Journal of Turkish Science Education, 2026, 23(3), 495-512
DOI no: 10.36681/tused.2026.024

Integrating *Minangkabau* culture into science education: preservice teachers' informal reasoning on ethnoscience for critical thinking and creativity

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ABSTRACT
This study analyzes how preservice science teachers construct informal reasoning when evaluating two Minangkabau cultural practices, namely *batik tanah liek* and the *balimau* tradition, as contexts for ethnoscience. *Batik tanah liek* emphasizes clay as a natural dye and fabric preservative, wheras *balimau* is a tradition of cleansing oneself using lime and flowers before Ramadan. This study contributes new insights by mapping the patterns of informal reasoning of preservice teachers on two traditions that have different scientific structures and religious values and linking them to pedagogical implications for ethnoscience learning. Data were collected through semi-structured questionnaires and analyzed using Braun and Clarke's inductive thematic analysis. Four categories of informal reasoning, namely personal, social, cultural, and environmental, guide how participants assess scientific relevance, cultural meaning, moral sensitivity, and learning potential. The results show that preservice teachers have stronger involvement and awareness of *batik tanah liek*, which provides concrete and structured scientific phenomena that trigger more rational-scientific reasoning and conceptual creativity. Conversely, *balimau* evokes moral-emotional reasoning due to its strong religious and socio-communal values, thus encouraging pedagogical caution. These differences indicate cultural bias and variations in epistemic access to traditional practices. Informal reasoning has been shown to play a role in training critical and creative thinking skills through evidence analysis, cultural context interpretation, and scientific solution exploration. This study emphasizes the need to integrate ethnoscience analysis into the PCK/TPACK curriculum to strengthen culturally responsive science education.

RESEARCH ARTICLE

ARTICLE INFORMATION
Received: 23.09.2025
Accepted: 16.02.2026
Available Online: 21.09.2026

KEYWORDS:
Critical thinking, creativity, ethnoscience, informal reasoning, Minangkabau culture, preservice teacher.

To cite this article: Roza, M., Azhar, M., Festiyed, F., & Asrizal, A. (2026). Integrating Minangkabau culture into science education: preservice teachers' informal reasoning on ethnoscience for critical thinking and creativity. *Journal of Turkish Science Education, 23*(3), 495-512. http://doi.org/10.36681/tused.2025.024

Introduction

Global science education currently faces demands to develop higher-order thinking skills, such as critical thinking, creativity, and evidence-based decision-making (Khahro & Javed, 2022; Liu et al.,

2024). These competencies are necessary for students to be able to respond to socioscientific issues and the dynamics of scientific development (Siew & Arifin, 2025). However, science learning practices in various contexts still tend to be detached from the socio-cultural realities of students, thereby limiting their opportunities to develop meaningful reasoning and relate it to their culture and life experiences.

In line with these challenges, the integration of cultural context has become an important concern in science education. A student's understanding of science is significantly influenced by the culture and traditions in which they live (Baptista & Molina-Andrade, 2023). They do not only use scientific knowledge, evidence, and data in making decisions and reasoning about science (Ladachart & Ladachart, 2021) but also use their personal experiences and socio-cultural backgrounds (Mansour, 2024; Mavuru & Ramnarain, 2020). Ethnoscience offers a framework for connecting local cultural practices with scientific explanations, allowing students to explore the empirical, procedural, and value dimensions inherent in traditional knowledge (Rexhepi & Bajrami, 2025). Indonesia has a wealth of traditions that have strong potential as a learning context, but studies examining how preservice teachers interpret and understand these traditions in a pedagogical context are still limited.

At the same time, informal reasoning becomes an important lens for understanding how individuals evaluate complex issues involving evidence, cultural norms, and moral considerations (Han-Tosunoglu & Ozer, 2022). Local cultural practices in ethnoscience naturally contain value dilemmas, such as tensions between spiritual meaning, social norms, and scientific explanations that trigger informal reasoning when preservice teachers interpret them (Kara, 2025; Sadler, 2004). This situation requires to combine scientific evidence, moral considerations, and cultural perspectives through various forms of reasoning, such as scientific-rational, sociocultural, intuitive, and emotive reasoning. Because these value dilemmas are a key feature of ethnoscience practice, preservice teachers need to be trained to integrate culture and informal reasoning so that they can design science learning that is socioculturally sensitive but still based on scientific principles (Aziz & Johari, 2023; Zeidler & Nichols, 2009).

Little research has examined how preservice teachers reason about local cultural practices through informal reasoning frameworks. Existing studies have tended to focus on students, single aspects of local wisdom, or conceptual understanding (Rizaldi et al., 2021; Sasmita et al., 2025) but have not yet described how preservice teachers evaluate the intersection between culture and science in a pedagogical context. To date, there has been no research that systematically examined the informal reasoning related to ethoscience issues in Minangkabau culture among science teacher candidates with the aim of fostering critical and creative thinking.

Focusing on preservice teachers is important because they are key actors in bridging cultural relevance in science classrooms. Pedagogical content knowledge (PCK), professional noticing skills, belief systems, and the integration of various domains of knowledge greatly determine how culture-based science learning will be implemented (Brown, J. C et al., 2022; Isa et al., 2022). Understanding how they reason about local cultural practices is a strategic step in designing teacher education programs that are capable of integrating ethnoscience in a meaningful and responsible manner and building socioculturally responsive professional competencies.

Based on this urgency, this study aims to analyze the reasoning patterns of preservice science teachers regarding two Minangkabau cultural practices that are relevant to ethnoscience, namely batik tanah liek and the balimau tradition. The key points of this study lie in the integration of three main elements: (1) the use of an informal reasoning framework to analyze preservice teachers' responses to ethnoscience practices; (2) analysis of preservice teachers' decisions, reasons, and perspectives for using culture as learning material; and (3) the contribution of ethnoscience-based learning to the development of critical and creative thinking skills in preservice science teachers. Thus, this study contributes to the development of science education theory and practice that is more reflective, contextual, and sensitive to local cultural values in shaping 21st-century professional competencies. The findings are expected to provide a theoretical and pedagogical basis for strengthening critical thinking, creativity, and ethnoscience learning design in teacher education.

Ethnoscience-Based Learning

Ethnoscience-based learning is a pedagogical approach that integrates local cultural knowledge and practices into formal science learning (Khery et al., 2025; Sumarni et al., 2025). This approach aims to bridge modern science with the cultural context of students (Idul & Fajardo, 2023; Yuliana et al., 2025) so that the learning process becomes more contextual, meaningful, and rooted in the social and cultural realities of students (Atmojo et al., 2025; Latip et al., 2024). Ethnoscience not only strengthens science literacy and ecological awareness but also increases appreciation for cultural heritage and develops an inclusive and pluralistic scientific attitude (Syahirah & Sriyati, 2024; Tovar-Gálvez, 2021).

In the Indonesian context, various local traditions have empirical value, simple technology, and chemical and biological principles that can be interpreted within the framework of science learning. In this study, two Minangkabau cultural practices were used as the context for ethnosicence-based learning. *Tanah liek* is a fabric dyeing technique that uses clay as a distinctive natural dye and makes *batik tanah liek* last for decades (Roza, 2025). *Balimau* is a tradition of cleansing oneself using water mixed with lime, which involves acid-base reactions and natural antiseptic processes (Khairani et al., 2020). These two practices were chosen because they contain scientific concepts that can be studied together with their value and symbolic dimensions, thus having the potential to trigger scientific as well as moral-cultural reasoning.

The selection of these two cultures with strong scientific and cultural dimensions positions ethnoscience not only as a learning context but also as a means to examine how preservice teachers assess, filter, and integrate cultural knowledge into their professional science practices. Culture has been shown to influence the quality and patterns of individuals' informal reasoning (Capkinoglu et al., 2020; D'Ambrosio, 2021). These two cultural practices provide an authentic context for understanding how preservice teachers who have grown up in that cultural environment construct their perspectives and pedagogical considerations (Reiser et al., 2021). Thus, strengthening the capacity of preservice science teachers to recognize, understand, and utilize ethnoscience is an important element in 21st-century science education reform (Sarkingobir & Bello, 2024).

Perspective and Informal Reasoning

Informal reasoning refers to the process of decision-making and argumentation by individuals when faced with complex, ambiguous, and value-laden situations (Beniermann et al., 2021; Sakamoto et al., 2021). In the context of science education, informal reasoning has been widely used to examine the responses of students and teachers to socioscientific issues (SSI), such as climate change, biotechnology, and vaccination (Jansong et al., 2022; Mnguni & Gasa, 2024). This reasoning demonstrated various considerations, including personal, social, cultural, and environmental aspects. These four aspects cannot always be explained through formal logic or scientific principles alone (Chan & Yeung, 2021; Zeidler, & Sadler, 2023).

The ability to construct informal reasoning is an important indicator in assessing preservice teachers' readiness to deal with the complexities of classroom and community realities (Han-Tosunoglu & Ozer, 2022). Cultural, spiritual, and environmental considerations greatly influence argumentation and are effective in training preservice teachers' reflective sensitivity, critical thinking, and creativity (Budiarti et al., 2025). In science education, informal reasoning is important because it provides an overview of how preservice teachers assess information, construct arguments, consider risks and benefits, and integrate scientific perspectives with cultural values (Ladachart & Ladachart, 2021).

However, research that integrates informal reasoning frameworks with ethnoscience contexts remains limited, particularly in science teacher education in Southeast Asia (Meral et al., 2021). Only a few studies have explored how local cultural practices can be used as a vehicle for training preservice teachers in informal reasoning and critical and creative thinking. Unlike previous studies, which generally examine ethnoscience from the perspective of students or merely map cultural elements descriptively, this study specifically highlights the reasoning process of preservice teachers when faced

with cultural dilemmas in ethnoscience practice. This focus provides a new contribution to understanding professional capacity, especially in integrating scientific knowledge, cultural values, and pedagogical considerations constructed through informal reasoning.

Method

Type of Research

This study used an exploratory qualitative design with a descriptive thematic approach to examine how preservice science teachers construct informal reasoning when interacting with ethnoscience practices rooted in Minangkabau culture. This design was chosen because it enables participants' authentic responses, culture-based interpretations, and reasoning patterns that emerge without limiting responses to specific theoretical categories. The general structure of the analysis was adapted from the method used by Ladachart and Ladachart (2021).

The exploratory nature of this study is in line with the objective of discovering variations in reasoning that emerge from the participants' perspectives, rather than testing hypotheses or measuring specific constructs. Therefore, this design well-suited for identifying the dynamics of preservice teachers' reasoning in the context of culture and ethnoscience.

Participants

This study involved 71 preservice science teachers (14 males and 57 females), aged between 22 and 24 years. All participants were in their fourth and fifth years of a science teacher education program at a university in West Sumatra, Indonesia, which is rich in cultural diversity and local wisdom. The students were selected because they had taken more science and pedagogy courses and had sufficient micro-teaching experience to provide more mature pedagogical assessments and reflective reasoning. Participants were selected purposively to ensure that they had a foundation of pedagogical and scientific knowledge, experience and exposure to local cultural traditions, and had achieved a sufficient level of reflective maturity to evaluate the context of ethnoscience from a teaching perspective. Participants had diverse cultural and geographical backgrounds. Based on their place of residence, participants came from urban centers (n = 9), urban (n = 32), rural (n = 25), and remote rurar (n = 5) areas of their home provinces.

Research Instruments

Data were collected through a semi-structured questionnaire with open-ended questions. The questionnaire was designed to explore the attitudes, scientific explanations, cultural value evaluations, and informal reasoning of participants in two local cultural practices, namely *batik tanah liek* and the *balimau* tradition. The questionnaire was distributed offline in class, and participants filled it out independently within 30–40 minutes. To minimize external influences during data collection, lecturers or facilitators were not present while participants completed the questionnaire.

The instrument consisted of (1) participant demographic information, (2) participant involvement in the two cultural practices, (3) decisions, reasons, and perspectives, and (4) perceptions of the potential of these cultures as science teaching materials that support critical and creative thinking skills.

Table 1

Research instruments

No	Aspect	Coding target	Questionnaire Items	Exploration focus
1	Demographic information	Gender, age, region of origin, family background, and geographical location	A1–A4	Demographic description of participants
2	Experience and involvement in culture	Exposure to and experience with *batik tanah liek* and the *balimau* tradition	B1–B4, C1–C2	Understanding individual backgrounds
		Understanding the use of natural materials	B5	Measuring locally based scientific reasoning abilities
3	Decisions, reasons, and perspectives	Views on the importance of preserving *batik* and *balimau* traditions	B6, C5	Assessing awareness of cultural values and local identity
		Perceptions of environmental impact	B7	Assessing the ability to analyze local environmental issues
4	The potential of culture as material for science learning	Identification of science concepts in *batik tanah liek* and the *balimau* tradition	B8, C4	Assessing the integration of culture and science
		Eligibility as material learning based ethnoscience	B9, C6	Testing the practical value of local culture in science education
		Impact of ethnoscience on critical and creative thinking skills	B10, C7	Assessing the relevance of local culture to the development of critical and creative thinking skills
		Reasons for belief to be used as teaching material	B11, C8	Measuring participants' level of argumentation and reflection
		Reflective attitude and analysis of religious and cultural values (specifically balimau tradition)	C6b	Assessing reflective attitudes and cross-cultural analysis

The instrument was validated by three experts to ensure content adequacy, clarity of meaning, and the suitability of each item with the focus of informal reasoning exploration. The experts' evaluations were analyzed using Aiken's validity formula (Aiken's, 1985). The validation results showed that the instrument is valid, with an average validity coefficient of 0.92, making it suitable for use as a data collection tool.

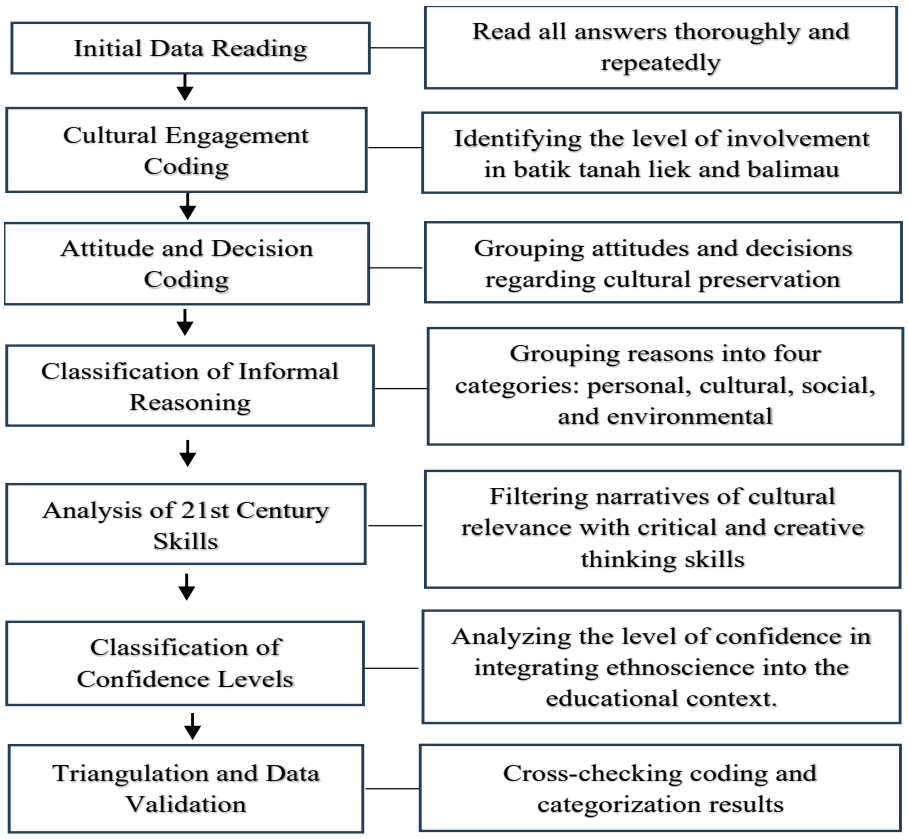
To ensure credibility and dependability, the instrument was piloted with 22 preservice science teachers to assess readability, clarity of items, and flexibility of narrative responses. The pilot test results indicated the need for minor revisions, particularly by expanding the open-ended questions so that respondents could convey their experiences, reasons, and arguments in greater depth. Subsequently, a discussion was held among all researchers to revise the instrument based on expert input and the results of the pilot test.

Data Analysis

The data were analyzed using the five main stages of Clarke and Braun (2006) inductive thematic analysis. First, the researchers conducted readings to understand the narrative context and cultural values that emerged from the participants' responses. Second, open coding included coding for cultural engagement and coding attitudes. Third, the codes were grouped through axial coding by mapping them into four categories of informal reasoning. Fourth, the main themes are determined by analyzing patterns of reasoning in relation to teaching materials to enhance critical and creative thinking. Fifth, triangulation and inter-researcher discussions are conducted to harmonize interpretations, verify inter-researcher consistency, and ensure analytical quality. The data analysis process is as follows:

Figure 1

Stages of data analysis



The data were analyzed using the analytical framework developed by Ladachart and Ladachart (2021). This approach was chosen because it provides greater theoretical clarity, particularly for examining informal reasoning processes in the context of SSI, which can be applied in the context of ethnoscience. The data were categorized based on two main dimensions: (1) the respondents' informal reasons or considerations in making decisions and (2) their perceptions of the potential of these cultures as ethnoscience-based teaching materials for developing critical and creative thinking skills.

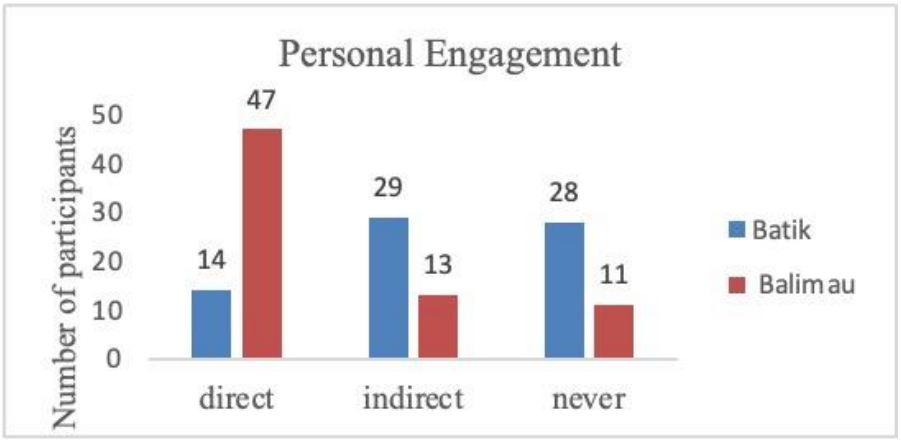
Results

Involvement in *Batik Tanah Liek* and The *Balimau* Tradition

As shown in Figure 2, the level of participant involvement in the two cultural practices shows different patterns. Only 14 of the 71 preservice teachers had been directly involved in making *batik tanah liek* process, while 29 had been indirectly involved, and 28 had no experience at all. In contrast, involvement in the *balimau* tradition was much higher, with 44 participants taking part in it. This variation in experience influenced the patterns of informal reasoning that emerged in the qualitative responses.

Figure 2

Number of participants and level of involvement



Participants with strong cultural involvement demonstrated richer cultural and social reasoning. In the *balimau* tradition, for example, "*Balimau* tradition is part of our customs before Ramadan, so if it is not done, it feels like a loss of family values" (P12). Conversely, participants without experience tended to rely on personal and intuitive reasoning, such as, "I only know that *Balimau* is bathing together, so I don't think it's very relevant to science" (P44). In the context of *batik tanah liek*, participants with direct experience displayed more scientific and environmental reasoning: "The use of clay as a natural dye can be studied from the aspects of material properties and chemical bonds that occur" (P07), and "Clay dyes are more environmentally friendly than chemical dyes" (P26). Conversely, participants without cultural experience showed personal, intuitive, or descriptive reasoning.

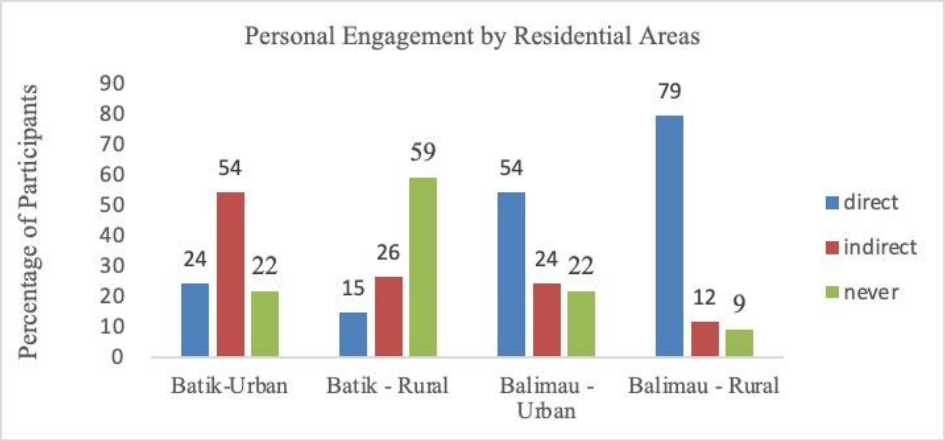
The consistency of this pattern suggested that the higher the cultural involvement, the more complex and reflective the reasoning that emerges. Meanwhile, low involvement tended to produce shallow, intuitive reasoning that is not connected to scientific concepts. These findings show how cultural experiences shape preservice teachers' assessment of the value, meaning, and pedagogical potential of batik (Pavitola et al., 2024).

Participants' engagement with *batik tanah liek* and the *balimau* tradition showed clear variations based on their region of residence, as shown in Figure 3. Respondents from urban areas were generally more familiar with *batik tanah liek* as a local craft product marketed in *batik* centers and souvenir shops, while respondents from rural areas were more familiar with the *balimau* tradition practiced in rivers or open water sources before Ramadan. These geographical differences not only determine cultural proximity but also influence the patterns of informal reasoning that emerge from participants' responses (Suri & Chandra, 2021).

Respondents from rural areas tended to use socio-cultural and personal reasoning, especially regarding the values of togetherness and the spiritual meaning of *balimau*. This is reflected in the statement: "In our village, *balimau* is a moment to cleanse ourselves and gather before fasting. It feels incomplete if you don't participate" (P18). In contrast, participants from urban areas showed more scientific and environmental reasoning when describing *batik tanah liek*; for example, "*Batik tanah liek* is interesting because it uses clay for coloring and is more environmentally friendly. This can be explained by the nature of the material and the coloring process" (P69).

Figure 3

Percentage of participation by region of residence



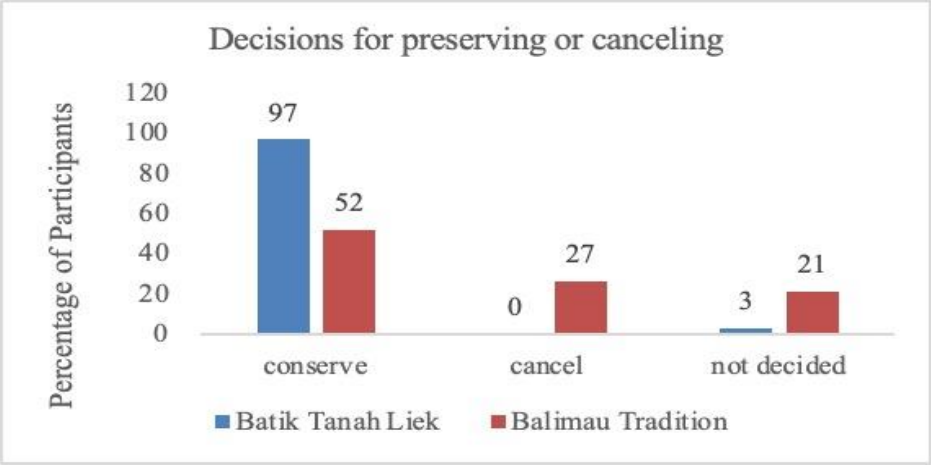
This difference in reasoning patterns indicates that geographical proximity shapes the epistemic orientation of preservice teachers, where proximity to social rituals encourages cultural and value-based reasoning, while proximity to material artifacts triggers scientific and ecological reasoning. These findings are consistent with ethnoscience literature, which asserts that local experiences, cultural identity, and ecological proximity strongly influence how individuals construct arguments on cultural and scientific issues (Sakamoto et al., 2021)

Decisions, Reasons, and Perspectives

Participants' choices about these topics were often reflected in their participation in the two cultural activities. Participants' decisions on whether the *batik tanah liek* and the *balimau* tradition should be abolished or preserved are illustrated in Figure 4.

Figure 4

Participants' decisions to preserve or cancel



Support for the preservation of *batik tanah liek* was generally based on rational-scientific, sociocultural, and environmental reasoning, mainly because of its unique natural dyeing practices as well as its economic and aesthetic value. This was reflected in the statement: "*Batik tanah liek* must clearly be preserved because of its distinctive dyeing technique" (P11). In contrast, decisions regarding the

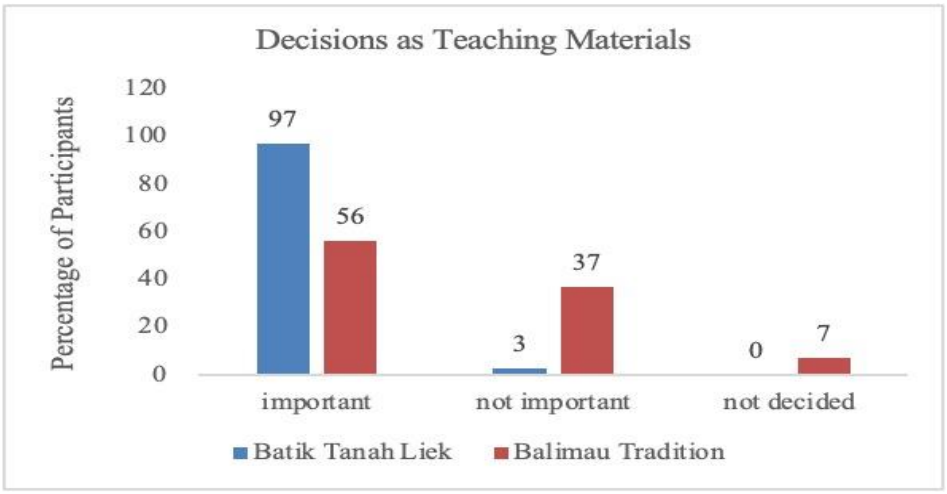
balimau tradition were more influenced by personal, religious-moral reasoning and community values, so support for its preservation was lower and often conditional. One participant stated, "The *balimau* tradition is good for togetherness, but it must be directed so that it does not conflict with religious values" (P34).

This pattern was in line with recent findings on socioscientific issues, which show that individual decisions regarding cultural practices are greatly influenced by the integration of moral values, cultural identity, and scientific considerations (Kılaç, 2024; Tekin & Aslan, 2024). The latest ethnoscience literature also confirms that preservice teachers' perceptions of cultural practices are determined by the extent to which these practices are considered consistent with spiritual values and relevant to the context of science education (Festiyed et al., 2026). Thus, the difference in decisions between the two cultures depended not only on the level of participant involvement but also on how they prioritize scientific, cultural, and religious values in the informal reasoning process that shapes their evaluation of the potential of these practices as sources of ethnoscience-based learning.

Participants indicated that *batik tanah liek* and the *balimau* tradition contain scientific concepts that can be reconstructed into science learning materials, covering aspects of chemistry, biology, and physics. As shown in Figure 5, the majority of participants considered that these two cultural practices are suitable for use as ethnoscience-based teaching materials.

Figure 5

Decision to develop ethnoscience-based teaching materials



The participants' decision to recommend both cultural practices was driven by personal reasoning, evident in their belief that culture-based learning experiences can improve understanding of scientific concepts and relate the material to everyday life. For example, one participant stated, "*Batik tanah liek* has the potential to be used as teaching material because the process is easy for students to understand and is directly related to science concepts" (P52). Social reasoning emerged strongly, especially in the *balimau* tradition, in which participants assessed that this practice contained values of togetherness, public health, and social interaction that were relevant to learning. Cultural reasoning was reflected in arguments that emphasized the importance of preserving ancestral heritage and emotional connections to culture as part of meaningful learning. Environmental reasoning was evident in participants who assessed the potential of teaching materials based on aspects of ecological sustainability. *Batik tanah liek* was considered relevant for teaching green chemistry principles through the use of natural dyes.

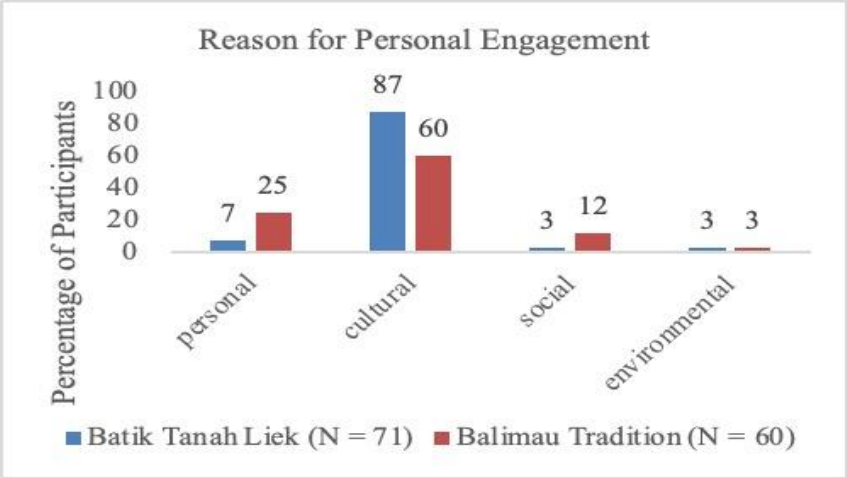
These findings indicate that informal reasoning in a cultural context involves a combination of personal, social, cultural, and environmental aspects, which together shape participants' decisions regarding the suitability of a practice to be used as science teaching material (Ladachart & Ladachart,

2021). Furthermore, these results are consistent with recent literature showing that ethnoscience can strengthen authentic learning contexts and stimulate the development of critical and creative thinking in preservice teachers through explicit links between local culture and scientific concepts (Bicaj et al., 2024; Gürhan, 2025; Koirala, 2023).

Preservice teachers' decisions to recommend *batik tanah liek* and the *balimau* tradition as ethnoscience teaching materials were primarily grounded in cultural reasoning. Figure 6 shows a pattern of reasoning that reflected the integration of personal, social, cultural, and environmental aspects. A total of 87% of participants considered *batik tanah liek* worthy of integration as teaching material because it was considered a cultural heritage rich in educational value, while 60% gave similar reasons for the *balimau* tradition.

Figure 6

Reasons for deciding on this culture as ethnoscience-based teaching material



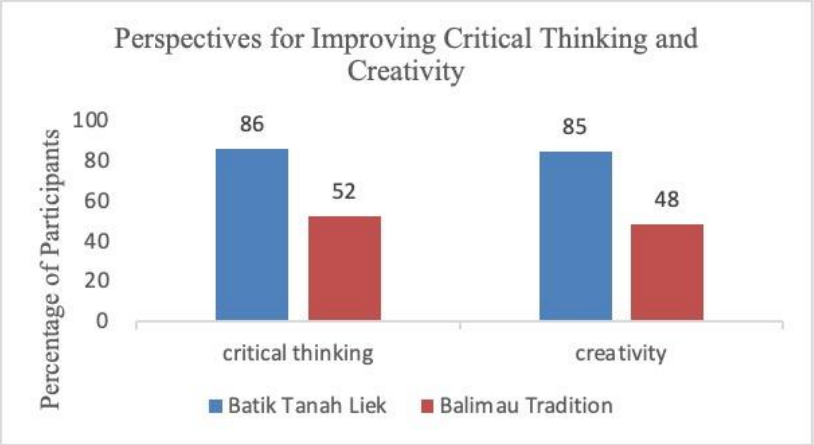
Personal reasons were reflected in responses that adressed the direct benefits of these cultural practices on student understanding and the potential for meaningful learning, such as "*Batik tanah liek* should be used as teaching material because the process contains many chemical and environmental concepts that are easy to explain to students" (P34). Social reasoning was particularly evident in responses related to *balimau*, where participants saw *balimau* as a means of understanding the relationship between humans and the environment and collective behavior. Cultural reasoning emerged from arguments emphasizing local identity, preservation of ancestral heritage, and cultural relevance in science education: "*Balimau* has become a tradition passed down from generation to generation. Teaching it in school will make students feel that our culture is valued" (P47). Environmental reasoning was evident in participants' concern for ecological sustainability and environmental impact: "The process of dyeing *batik* with natural dyes is more environmentally friendly than synthetic dyes" (P14); and "If the *balimau* tradition is not controlled, waste and soap can pollute the water. This is relevant to the topic of environmental pollution" (P58).

The results show that participants' decisions were an integration of scientific assessment, socio-cultural considerations, ecological reflection, and personal experience. This emerging pattern was in line with the framework of SSI, which asserts that informal reasoning in a cultural context involves complex interactions between emotions, intuition, scientific rationality, and socio-cultural values. These findings are consisted with recent research showing that ethnoscience enriches knowledge construction, strengthens authentic learning contexts, and facilitates the development of critical thinking in preservice teachers (Khusniati et al., 2023; Putu Verawati et al., 2022).

Analysis of participants' perspectives (Figure 7) shows that the majority of preservice teachers view *batik tanah liek* as having strong potential for developing critical thinking skills (86%) and creativity (85%), while the level of belief in the *balimau* tradition was relatively lower.

Figure 7

Perspective on ethnoscience-based teaching materials to improve critical and creative thinking



The critical thinking skills that emerged included the participants' ability to analyze cause-and-effect relationships in the *batik* production process, such as the effect of soaking the fabric in clay and the effect of pH changes on color. As one participant stated, "*Batik tanah liek* helps me think more carefully because every stage of its production has a scientific reason" (P32). Creativity was also evident in the participants' ability to propose innovative solutions, such as recommending various plants as natural dyes or developing learning media that combines *batik* motifs and visualizations of chemical compound structures. This pattern was in line with the latest literature findings, which show that cultural context can stimulate critical and creative thinking in preservice teachers (Falah et al., 2024; Fitrianto & Farisi, 2025; Harjono et al., 2025). Thus, participants' belief in the effectiveness of *batik tanah liek* and *balimau* as ethnoscience teaching materials were not merely a positive perception but is reflected in their real cognitive experiences when they reason critically, creatively, and contextually through cultural practices.

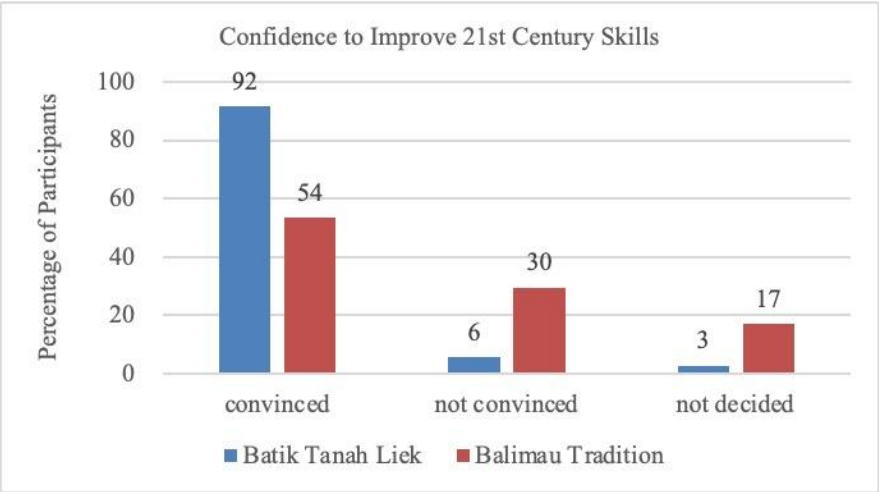
Perception to Potential as Science Teaching Materials

Analysis of participants' beliefs (Figure 8) showed that 92% of preservice teachers believed that *batik tanah liek* has strong potential to support the development of 21st-century skills, especially critical and creative thinking skills. Belief in the *balimau* tradition was lower, mainly because participants considered that its religious and ecological context requires more careful pedagogical consideration.

Preservice teachers' perceptions of the potential of *batik tanah liek* and the *balimau* tradition as science teaching materials were predominantly influenced by scientific-environmental reasoning, as participants mainly assessed the suitability of teaching materials based on the existence of science concepts that could be explored and aspects of environmental sustainability. For example: "*Batik tanah liek* has the potential to teach stoichiometry, chemical bonds, material properties, and natural dyes" (P52). Next is cultural reasoning, in the form of reasons for preserving local identity and heritage values that facilitate contextual learning. For example: This *batik* is the heritage of our ancestors; by teaching it, we will also preserve our culture" (P34).

Figure 8

Belief in ethnoscience-based teaching materials can improve 21st century skills



These findings were in line with the results of ethnoscience research and informal reasoning studies, which show that preservice teachers tend to prioritize direct relevance to science concepts and environmental issues when assessing pedagogical potential, while cultural and social reasons support the relevance of the learning context (Zidny & Eilks, 2022; Koirala, 2023; Sya'ban et al., 2024). These findings were also consistent with research emphasizing that ethnoscience strengthens higher-order thinking constructs and 21st-century science literacy (Dewi et al., 2019; Atmojo et al., 2025). Thus, the participants' beliefs reflect a mature pedagogical understanding of how cultural contexts can be utilized as conceptual and methodological bridges in modern science education.

Discussion

The results of the study show that preservice science teachers had a high level of cultural involvement and awareness of *batik tanah liek* and the *balimau* tradition, two local practices unique to Minangkabau that are rich in scientific and social values. This involvement was an important basis for developing an ethnoscience approach in science education, where traditional knowledge is not positioned as opposed to modern science but as a source of contextual learning that enriches students' understanding of science (Aydin-Ceran, 2021; Syahirah & Sriyati, 2024).

Preservice teachers' interpretations of *batik tanah liek* and the *balimau* tradition as ethnoscience contexts were greatly influenced by variations in cultural experiences, family backgrounds, and ecological proximity to these traditional practices. Thematic analysis showed that four forms of informal reasoning—personal, social, cultural, and environmental—were consistently arranged in the participants' responses and explained the differences in how preservice teachers interpret the two cultural practices as sources of science learning. These findings become more comprehensive when examined using the Ladachart and Ladachart (2021) framework, which maps emotional, intuitive, scientific rational, and socio-cultural reasoning as part of the informal thinking structure in socioscientific issues.

Participants with high cultural experience, especially those directly involved in *balimau* or who had visited a *batik tanah liek* house or center, tended to demonstrate scientific rational reasoning. They were able to identify scientific mechanisms in cultural processes, such as chemical bonds in the *batik* dyeing process, the physical properties of clay, diffusion and temperature changes, and the ecological dynamics of rivers in the *balimau* tradition. This reasoning demonstrates the participants' ability to perform causal analysis, evaluate evidence, identify scientific variables, and construct justifications based on scientific mechanisms. Theoretically, this pattern suggested that concrete cultural experiences function as cognitive triggers that strengthen critical thinking structures and activate conceptual

creativity, namely the ability to produce alternative procedures, modify techniques, or design new representations of scientific processes.

Conversely, participants with low cultural experience more often demonstrated intuitive reasoning. They often gave assessments such as "suitable" or "irrelevant" as science teaching materials without arguments. This is consistent with the theory of informal reasoning, which states that intuition dominates when individuals do not have direct experience or substantive knowledge of an issue (Tarzi, 2025). Meanwhile, emotional reasoning emerged strongly in the *balimau* tradition, which was view as a spiritual and communal practice rich in moral values. Emotions such as pride, a sense of belonging, and religious sensitivity influenced participants' decisions, leading them to assess the practice with pedagogical caution. This factor explains why support for *balimau* as teaching material was lower than for *batik tanah liek*, as the practice carries moral dilemmas and religious sensitivities that demand pedagogical caution.

Socio-cultural reasoning appeared dominant when participants highlighted the function of tradition as collective identity, ancestral heritage, and communal practices that have educational relevance. This form of reasoning demonstrated the participants' ability to weigh the harmony between cultural values, learning objectives, and the social and spiritual impacts of integrating culture into science. Meanwhile, environmental reasoning was strongest in the context of *batik tanah liek*, particularly in relation to the use of natural dyes, ecological sustainability, and the issue of river pollution in *balimau* activities. These findings were in line with studies that confirm that the ethnoscience context allows for complex interactions between values, scientific evidence, and ecological considerations in decision-making (Beniermann et al., 2021; Sakamoto et al., 2021).

Culture functions not only as a context but also as a trigger for critical and creative thinking skills. *Batik tanah liek* offered participants opportunities to analyze the cause and effect relationships in the color fixation process by using natural materials, identify variables such as pH and mordant type, and evaluate the influence of clay quality on dye and fabric durability. Such analytical activities encouraged the development of scientific argumentation and conceptual creativity relevant to science learning. Participants also proposed innovations such as exploring natural dye sources from local plants, varying maceration techniques, or designing *batik*-motif-based learning media. The *balimau* tradition, despite its religious connotations, sparked creative ideas on topics such as health, river ecosystems, and human-environment behavior. These patterns support the finding that authentic cultural contexts enhance preservice teachers' constructive, divergent, and analytical abilities (Idul & Fajardo, 2023).

Furthermore, culture has been shown to stimulate epistemic curiosity, especially when participants discover discrepancies between cultural explanations and scientific mechanisms. This epistemic curiosity encourages deeper exploration and plays an important role in developing inquiry-based learning. In the context of *batik tanah liek*, participants questioned how clay also functions as a color and fabric preservative, why pH changes cause color changes, and how chemical reactions occur in the fixation process. In the *balimau* tradition, participants questioned how *balimau* activities affect body hygiene and river ecological parameters. It is this epistemic curiosity that strengthens scientific argumentation and provides the basis for the development of inquiry-based learning. In ethnoscience-based learning, this scientific argumentation is obtained from the results of analyzing the reconstruction of the community's original science into scientific science. It is this scientific reconstruction that facilitates the simultaneous development of critical and creative thinking skills.

The implications of these findings for teacher education are significant. First, teacher education programs need to explicitly integrate ethnoscience into PCK and TPACK so that preservice teachers not only understand scientific concepts but also able to relate them to cultural contexts in a sensitive and scientific manner. This integration can be achieved through cultural analysis assignments, interactive learning media such as ethnovlogs, ethnoscience-based learning designs, or field experiences involving local practices (Sudarmin et al., 2020). This study emphasizes the importance of training preservice teachers to adress socio-cultural dilemmas—such as conflicts between religious values and traditional practices—through case-based reasoning, reflective dialogue, and culturally responsive pedagogy.

Third, teacher education programs need to strengthen professional competencies in evaluating evidence and constructing scientific arguments, given that intuitive and emotional reasoning still dominates among participants with low cultural engagement. Fourth, these findings indicate that direct experience with local culture can deepen preservice teachers' pedagogical sensitivity, so educational institutions need to facilitate authentic experiences to strengthen the relationship between culture, science, and learning.

Overall, this study confirms that the integration of ethnoscience functions not only as a contextual approach but also as an epistemological space in which preservice teachers develop critical reasoning, creativity, and socio-cultural sensitivity. The variations in informal reasoning found reveal the complexity of how preservice teachers combine scientific evidence, cultural values, emotional experiences, intuition, and ecological considerations to understand socioscientific issues. Thus, ethnoscience has the potential to become an important foundation in developing a culturally responsive teacher education curriculum that equips preservice educators to adress the diversity of values and complexities of 21st-century science education.

Conclusion

This study indicates that preservice teachers' informal reasoning in evaluating *batik tanah liek* and the *balimau* tradition is influenced by cultural experiences, family background, and ecological proximity. Four categories of reasoning—personal, social, cultural, and environmental—emerge as the main framework explaining how preservice teachers weigh the scientific, social, and pedagogical values of this ethnoscience. These findings make an important theoretical contribution by expanding the ethnoscience framework through the integration of the informal reasoning dimension so that cultural meaning in science education is not only understood as the transfer of local knowledge but as a cognitive process involving the evaluation of evidence, cultural intuition, and moral and social considerations. The resulting reasoning categorization model offers new analytical contributions that can be used to examine how preservice teachers construct scientific arguments in ethnoscience.

This study directly addresses a gap in the literature on how preservice teachers argue about cultural practices in the context of ethnoscience to develop critical and creative skills, a theme that is still rarely researched in the context of Southeast Asia. The dilemma between religious-moral values and scientific accuracy was found to influence how preservice teachers make pedagogical decisions. They view this conflict of values as a professional challenge that requires a balance between scientific integrity, respect for students' beliefs, and cultural sensitivity. From the perspective of preservice teachers, value conflicts are not considered obstacles but rather spaces for negotiation that must be carefully managed through culturally responsive pedagogical approaches. The findings of this study emphasize the importance of exploring local culture as a means of training prospective teachers' logical thinking skills, because cultural contexts provide authentic phenomena that stimulate evidence analysis, scientific reasoning, and value evaluation. Furthermore, this study emphasize the necessity to integrate ethnoscience into the teacher education curriculum and to use informal reasoning models as assessment tools to map prospective teachers' epistemological readiness in dealing with culture-based socioscientific issues.

Limitation

This study has several limitations that need to be considered in interpreting the findings. First, the use of open-ended questionnaires as the main instrument limits the depth of analysis, as the qualitative data produced is declarative and does not allow for a more comprehensive exploration of the dynamics of participants' reasoning in real situations. Second, cultural and religious topics—particularly those related to the *balimau* traditions—have the potential to produce social desirability bias, so that some participants may give answers that are considered most socially or religiously acceptable. Third, data interpretation may be influenced by researcher positionality, given that the

researchers were in the same cultural context as the participants. Although this potential bias was minimized through discussions among researchers and peer debriefing, reflection on the researchers' position remains an important consideration in culture-based qualitative research.

Suggestion

Based on the research results and existing limitations, several recommendations are put forward for further research and ethnoscience education practices.

Recommendations for Further Research

Future research needs to develop a specific informal reasoning framework for ethnoscience so that socio-cultural practices in science education can be analyzed more systematically. In addition, quasi-experimental studies are needed to test the effectiveness of ethnoscience interventions on critical thinking, creativity, and science literacy. An ethnoscience-based teacher education model that integrates PCK/TPACK, cultural dilemma analysis, and informal reasoning development also needs to be developed.

Practical Suggestions for Education and Learning

Lecturers who teach at educational institutions are advised to integrate ethnoscience-based microteaching so that students practice designing and reflecting on science learning based on local culture. School teachers need to implement cultural practice analysis, science concept mapping, and contextual socioscientific issue discussions to strengthen the relevance of learning. Curriculum developers need to prepare assessment rubrics for culture-based informal reasoning that cover scientific, social, moral, and environmental dimensions. Schools and communities also need to expand collaboration with *batik* artisans, traditional leaders, or cultural actors to provide authentic experiences that support deep learning and ethnoscience-based science.

Acknowledgements

The authors would like to thank the preservice science teachers who participated in this study for their valuable insights. Appreciation is also extended to colleagues and experts who provided feedback during the validation of instruments. This research was supported by the Faculty of Tarbiyah and Education Universitas Islam Negeri Imam Bonjol Padang and The Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Indonesia. This research did not receive specific funding from any public, commercial, or non-profit organization.

Declaration of Interest

The authors declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. *Educational and Psychological Measurement*, *45*(1), 131–142. https://doi.org/doi.org/10.1177/0013164485451012

Atmojo, S. E., Anggriani, M. D., Rahmawati, R. D., Skotnicka, M., Wardana, A. K., & Anindya, A. P. (2025). Bridging Stem and culture: the role of ethnoscience in developing critical thinking and cultural literacy. *Jurnal Pendidikan IPA Indonesia*, *14*(2), 251–266. https://doi.org/10.15294/jpii.v14i2.23505

Aydin-Ceran, S. (2021). *Contextual learning and teaching approach in 21st century science education. Current Studies in Social Sciences*. ISRES Publishing.

Aziz, A. A., & Johari, M. (2023). The effect of argumentation about socio-scientific ıssues on secondary students' reasoning pattern and quality. *Research in Science Education*, *53*(4), 771–789. https://doi.org/10.1007/s11165-023-10099-5

Baptista, G. C. S., & Molina-Andrade, A. (2023). Science teachers' conceptions about the ımportance of teaching and how to teach western science to students from traditional communities. *Human Arenas*, *6*(4), 704–731. https://doi.org/10.1007/s42087-021-00257-4

Beniermann, A., Mecklenburg, L., & Upmeier Zu Belzen, A. (2021). Reasoning on controversial science issues in science education and science communication. *Education Sciences*, *11*(9). https://doi.org/10.3390/educsci11090522

Bicaj, A., Berisha, F., & Gisewhite, R. (2024). Exploring ın-service science teachers' self-perceptions of competence and pedagogical approaches to socioscientific ıssues in education. *Education Sciences*, *14*(11). https://doi.org/10.3390/educsci14111249

Brown, J. C., Pringle, R. M., & Kotluk, N. (2022). *A literature review of global perspectives on the professional development of culturally responsive science teachers*. Handbook of research on science teacher education.

Budiarti, A., Haryani, S., Sumarni, W., & Prasetya, A. T. (2025). Health issues within the socioscientific context: Systematic literature review. *Journal of Turkish Science Education*, *22*(2), 220–247. https://doi.org/10.36681/tused.2025.012

Capkinoglu, E., Yilmaz, S., & Leblebicioglu, G. (2020). Quality of argumentation by seventh-graders in local socioscientific issues. *Journal of Research in Science Teaching*, *57*(6), 827–855. https://doi.org/10.1002/tea.21609

Chan, C. K. Y., & Yeung, N. C. J. (2021). To assess or not to assess holistic competencies – Student perspectives in Hong Kong. *Studies in Educational Evaluation*, *68*. https://doi.org/10.1016/j.stueduc.2021.100984

Clarke, V., & Braun, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *12*(3), 297–298. https://doi.org/10.1080/17439760.2016.1262613

D'Ambrosio, U. (2021). Socio-cultural foundation of mathematics and science education. In *Cuadernos de Investigación y Formación En Educación Matemática, Especial*. https://archivo.revistas.ucr.ac.cr/index.php/cifem/article/view/49177/48949.

Dewi, C. A., Khery, Y., & Erna, M. (2019). An ethnoscience study in chemistry learning to develop scientific literacy. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 279–287. https://doi.org/10.15294/jpii.v8i2.19261

Falah, M. M., Hartono, Nugroho, S. E., & Ridlo, S. (2024). Socio-scientific Issues (SSI) research trends: A systematic literature review of publications 2011 – 2022. *Journal of Turkish Science Education*, *21*(1), 61–81. https://doi.org/10.36681/tused.2024.004

Festiyed, Ismail, I. A., Lufri, L., Mawardi, M., & Insani, M. (2026). Culturally responsive science education through ethnoscience: A meta-analysis of impact on junior high school students. *Multidisciplinary Reviews*, *9*(1). https://doi.org/10.31893/MULTIREV.2026004

Gürhan, E. (2025). Prospective primary school teachers' perspectives on environmental education, cultural heritage, and values education: an action research study. Tarbiyah. *Jurnal Ilmiah Kependidikan*, *14*(1), 43–55. https://doi.org/https://doi.org/10.18592/tarbiyah.v14i1.15808

Han-Tosunoglu, C., & Ozer, F. (2022). Exploring pre-service biology teachers' ınformal reasoning and decision-making about COVID-19. *Science and Education*, *31*(2), 325–355. https://doi.org/10.1007/s11191-021-00272-5

Harjono, A., Verawati, N. N. S. P., Wahyudi, Gummah, S., & Prayogi, S. (2025). Integrating ethnoscience in inquiry-creative learning: a new breakthrough in enhancing critical thinking. *International Journal of Evaluation and Research in Education*, *14*(1), 636–647.

https://doi.org/10.11591/ijere.v14i1.29259
Ibnu Fitrianto, & Muhammad Farisi. (2025). Integrating local wisdom into 21st century skills: a contextual framework for culturally relevant pedagogy in rural classrooms. *International Journal of Post Axial: Futuristic Teaching and Learning*, 109–121. https://doi.org/10.59944/postaxial.v3i2.444
Idul, J. J. A., & Fajardo, M. T. M. (2023). Ethnoscience-based physical science learning and its effects on students' critical thinking skills: A meta-analysis study. *Journal of Mathematics and Science Teacher*, *3*(2), em048. https://doi.org/10.29333/mathsciteacher/13700
Isa, I. M. M., Bunyamin, M. A. H., & Phang, F. A. (2022). Bridging culture and science education: ımplications for research and practice. *International Journal of Learning, Teaching and Educational Research*, *21*(10), 362–380. https://doi.org/10.26803/ijlter.21.10.20
Jansong, C., Pitiporntapin, S., Chumnanpuen, P., Hines, L. M., & Yokyong, S. (2022). Using socio-scientific issues-based teaching to develop grade 10 students' informal reasoning skills. *Kasetsart Journal of Social Sciences*, *43*(1), 217–222. https://doi.org/10.34044/j.kjss.2022.43.1.29
Kara, S. (2025). Evaluation of interdisciplinary science teaching practices in the context of socioscientific issues. *International Journal of Science Education*. https://doi.org/10.1080/09500693.2025.2540620
Khahro, S. H., & Javed, Y. (2022). Key challenges in 21st century learning: a way forward towards sustainable higher educational ınstitutions. *Sustainability (Switzerland)*, *14*(23). https://doi.org/10.3390/su142316080
Khairani, Dewata, I., & Angraina, D. (2020). *Direction of sustainable development policy in the water catchment areas (watershed) Koto Panjang Reservoir*. https://doi.org/10.2991/assehr.k.200824.041
Khery, Y., Hakim, A., Rokhmat, J., & Sukarso, A. (2025). Effectiveness of ethnoscience oriented project to improve students performance. *Multidisciplinary Science Journal*, *7*(8). https://doi.org/10.31893/multiscience.2025417

Khusniati, M., Heriyanti, A. P., Aryani, N. P., Fariz, T. R., & Harjunowibowo, D. (2023). Indigenous science constructs based on Troso woven fabric local wisdom: a study in ethnoscience and ethnoecology. *Journal of Turkish Science Education*, *20*(3), 549–566. https://doi.org/10.36681/tused.2023.031
Kılaç, E. (2024). *Facilitating preservice science teachers' shift from learner to teacher of socioscientific issue-based science teaching (Master's thesis.* [Middle East Technical University]. https://hdl.handle.net/11511/111435
Koirala, K. P. (2023). Ethno science practice as ındigenous wisdom: challenges to braiding with Western-based school science curriculum. *Diaspora, Indigenous, and Minority Education*, *17*(4), 270–282. https://doi.org/10.1080/15595692.2022.2138321
Ladachart, L., & Ladachart, L. (2021). Preservice biology teachers' decision-making and informal reasoning about culture-based socioscientific issues. *International Journal of Science Education*, *43*(5), 641–671. https://doi.org/10.1080/09500693.2021.1876958
Latip, A., Hernani, & Kadarohman, A. (2024). Local and indigenous knowledge (LIK) in science learning: A systematic literature review. *Journal of Turkish Science Education*, *21*(4), 651–667. https://doi.org/10.36681/tused.2024.035
Liu, J., Liu, Z., Wang, C., Xu, Y., Chen, J., & Cheng, Y. (2024). K-12 students' higher-order thinking skills: Conceptualization, components, and evaluation indicators. *Thinking Skills and Creativity*, *52*. https://doi.org/10.1016/j.tsc.2024.101551
Mansour, N. (2024). Students' and facilitators' experiences with synchronous and asynchronous online dialogic discussions and e-facilitation in understanding the Nature of Science. *Education and Information Technologies*, *29*(12), 15965–15997. https://doi.org/10.1007/s10639-024-12473-w
Mavuru, L., & Ramnarain, U. (2020). Learners' socio-cultural backgrounds and science teaching and learning: a case study of township schools in South Africa. *Cultural Studies of Science Education*, *15*(4), 1067–1095. https://doi.org/10.1007/s11422-020-09974-8
Meral, E., Namli, Z. B., & Kayaalp, F. (2021). The effect of argumentation-based teaching on developing argument skills of prospective teachers, and on their willingness to debate. *International Journal of*

Curriculum and Instruction, *13*(2), 1039–1062.

Mnguni, L., & Gasa, V. (2024). The socioscientific ıssues framework as a tool to enhance health education within the life sciences curriculum in South Africa. *Contemporary Trends and Issues in Science Education*, *61*, 269–285. https://doi.org/10.1007/978-3-031-63382-9_15

Pavitola, L., Latsone, L., & Usca, S. (2024). The transformation of educational values via cultural offerings in the context of teacher education. *Social Sciences*, *13*(4). https://doi.org/10.3390/socsci13040188

Putu Verawati, N. N. S., Harjono, A., Wahyudi, & Gummah, S. (2022). Inquiry-creative learning ıntegrated with ethnoscience: efforts to encourage prospective science teachers' critical thinking in Indonesia. *International Journal of Learning, Teaching and Educational Research*, *21*(9), 232–248. https://doi.org/10.26803/ijlter.21.9.13

Reiser, B. J., Novak, M., McGill, T. A. W., & Penuel, W. R. (2021). Storyline units: an ınstructional model to support coherence from the students' perspective. *Journal of Science Teacher Education*, *32*(7), 805–829. https://doi.org/10.1080/1046560X.2021.1884784

Rexhepi, B., & Bajrami, A. (2025). Ethno-pedagogical module: a theoretical exploration of knowledge transmission in ethnobiological systems. *International Journal of Environment, Engineering and Education*, *7*(1), 1–12. https://doi.org/10.55151/ijeedu.v7i1.181

Rizaldi, D. R., Andayani, Y., Doyan, A., Makhrus, M., Fatimah, Z., & Nurhayati, E. (2021). The use of Betel leaf in Nyirih tradition: Analyzing an ethnoscience-based learning material. *International Journal on Education Insight*, *2*(1), 29. https://doi.org/10.12928/ijei.v2i1.3579

Roza, M. N. (2025). Identification of scientific knowledge in the making process of batik tanah liek as teaching materials in ethnoscience-based learning. *International Journal of Latest Engineering Research and Applications (IJLERA)*, *10*(1), 01–11. https://doi.org/10.56581/IJLERA.10.1.01-11

Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, *41*(5), 513–536. https://doi.org/10.1002/tea.20009

Sakamoto, M., Yamaguchi, E., Yamamoto, T., & Wakabayashi, K. (2021). An intervention study on students' decision-making towards consensus building on socio-scientific issues. *International Journal of Science Education*, *43*(12), 1965–1983. https://doi.org/10.1080/09500693.2021.1947541

Sasmita, Lukum, A., Thayban, T., Kunusa, W. R., & Munandar, H. (2025). Integrating ethnoscience into project-based learning: enhancing creative thinking and learning motivation on reaction rate. Journal of Physics: Conference Series, 3148(1). https://doi.org/10.1088/1742-6596/3148/1/012025

Sarkingobir, Y., & Bello, A. (2024). Enhancing critical thinking through ethnoscience-ıntegrated problem-based learning: a comparative study in secondary education. *International Journal of Ethnoscience and Technology in Education*, *1*(1), 1. https://doi.org/10.33394/ijete.v1i1.10878

Siew, N. M., & Arifin, S. (2025). Fostering creative thinking in entrepreneurship among rural students through socio-scientific ıssues and design thinking ıntegration in science education. *Journal of Baltic Science Education*, *24*(1), 169–186. https://doi.org/10.33225/jbse/25.24.169

Sudarmin, Sumarni, W., Mursiti, S., & Sumarti, S. S. (2020). Students' innovative and creative thinking skill profile in designing chemical batik after experiencing ethnoscience integrated science technology engineering mathematic integrated ethnoscience (ethno-stem) learnings. *Journal of Physics: Conference Series*, *1567*(2). https://doi.org/10.1088/1742-6596/1567/2/022037

Sumarni, W., Kadarwati, S., & Susilaningsih, E. (2025). Ethno-STEAM science learning to improve prospective teachers' creative thinking and problem-solving skills. *Journal of Turkish Science Education*, *22*(3), 488–507. https://doi.org/10.36681/tused.2025.025

Suri, D., & Chandra, D. (2021). Teacher's strategy for implementing multiculturalism education based on local cultural values and character building for early childhood education. *Journal of Ethnic and Cultural Studies*, *8*(4), 271–285. https://doi.org/10.29333/ejecs/937

Sya'ban, M. F., Rahmat, A., Sriyati, S., & Sumarna, O. (2024). Research on ethnoscience in science education: an analysis of the literature. *KnE Social Sciences*. https://doi.org/10.18502/kss.v9i13.16065

Syahirah, S., & Sriyati, S. (2024). Study of the malabot tumpe tradition in Banggai regency as an

ethnopedagogical ımplementation of biology material. *Journal of Innovation in Educational and Cultural Research*, *5*(4), 702–712. https://doi.org/10.46843/jiecr.v5i4.1939

Tarzi, A. (2025). *Intuition in decision making* (Unpublished doctoral dissertation). Saybrook University.

Tekin, N., & Aslan, O. (2024). Informal reasoning patterns and ınfluencing factors of science teachers in the context of local socioscientific ıssues. *Malaysian Online Journal of Educational Sciences (MOJES)*, *12*(2), 35–46. https://doi.org/10.22452/mojes.vol12no2.3

Tovar-Gálvez, J. C. (2021). The epistemological bridge as a framework to guide teachers to design culturally inclusive practices. *International Journal of Science Education*, *43*(5), 760–776. https://doi.org/10.1080/09500693.2021.1883203

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). https://doi.org/10.31893/multirev.2025343

Zeidler, D. L., & Sadler, T. D. (2023). *Exploring and expanding the frontiers of socioscientific issues.* In Handbook of research on science education, Routledge.

Zeidler, D. L., & Nichols, B. H. (2009). Socioscientific issues: Theory and practice. *Journal of Elementary Science Education*, *21*(2), 49–58. https://doi.org/10.1007/bf03173684

Zidny, R., & Eilks, I. (2022). Learning about pesticide use adapted from ethnoscience as a contribution to green and sustainable chemistry education. *Education Sciences*, *12*(4). https://doi.org/10.3390/educsci12040227