

The effectiveness of problem-based learning (PBL) model integrated with ethnoscience in improving students' higher-order thinking skills and scientific literacy



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Abstract The higher-order thinking skills and scientific literacy of elementary school students are still low. One way to improve them is by implementing a problem-based learning (PBL) model integrated with ethnoscience. The purpose of this study was to examine the effectiveness of a PBL model integrated with ethnoscience in improving students' higher-order thinking skills and scientific literacy. A quasi experimental pretest-posttest control group design was used, with 115 elementary school students participating in the study. Students were divided into two groups, with one group being taught using the PBL model integrated with ethnoscience and the other group using a conventional model as a comparison. Data were collected using a researcher-developed test that was validated by experts. Data were analyzed using the N-Gain score and MANOVA. Pillai's Trace assessed multiple outcomes due to heterogeneity of variance-covariance matrices. The Welch test evaluated model effectiveness for higher-order thinking skills because variance homogeneity was unmet. For scientific literacy, a one-way ANOVA was used as all assumptions held. The criterion for accepting the hypothesis was set at a p-value (Sig.) of less than 0.05. The results showed that the N-Gain score for higher-order thinking skills was 0.41, categorized as moderate, and the N-Gain score for students' scientific literacy was 0.5, also in the moderate category. This suggests that the PBL model integrated with ethnoscience moderately enhances elementary students' higher-order thinking and scientific literacy. This finding was further supported by the p-value obtained in the analysis of the Pillai's Trace test, Welch's test, and one-way ANOVA were all 0.000, which is less than 0.05. Consequently, this study recommends the integrated ethnoscience to PBL model as an alternative approach for elementary school teachers to enhance students' higher-order thinking skills and scientific literacy.

Keyword: culturally responsive teaching, constructivist learning, contextual learning, indigenous knowledge system, 21-century skills

1. Introduction

The 21st century is characterized by the emergence of the Fourth Industrial Revolution, also known as the Internet of Things (IoT) era (Roll & Ifenthaler, 2020). This revolution necessitates changes across all facets of life (Trilling & Fadel, 2009) and has significant implications for societal demands. The advancement of technologies such as computers, robots, and artificial intelligence (AI) may lead to workforce reductions unless new tasks are created to replace those automated tasks (Peetz, 2019). AI facilitates various platforms for transactions involving goods and services (Tyson & Zysman, 2022; Acemoglu & Restrepo, 2019), which can replace many jobs once performed by humans. As a result, individuals in this era must be adept at locating and analyzing information from multiple sources, using that information to make informed decisions and generate new ideas (Silva, 2009). This necessity underscores the importance of developing the skills and knowledge essential for success now and in the future. Key competencies include higher-order thinking skills (Saavedra & Opfer, 2012) and scientific literacy (UNEP, 2012). However, in Indonesia, the levels of scientific literacy among students remain low. This concern is highlighted by the PISA results, which placed Indonesia ranked in the bottom 10 of 79 participating countries in 2018 (Badan Penelitian dan Pengembangan dan Perbukuan Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2021), particularly 70th (Anggraena, 2021). Research indicates that elementary school students exhibit low levels of scientific literacy (Astria et al., 2024; Handayani et al., 2023; Harahap et al., 2022; Utami et al., 2022). Furthermore, their higher-order thinking skills are also relatively underdeveloped (Kurniawati et al., 2020; Maryani et al., 2021).

Higher-order thinking skills involve complex cognitive processes such as analyzing information, generating conclusions, constructing representations, and establishing connections through basic mental activities (Resnick, 1987). These skills require

students not only to reproduce knowledge but also to build understanding, connect information, evaluate arguments, and develop original solutions. In other words, higher-order thinking is a form of reflective and logical thinking that enables individuals to solve complex problems, make informed decisions, and creatively generate new ideas (Zohar & Dori, 2003).

These skills encompass knowledge transfer, critical thinking, and problem-solving activities (Brookhart, 2010; Ariyana, et al., 2018; Thahir et al., 2021). Additionally, scientific literacy plays a crucial role in shaping thought patterns and behaviors, as well as fostering a sense of responsibility and care within individuals, for themselves, society, and the universe (Kemendikbud, 2017). Literate individuals should understand that science not only provides solutions but also carries risks that can lead to various problems. By recognizing this, they can make informed and wise decisions when utilizing scientific knowledge.

According to the OECD, scientific literacy refers to the ability to engage with science-related issues and concepts as thoughtful citizens (OECD, 2019b). It involves using scientific knowledge to identify questions, draw evidence-based conclusions, and understand nature, including the changes brought about by human activities (Holbrook & Rannikmae, 2009). This study synthesizes the above definitions into three dimensions of scientific literacy: (1) Content dimension: This refers to knowledge of basic scientific concepts and principles; (2) Procedural dimension: This involves understanding how science operates, including skills such as observing, generating conclusions, designing experiments, and validating data; (3) Contextual dimension: This relates to the ability to connect science to real-life situations and apply it in various areas such as health, the environment, and technology.

One reason for the low levels of higher-order thinking skills and scientific literacy among students is non-contextual learning (Fuadi et al., 2020; Suparya et al., 2022). Non-contextual learning often presents material in an abstract way, making it less relevant to students' lives. Without a relevant context, students find it difficult to think analytically, evaluatively, and creatively, which are essential components of higher-order thinking (Anderson et al., 2010). When learning is disconnected from real-world contexts, students have difficulty to apply scientific concepts to everyday situations, which is fundamental to achieving scientific literacy (Bybee, 1997).

In response to this issue, PBL (Problem-Based Learning) has emerged as a relevant solution. Problem Based Learning (PBL) is a teaching strategy that starts with presenting students with unstructured and complex problems. This approach encourages students to identify their learning needs, gather relevant information, and apply that knowledge to solve the problems they encounter (Barrows & Tamblyn, 1980). Additionally, Hmelo-Silver explains that PBL is designed to help students to develop flexible knowledge that can be utilized in various contexts, enhance their reasoning and problem-solving abilities, foster lifelong learning skills, and promote teamwork (Hmelo-Silver, 2004). Research by (Smith et al., 2022) suggests that the PBL approach can effectively to help students to improve their critical thinking skills, problem-solving capabilities, and the ability to integrate knowledge.

There are several characteristics of Problem-Based Learning (PBL) outlined by (Kek & Huijser, 2016). These include the following; (1) authentic problems that serve as learning triggers (Barrows & Barrows, 1986; Dolmans et al., 2005). (2) the development of problem-solving skills and meaningful learning experiences (Dolmans et al., 2005). (3) student-centered learning approach (Hmelo-Silver, 2004; Savery & Savery, 2006). (4) Inquiry-based learning practices (Hmelo-Silver et al., 2007; Hmelo-Silver & Barrows, 2006). (5) emphasis on collaboration and teamwork (De Graaff & Kolmos, 2003). (6) evaluation is based on both process and products (Savery, 2015).

PBL promotes the development of Higher Order Thinking Skills (HOTS) through activities such as formulating meaningful questions, assessing the validity of information, organizing ideas, and reflecting on the strategies employed (Hmelo-Silver, 2004). In PBL, students are consistently presented with open-ended or unstructured problems that encourage them to analyze information, evaluate various alternative solutions, and design new approaches based on arguments and evidence (Hung et al., 2020; Savery & Savery, 2006). Numerous studies have demonstrated the effectiveness of PBL in enhancing HOTS (Affandy et al., 2024; Arviani et al., 2023; Sutika et al., 2023; Utomo et al., 2019; Yew & Goh, 2016). In elementary schools, implementing the PBL model allow the students to improve one aspect of higher-order thinking, specifically critical thinking skills (Jalinus et al., 2017; Yuniyanto et al., 2024).

Project-Based Learning (PBL) offers students the opportunity to develop a deeper understanding of concepts through inquiry practices. This includes formulating hypotheses, designing experiments, collecting data, and drawing conclusions. By engaging in these activities, students not only learn scientific content but also gain insight into how science functions in everyday life (Hmelo-Silver et al., 2007). In elementary schools, implementing the PBL model can enhance students' scientific literacy (Aiman et al., 2019; Aiman & Ahmad, 2020; Azka et al., 2023; Indrawan et al., 2022; Nurfadilah & Cahyaningsih, 2024).

In project-based learning (PBL), the problems presented for study are real-world, relevant, and contextual (Stepien et al., 1993). To make the learning experience truly meaningful for elementary school students, the problems or materials should come from the socio-cultural environments that are familiar to them. Learning based on local knowledge allows the students to develop scientific understanding rooted in their everyday experiences (Aikenhead & Ogawa, 2007; Snively & Corsiglia, 2001). This local knowledge is referred to by various terms, such as indigenous science (Kawagley, 2009; Snively & Corsiglia, 2001), indigenous knowledge (Agrawal, 1995), and native science (Cajete, 2000). In Indonesia, researchers use the term "ethnoscience" to describe this concept (Sudarmin, 2014).

The term “ethnoscience” is derived from the words “ethno,” meaning nation or cultural group, and “science” (Williams & Ortiz-Solorio, 1981). It literally refers to “the science possessed by a cultural group.” Ethnoscience represents a unique system of knowledge and cognition specific to a particular culture (Toledo, 1992). This knowledge system includes the scientific understanding and practices of an indigenous culture (Snively & Williams, 2018), encompassing insights about nature, ecosystems, and the relationship between humans and the natural world. Ethnoscience develops through direct experience and observation (Cajete, 2000; Zidny & Eilks, 2022), allowing cultures to adapt and live in harmony with natural principles (Kawagley, 2009).

Ethnoscience is a type of indigenous science that includes not only practical knowledge but also the values, ethics, and belief systems of local communities regarding nature (Snively & Corsiglia, 2001). Communities use this knowledge to understand natural phenomena, classify organisms, predict weather patterns, manage agricultural systems, and maintain health, all of which are based on traditions and experiences passed down through generations (Semali & Kincheloe, 2002; Snively & Corsiglia, 2001). The study of ethnoscience is grounded in the idea that culture functions as a system of knowledge, which helps a community to understand and respond to their situations. This knowledge is crucial for interpreting and managing various phenomena in their lives (Putra, 2021). Therefore, ethnoscience focuses on comprehending culture as a body of knowledge developed by a community to address the challenges and phenomena they encounter.

The ethnoscience approach connects scientific learning materials more closely with the existing knowledge within local communities. This connection helps students better understand scientific concepts because they relate directly to their own lives (Aikenhead & Michell, 2011). Integrating ethnoscience into Problem-Based Learning models can serve as an effective solution to the low levels of higher-order thinking skills and scientific literacy among students. Therefore, the purpose of this study is to evaluate the effectiveness of the ethnoscience-integrated Problem-Based Learning model in enhancing higher-order thinking skills and scientific literacy among elementary school students.

2. Materials and Methods

This study is part of research focused on developing the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), as designed by (Branch, 2009). The aim of this study is to evaluate the effectiveness of an integrated ethnoscience problem-based learning model in enhancing the higher-order thinking skills and scientific literacy of elementary school students. A quasi-experimental pretest-posttest control group design was utilized, as described by (Creswell, 2012), involving 115 students from six elementary schools in East Lombok, West Nusa Tenggara, Indonesia. These schools were selected based on their regional characteristics, which included coastal, rural, and urban areas. Out of the 115 students, 58 students were taught using the integrated ethnoscience problem-based learning model, while the remaining 57 students were received instruction through a conventional model that relied primarily on teacher and standard question-and-answer sessions.

Data were collected using tests developed in-house that focused on higher-order thinking skills (Anderson & Krathwohl, 2010; Brookhart, 2010) and scientific literacy (OECD, 2019a). The instruments were validated by experts, and the learning model was developed and analyzed according to (Lawshe, 1975). Data analysis was conducted simultaneously using MANOVA (Pituch & Stevens, 2016), applying Pillai’s Trace method since the assumption of multivariate homogeneity was not met (Candiasa, 2020; Olson, 1974). For partial tests, Welch’s test (Welch, 1951) was utilized for non-homogeneous data, while one-way ANOVA was used for homogeneous data. Testing was performed by using SPSS 25.0, and the hypothesis was accepted if the significance level (Sig.) was less than 0.05.

3. Results

3.1. Profile of Students' Higher-Order Thinking Skills

The analysis results comparing the higher-order thinking skills of the students in the two treatment groups are presented in Table 1. The experimental group utilized an integrated ethnoscience problem-based learning model, while the control group followed a conventional learning model. The data includes average pretest and posttest scores, N-Gain scores, and improvement categories.

Table 1 Profile of Students' Higher-Order Thinking Skills.

Group	Mean		N-Gain	Category
	Pretest	Posttest		
PBL integrated ethnoscience	44,26	67,95	0,43	Moderate
Conventional model	43,09	47,82	0,06	Low

Table 1 illustrates that in the group employing the integrated ethnoscience problem-based learning model, the average pretest score was 44.26, indicating the students' initial abilities prior to the learning intervention. Following the learning process with this model, the average posttest score rose to 67.95. This increase in scores demonstrates a significant enhancement in higher-order thinking skills. The average N-Gain score of 0.43 categorizes this improvement as moderate. This

finding suggests that the integrated ethnoscience problem-based learning model is effective in promoting the development of students' analytical, evaluative, and creative abilities.

In the group that received instruction through the conventional model, the average pretest score was 43.09, which was only slightly lower than that of the integrated PBL model group. However, after the learning process, the average posttest score increased to only 47.82, indicating a minimal improvement. The calculated N-Gain score was 0.06, which falls into the low category. This suggests that the conventional approach has a limited impact on the development of students' higher-order thinking skills.

3.2. Profile Students' Scientific Literacy

The data on students' scientific literacy obtained from descriptive analysis is presented in the following Table 2:

Table 2 Profile Students' Scientific Literacy.

Group	Mean		N-Gain	Category
	Pretest	Posttest		
PBL integrated ethnoscience	38,07	69,67	0,5	Sedang
Conventional model	39,11	40,44	0,01	Rendah

Based on the table above, the group that utilized the integrated ethnoscience in to Problem-Based Learning (PBL) model demonstrated notable improvements in their academic performance. Before receiving the intervention, their average pretest score was 38.07. After engaging in the learning experience with the integrated ethnoscience PBL model, the average posttest score rose significantly to 69.67. This increase indicates a substantial enhancement in the students' scientific literacy. Furthermore, the average N-Gain value of 0.5 suggests that the integrated ethnoscience PBL model is quite effective in helping students understand, engage with, and apply scientific concepts.

In contrast, the group using conventional model recorded an average pretest score of 39.11, which was slightly higher than that of the integrated PBL group. However, after the learning process, this group only achieved an average post-test score of only 40.44. This minimal increase in scores is reflected in the average N-Gain score of 0.01, which is categorized as low. This result indicates that the conventional learning model is less effective in improving students' scientific literacy.

3.3. The Effectiveness of the Integrated Ethnoscience Problem-Based Learning Model in Improving Higher-Order Thinking Skills and Scientific Literacy.

The effectiveness of the integrated ethnoscience problem-based learning model in enhancing higher-order thinking skills and scientific literacy is illustrated in the following Table 3:

Table 3 Results of Model Effectiveness Testing.

Hypothesis	Type of Test	Statistical Value	Significance (Sig.)
I	Pillai's Trace	20,168	0,000
II	Welch Test	76,541	0,000
III	One Way Anova	132,661	0,000

Based on the information presented in Table 3, there are three types of statistical tests were employed due to the violation of one of the assumption tests, specifically homogeneity. In Hypothesis I, which examines the effectiveness of the Problem-Basee Learning with Integrated Ethnoscience (PBLIE) model in improving students' higher-order thinking skills and scientific literacy, the Pillai's Trace method was utilized as part of the Multivariate Analysis Of Variance (MANOVA) test. The results showed a statistical value of 20.168 with a significance level of 0.000. This significance value is well below the established threshold ($\alpha = 0.05$), which indicates a statistically significant difference between the group of students taught using the integrated ethnoscience PBL model and the group of students instructed with the conventional model. Thus, it can be concluded that the integrated ethnoscience PBL model is effective in enhancing students' higher-order thinking skills and scientific literacy in elementary school settings.

Hypothesis II was tested using the Welch Test, which serves as an alternative to the ANOVA test when the assumption of homogeneity of variances is not satisfied. The test results yielded a statistical value of 76.541 with a significance level of 0.000, which is less than 0.05. This finding indicate that the integrated Problem-Based Learning (PBL) model of ethnoscience is effective in enhancing students' higher-order thinking skills. For Hypothesis III, the One-Way ANOVA was used, resulting in a statistical value of 132.661 with a significance level of 0.000, again less than 0.05. These results suggest that the PBL with Integrated Ethnoscience (PBLIE) model is effective in improving students' scientific literacy.

4. Discussion

The results from the pretest, posttest, and N-Gain analysis showed an improvement in students' higher-order thinking skills and scientific literacy when using the integrated ethnoscience Problem-Based Learning (PBL) model using. Hypothesis



testing, both simultaneous and partial, confirms these findings, with a significance value of 0.000, which is less than 0.05. This finding indicates that the integrated PBL model that incorporates ethnoscience is effective in enhancing students' higher-order thinking skills and scientific literacy in both a simultaneous and individual capacity. The observed improvement in these skills highlights the effectiveness of the integrated ethnoscience PBL model in fostering the critical thinking skills necessary to tackle various complex issues encountered in everyday life.

The present findings are consistent with the studies conducted by Damayanti et al. (2024) and Fitria et al. (2025) which revealed that the implementation of ethnoscience-integrated Problem-Based Learning (PBL) has a significant effect on enhancing student's critical thinking skills, one of the core elements of higher-order thinking. This suggests that problem-based learning, when contextualized through local community knowledge, provides a powerful stimulus for learners to engage in reflective, analytical, and solution-oriented reasoning when addressing complex issues. As Damayanti et al. (2024) emphasized, incorporating local cultural contexts into PBL makes the learning process more contextual, meaningful, and relevant to student's everyday lives. Furthermore, integrating local culture into science learning increases student's engagement, curiosity, and motivation, as the learning materials become more relatable and informative, thereby fostering deeper critical reflection when the content aligns with student's immediate environment and cultural background (Ramdani et al., 2023). The integration of ethnoscience within the PBL framework also promotes the development of higher-order thinking skills, where ethnoscience strengthens the contextual dimension of learning (Koirala, 2023), while PBL simultaneously stimulates active participation, collaboration, and problem-solving competence (Aliyu et al., 2023).

The integrated ethnoscience problem-based learning model combines elements of ethnoscience with science education. This approach addresses the dilemma noted by (G. S. Aikenhead & Jegede, 1999) regarding how to bridge the divide between ethnoscience and modern science. It also aligns with the (Gay, 2002) concept of culturally responsive teaching, which posits that students learn more effectively when the learning process is connected to their cultural backgrounds. Given Indonesia's rich cultural diversity, the ethnoscience approach is particularly relevant in this context.

Problem-based learning is a constructivist approach that positions students as active participants in the learning process. This method involves a series of activities that require students to identify problems, gather information, analyze data, and find solutions. As a result, students are encouraged to engage their critical, analytical, evaluative, and creative thinking skills. The problem-based learning model enhances students' abilities to analyze (C4) and evaluate (C5), promoting higher-order thinking skills. (Nanda et al., 2023).

Engaging students in information management and decision-making is essential for developing higher-order thinking skills. This approach aligns with the revised Bloom's taxonomy created by Anderson and Krathwohl, which classifies learning into six cognitive levels. The highest level includes skills such as analysis, evaluation, and creation (Anderson & Krathwohl, 2010).

Ethnoscience-based learning is crucial in the era of Industry 4.0, as it helps students understand material in a contextual manner while preserving local scientific cultures that may be threatened by technology and digitalization. Various models, methods, media, and instructional materials designed around local wisdom have been shown to improve higher-order thinking skills (Widyawati & Sujatmika, 2020). Integrating Problem-Based Learning (PBL) with an ethnoscience approach makes learning more meaningful by connecting it to the cultural context of the students.

Higher-order thinking skills (HOTS) and scientific literacy are not two separate entities; rather, they are mutually reinforcing constructs that together form a comprehensive competence required by students in the twenty-first century (Turiman et al., 2012). HOTS provides the cognitive framework for critical and creative reasoning necessary to process and interpret scientific information at a deeper level. In parallel, scientific literacy offers the contextual and content knowledge essential for developing arguments, making informed decisions, and solving scientifically grounded problems. Within this framework, problem-based learning (PBL) integrated with ethnoscience emerges as a strategic pedagogical alternative capable of developing both competencies simultaneously (Idul & Fajardo, 2023). The integration of local culture connects indigenous knowledge with modern science (Sihombing et al., 2025), embedding cultural relevance and authentic context into the learning process. Meanwhile, the PBL model fosters collaborative inquiry and reflective problem-solving (Verawati et al., 2025), allowing students to engage more meaningfully with scientific concepts while grounding their understanding in real-life and cultural experiences.

The integrated ethnoscience problem-based learning model emphasizes the use of ethnoscience as a genuine context for education. The development of this model aims to foster more meaningful learning experiences. This approach aligns with the perspective that learning becomes more impactful when it originates from the social and cultural environments that are familiar to the students (Moll et al., 1992; Vygotsky & Cole, 1978).

Problem-based learning (PBL) is a teaching strategy that starts with the presentation of complex and unstructured problems. This approach encourages students to identify their learning needs, gather relevant information, and apply it to solve the problems they encounter (Barrows & Tamblyn, 1980). In the ethnoscience-integrated PBL model, students engage in various scientific investigation activities centered around local cultural practices, both individually and collaboratively. Within this model, students analyze problems related to ethnoscience, explore the relevant aspects of ethnoscience connected to the subject matter, and scientifically analyze these problems. They are encouraged to compare, connect, and synthesize problem-

solving strategies from both ethnoscience and scientific viewpoints. Additionally, students develop presentations to share their synthesis results and present their findings to both teachers and peers.

The integrated ethnoscience problem-based learning model immerses students in authentic, challenging situations (Barrows & Barrows, 1986; Dolmans et al., 2005), encouraging them to analyze various relevant information and phenomena. When problems are framed within a local cultural context (ethnoscience), students are motivated not only to understand the issues but also to explore the connections between cultural practices and scientific concepts. These activities reflect students' active participation in the complete scientific inquiry process. They are consistent with the principles of student-centered learning, where students play a central role in their own education (Hmelo-Silver, 2004; Savery & Savery, 2006; Slavin, 2018).

The ethnoscience-based problem-based learning model encourages students to work in groups, where each individual is responsible for their own learning process. Collaboration and teamwork are essential aspects of problem-based learning (De Graaff & Kolmos, 2003). This approach prompts students to actively engage with one another while solving problems during their learning activities. It aligns with the notion that effective learning often requires active participation, which is reflected in the questions that students ask, as they think critically about the subject matter (Jaelani et al., 2016).

A learning model that connects educational content to everyday life helps students understand the material better, enabling them to apply it in social situations (Dinissjah et al., 2019). By incorporating real-life cases, students can actively engage with knowledge while seeking solutions to problems based on their experiences (Birgili, 2015). This approach, known as problem-based learning, fosters problem-solving skills and promotes meaningful learning (Dolmans et al., 2005), as supported by (Hmelo-Silver et al., 2007; Hmelo-Silver & Barrows, 2006).

The ethnoscience-integrated problem-based learning (PBL) model represents a constructivist instructional approach that emphasizes the role of local culture in shaping student's understanding. Within a constructivist learning framework, the teacher functions as a facilitator, motivator, guide, and scaffolder who supports student's constructive mental activities (Rodriguez Sandoval et al., 2022). These constructive activities are facilitated through the incorporation of local community knowledge (ethnoscience) drawn from student's surrounding environment. In this regard, the teacher also acts as a cultural mediator, aligning with the concept of culturally responsive teaching proposed by Gay (2018). The teacher's role extends beyond academic guidance serving as a bridge between scientific knowledge and local cultural practices that have long been embedded in student's daily lives. Through this mediating role, learning becomes more contextual, meaningful, and culturally relevant, fostering deeper engagement and critical understanding of scientific phenomena.

The implementation of an integrated ethnoscience problem-based learning model has proven to be effective in enhancing students' higher-order thinking skills and scientific literacy. Activities such as analyzing, evaluating, and creating scientific reports based on cultural practices are effective ways to develop these higher-order thinking skills (Anderson & Krathwohl, 2001). Additionally, employing an inquiry-based approach in teaching scientific concepts can further maximize students' higher-order thinking skills (Antonio & Prudente, 2023).

Integrating culture into science education can foster essential competencies for the 21st century, such as higher-order thinking skills (HOTS), critical thinking, collaboration, scientific literacy, creative thinking, and problem-solving (Syazali & Umar, 2022). Research also indicates that an ethnoscience-based, problem-based learning model positively affects students' critical thinking skills (Amini et al., 2021; Sarwi et al., 2021). Learning that incorporates ethnoscience creates engaging experiences that enable students to participate actively in their education, thereby enhancing their critical thinking abilities (Budiarti & Airlanda, 2019). The dimensions of higher-order thinking include the ability to analyze, evaluate, create, think critically, and solve problems (Brookhart, 2010). Higher-order thinking challenges students to move beyond merely reproducing information; instead, they are encouraged to construct understanding, make connections between concepts, evaluate arguments, and generate original solutions (Resnick, 1987). In essence, students equipped with higher-order thinking skills can tackle complex problems, make informed decisions, and creatively generate new ideas (Zohar & Dori, 2003).

To enhance scientific literacy, it is essential for learning experiences to involve students in observing phenomena from their daily lives. This approach helps students understand scientific concepts, evaluate and formulate scientific questions, and interpret scientific evidence—key indicators of scientific literacy (Yuliana et al., 2021). The ethnoscience approach serves as an effective strategy for creating a learning environment that integrates cultural aspects into the educational process (Solheri et al., 2022). Such educational experiences foster confidence, independence, collaboration, and motivation among students in their study of science, ultimately leading to improved scientific literacy outcomes (Ding, 2022). With strong scientific literacy, students are better equipped to engage with scientific issues and ideas as thoughtful citizens (OECD, 2019b) and to make informed decisions about environmental issues and the impact of human activities (Holbrook & Rannikmae, 2009).

The framework of the Problem-Based Learning (PBL) model actively fosters scientific literacy across the domains of content, process, and context through activities such as investigation, information gathering, data analysis, and evidence-based reasoning (Hmelo-Silver, 2004). Incorporating of ethnoscience within this framework enables students to connect scientific concepts with their cultural and environmental realities, thereby deepening both their understanding and meaningful application of scientific knowledge (Snively et al., 2011). This fusion allows students to comprehend scientific material more easily and contextually, as the learning experiences become more relevant to their everyday lives (Hikmah et al., 2025). Consequently, the ethnoscience-integrated PBL model serves as an innovative pedagogical approach for enhancing students'

higher-order thinking skills and scientific literacy, ensuring that learning is not only cognitively engaging but also culturally grounded and contextually meaningful.

5. Conclusions

This study provides an overview of the higher-order thinking skills and scientific literacy of students who learn through an integrated ethnoscience problem-based learning (PBL) model. It highlights how this model can enhance both competencies. The findings emphasize the significance of incorporating ethnoscience as a contextual element in problem-based learning. By integrating ethnoscience into PBL, students can more easily identify and understand problems, which helps them to better plan and conduct investigations. Additionally, they can more effectively analyze, evaluate, and create solutions, ultimately applying these solutions in their daily lives. These findings serve as valuable references for teachers in selecting and implementing effective learning models to improve students' higher-order thinking skills and scientific literacy.

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Ethical considerations

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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