community (Rahmayanti et al., 2021) are part of the cultural identity of the community that students have known and experienced for a long time. When these phenomena are raised in science learning, students feel that the knowledge they learn is directly related to their own lives and culture, making learning more meaningful and contextual (Muliadi et al., 2022; Rahmawati & Atmojo, 2021).

A sense of belonging to the local culture encourages greater emotional involvement and motivation to learn. Students tend to be more active in asking questions, discussing, and participating in learning activities when the material being studied is considered relevant and meaningful. This increased learning motivation contributes to a more effective and sustainable learning process. Thus, cultural relevance in ethnoscience not only enriches the learning context but also creates a learning environment that encourages active student participation (Hikmawati et al., 2020). These conditions support the achievement of science competencies more optimally.

Comparison with Previous SLR and Gaps Identified

The findings of this review are consistent with previous studies, which suggest that research on ethnoscience-based science learning has largely focused on the cognitive dimension rather than investigative competencies. Prior studies tend to emphasize the enhancement of conceptual understanding and cognitive achievement, while the development of scientific process skills has received limited scholarly attention. Furthermore, the synthesis of this systematic literature review (SLR) indicates that only a small number of investigations have explicitly evaluated students' abilities to design scientific inquiries, construct evidence-based arguments, or interpret data in a comprehensive manner.

Despite this tendency, ethnoscience possesses considerable potential as a contextual medium for fostering inquiry-based and analytical activities in science education. However, existing studies remain predominantly situated within primary and lower secondary education contexts. Research focusing on senior high school and higher education settings is still scarce, implying that the application of ethnoscience for cultivating higher-order scientific competencies remains underexplored. These findings underscore a significant research gap that should be addressed through future studies emphasizing investigative approaches and the integration of ethnoscience at more advanced educational levels.

Implications for Future Teaching and Research

Ethnoscience-based science learning has been proven to connect cultural experiences with scientific concepts, making it easier for students to understand abstract scientific principles (Hastuti et al., 2019). Teachers are also required to develop contextual teaching materials, such as modules and student worksheets, based on local phenomena to improve concept understanding (Anattri et al., 2024). In addition, the integration of culture in learning has been proven to improve students' science literacy and critical thinking skills (Hikmawati et al., 2020).

Ethnoscience-based learning needs to be directed towards exploratory activities that encourage students to analyze, interpret, and explain the scientific processes behind the cultural phenomena they observe. The integration of ethnoscience has been proven to connect scientific concepts with cultural practices, thereby improving students' conceptual understanding (Putri et al., 2024). Its effectiveness will be even stronger when combined with inquiry-based and project-based learning models, as these two approaches provide space for students to observe, formulate questions, and solve problems in real-world contexts. From a research perspective, measuring science competency is not sufficient in terms of conceptual understanding alone, but must also include the ability to design scientific investigations and critically evaluate evidence, as recommended in ethnoscience-based science literacy studies (Pertiwi & Firdausi, 2019). Future research also needs to expand the context of the study to the high school and college levels so that the application of ethnoscience in advanced learning can be described more comprehensively. In addition, the use of strong quantitative data and controlled experimental designs is essential to strengthen empirical evidence on the effectiveness of ethnoscience-based science learning (Pertiwi & Firdausi, 2019).

Contribution of This SLR

This systematic literature review makes an important contribution by presenting a more structured understanding of ethnoscience-based science learning. Unlike previous studies, which generally highlight ethnoscience phenomena separately, this study groups these various phenomena into four main themes so that patterns of their use in the context of science learning can be seen more clearly (Pertiwi & Firdausi, 2019). In addition, this study maps the relationship between ethnoscience phenomena and the aspects of science competency developed, showing that ethnoscience not only plays a role in strengthening conceptual understanding but also has the potential to improve science competency more comprehensively (Nurrubi et al., 2022). Furthermore, this SLR provides a theoretical basis regarding the mechanisms for improving science competencies through concrete experiences, cognitive demands, and cultural relevance. This study also successfully identified open research gaps, particularly related to the investigative aspects of science competencies and the context of advanced education, which can be used as directions for further research development.

Conclusion

This systematic literature review shows that the integration of ethnoscience in science education plays an effective role as a contextual framework for improving students' science competencies. Local cultural phenomena grouped into the themes of food processing, ecology and the environment, traditional technology, and material culture have been proven to have a strong connection with science concepts in the fields of biology, physics, and chemistry. The use of ethnoscience helps students understand scientific concepts more concretely, increases cognitive demands, and strengthens learning motivation through cultural relevance. These findings confirm that ethnoscience not only supports conceptual understanding but also has the potential to develop the ability to explain scientific phenomena, design investigations, and interpret data. However, research on investigative competence at the senior high school and university levels is still limited, so further studies with stronger empirical designs are needed to expand and deepen the use of ethnoscience in science education.

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Author Contributions

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Conflicts of Interest

The authors declare no conflict of interest.

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