



Teachers' Perspectives on Ethnoscience-Based Chemistry Learning: Challenges and Opportunities in Senior High Schools

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ABSTRACT

Ethnoscience integrates modern scientific knowledge with indigenous and local wisdom to enhance the contextual relevance of science learning. Despite its potential, empirical studies focusing on teachers' perspectives on ethnoscience implementation in chemistry education remain limited. This study aims to analyze the challenges and opportunities faced by senior high school chemistry teachers in implementing an ethnoscience-based approach. A descriptive qualitative design was employed, involving in-depth interviews, classroom observations, and document analysis of lesson plans and instructional materials. The findings reveal pedagogical, institutional, and contextual factors that influence the successful integration of ethnoscience in chemistry classrooms. This study contributes to the discourse on culturally responsive chemistry education and offers practical insights for developing adaptive teaching strategies aligned with local contexts and Indonesia's *Merdeka Belajar* (Independent Learning) policy.

INTRODUCTION

Chemistry learning at the high school level is often viewed as an abstract and complex subject, which can limit student engagement and lead to low motivation and poor conceptual understanding (Wibowo & Ariyatun, 2020; Alia, 2024). The dominant chemical concepts are theoretical in nature without strong links to students' real-life experiences, which is often the main reason for low achievement and science literacy among students (Dewi et al., 2023). This condition is in line with PISA findings, which show the low scientific literacy index of Indonesian students in science education (Alia, 2024; Wibowo & Ariyatun, 2020).

To overcome this problem, the ethnoscience approach has been proposed as a contextual and culturally relevant pedagogical alternative. Ethnoscience is an approach that integrates scientific knowledge with local community wisdom so that science learning, including chemistry, can be linked to cultural practices and local phenomena familiar to students (Setiawan & Rahayu, 2023; Munawwarah & Alqadri, 2025). Various studies show that ethnoscience-based chemistry learning can increase student motivation while strengthening conceptual understanding through clear connections between scientific theory and local cultural practices (Wibowo & Ariyatun, 2020; Alia, 2024).

This approach has also been reported to be effective in developing scientific literacy, which is the ability of students to understand scientific issues in a socio-cultural context and to relate scientific concepts to real life (Djarwo et al., 2025; Dewi et al., 2023). Recent studies indicate that ethnoscience can be integrated into various contextual learning models, such as problem-based learning and ethno-STEM, which support conceptual understanding and strengthen students' critical, creative, and collaborative thinking skills (Nur Khoiriyah et al., 2025; Wibowo & Ariyatun, 2020).

In addition, previous studies have shown that the use of local phenomena – such as regional specialties or traditional crafts such as keris – can make it easier to relate abstract chemistry concepts to something more concrete and meaningful for students (Nur Halimah et al., 2024; Kamaludin et al., 2024). The integration of cultural elements in the context of chemistry also has a positive impact on students' appreciation of local culture, making education more inclusive and meaningful in sociocultural terms.

However, the implementation of ethnoscience in chemistry education in schools also faces various challenges, especially those related to teacher competence. Many teachers do not yet have the knowledge or skills to design learning materials that integrate local cultural elements into the chemistry curriculum (Laksono et al., 2023). In addition, the limited availability of relevant learning resources, lack of curriculum support, and variations in technological readiness in schools are also obstacles to the success of the ethnoscience approach (Allo & Jumriati, 2024; Alia, 2024).

Meanwhile, opportunities arise from contemporary education policies such as the implementation of the Merdeka Curriculum in Indonesia, which provides greater space for teachers to apply contextual and adaptive learning approaches to local needs (Allo & Jumriati, 2024). Additionally, the emergence of

novel educational technologies and the development of ethnoscience-oriented instructional resources present significant opportunities to enrich students' learning experiences and render chemistry education more relevant.

Considering these challenges and opportunities, it is crucial to understand the perspective of teachers as key actors in the implementation of ethnoscience-based chemistry learning. Analysis of teachers' views and experiences can offer substantial assistance in formulating more effective and sustainable pedagogical strategies. Thus, this study aims to comprehensively explore the challenges and opportunities faced by high school teachers in applying ethnoscience in chemistry learning.

LITERATURE REVIEW

Ethnoscience in Science and Chemistry Education

Ethnoscience refers to the integration of indigenous knowledge systems with modern scientific concepts to create culturally responsive and contextually meaningful learning experiences. In science education, ethnoscience serves as a bridge that connects students' cultural backgrounds with formal scientific knowledge, reducing the cognitive and cultural gap often encountered in conventional science instruction. Aikenhead and Jegede (1999) conceptualize this process as cultural border crossing, where learners transition between their everyday cultural knowledge and the culture of Western science.

Several studies have emphasized that incorporating local wisdom into science learning enhances students' conceptual understanding and engagement. Snively and Corsiglia (2001) argue that indigenous knowledge systems provide rich epistemological resources that can deepen scientific reasoning when appropriately integrated into classroom instruction. In chemistry education, ethnoscience enables abstract concepts—such as reaction processes, acid-base phenomena, and material transformations—to be contextualized through culturally familiar practices, making learning more meaningful and accessible.

Contextual Learning Theory

Contextual learning theory posits that knowledge is constructed more effectively when learners can relate new information to real-life situations. Johnson (2002) emphasizes that learning becomes meaningful when students actively connect academic content with their personal, social, and cultural contexts. In chemistry education, contextual learning has been shown to improve conceptual understanding by grounding abstract chemical principles in observable phenomena.

Gilbert (2006) further explains that context in chemistry education functions as both a cognitive and motivational tool. When chemical concepts are embedded in authentic contexts—such as food processing, traditional materials, or local environmental practices—students are more likely to develop coherent mental models. Ethnoscience-based instruction aligns strongly with contextual learning theory by using culturally situated contexts as entry points for scientific inquiry.

Constructivist Learning Theory

Constructivist theory asserts that learners actively construct knowledge through interaction with their environment and social experiences. Vygotsky (1978) highlights the central role of social interaction, language, and cultural tools in cognitive development. From this perspective, learning is not a passive reception of information but a process of meaning-making shaped by cultural and social contexts.

Ethnoscience-based chemistry learning reflects constructivist principles by positioning students' cultural knowledge as a legitimate foundation for scientific understanding. By engaging with familiar cultural practices, students are encouraged to negotiate meaning, reflect critically, and reconstruct their understanding of chemical concepts through dialogue and collaborative learning.

Culturally Responsive Pedagogy

Culturally responsive pedagogy emphasizes the importance of recognizing students' cultural identities as assets in the learning process. Gay (2010) argues that teaching should be culturally validating and empowering, enabling students to see their cultural experiences reflected in academic content. In science education, this approach has been shown to improve motivation, participation, and equity.

Ethnoscience operationalizes culturally responsive pedagogy by embedding local knowledge and practices into science instruction. This approach not only enhances scientific literacy but also fosters cultural awareness and respect for indigenous knowledge systems, contributing to holistic student development.

Implications of Ethnoscience-Based Learning in Chemistry

Research indicates that ethnoscience-based learning supports higher-order thinking skills, including critical thinking, problem-solving, and scientific reasoning (Bybee, 2013). When combined with inquiry-based or problem-based learning models, ethnoscience encourages students to collaboratively explore real-world problems grounded in their cultural environment.

In the context of chemistry education, ethnoscience contributes to the development of scientifically literate learners who are capable of applying chemical concepts to societal and environmental issues relevant to their communities. This aligns with global educational goals emphasizing scientific literacy and sustainability (OECD, 2019).

METHODOLOGY

This study uses a descriptive qualitative approach that aims to describe in depth the phenomenon of implementing ethnoscience in chemistry learning in accordance with its natural context (Sugiyono, 2019). This approach was chosen because it is relevant to examining teachers' perspectives on the application of local wisdom-based learning, particularly in identifying challenges and opportunities that arise in chemistry-teaching practices in senior high schools. Through this approach, researchers can understand the meanings, experiences,

and strategies developed by teachers in linking chemistry concepts to cultural practices that exist in society.

Data collection was conducted through in-depth interviews, participatory observation, and document analysis (Sugiyono, 2019). In-depth interviews were used to explore chemistry teachers' views on the effectiveness of applying ethnoscience, the obstacles encountered in planning and implementing learning, and the efforts made to overcome them. In addition, interviews were also conducted with chemistry education students who had participated in ethnoscience-based learning to obtain reflective perspectives as both learners and future educators.

Participatory observation was conducted by directly watching the chemistry learning process that integrated ethnoscience, covering the stages of planning, implementation, and evaluation of learning. This observation aimed to obtain an empirical picture of classroom learning practices, interactions between teachers and students, and student responses to contextual and locally based chemistry learning. The observation data was used to strengthen and verify the findings obtained through interviews.

Document analysis was conducted on school curriculum documents, syllabi, lesson plans, teaching materials, and other learning archives. This analysis aimed to examine the extent to which ethnoscience has been integrated into chemistry learning planning, as well as its compatibility with applicable education policies, including the principles of the Merdeka Curriculum.

The data sources in this study consisted of primary and secondary data. Primary data was obtained from two chemistry teachers who had experience in applying the ethnoscience approach in learning, as well as three chemistry education students who had experienced ethnoscience-based learning during their studies. Secondary data included learning documents and literature as well as education policies related to ethnoscience and Merdeka Belajar. Informants were selected purposively, considering their direct involvement and experience in implementing ethnoscience, both as educators and as students.

Data analysis was conducted using Miles and Huberman's interactive analysis model, which includes three main stages: data reduction, data presentation, and conclusion drawing and verification. Data reduction was carried out through the selection, focus, and simplification of data from interviews, observations, and documents on an ongoing basis from the start of data collection. The reduced data was then presented in the form of descriptive narratives and thematic tables to facilitate the identification of patterns, categories, and relationships between findings.

Conclusions were drawn gradually and verified through source triangulation and method triangulation by comparing data obtained from various informants and data collection techniques. This process was carried out iteratively to maintain the consistency and validity of the research findings. Data validity was maintained through the application of triangulation so that the research results could accurately represent the real conditions in the field and be scientifically accountable (J. W. Creswell & Creswell, 2018). With this methodological approach, the study is expected to provide a concise yet

comprehensive overview of the implementation of ethnoscience in chemistry education, particularly regarding the challenges and opportunities faced by teachers in senior high schools.

RESULTS AND DISCUSSION

Ethnoscience in chemistry education is understood as a pedagogical approach that integrates modern chemistry concepts with local cultural knowledge and practices developed in community life. This approach has the potential to bridge the gap between abstract chemistry knowledge and students' empirical experiences, making learning more contextual, meaningful, and relevant to students' socio-cultural realities.

However, research shows that the implementation of ethnoscience in chemistry learning still faces various structural and pedagogical challenges. One of the main obstacles identified is the limited understanding of teachers in systematically integrating chemistry concepts with local cultural practices. Most teachers still tend to use conventional learning approaches that are oriented toward mastery of theory and memorization of concepts, with minimal connection to local phenomena in the students' environment. This problem is made worse by the lack of teaching materials that clearly connect chemical concepts to cultural practices, like sago processing, which makes it hard for teachers to create lessons based on local science.

In addition to pedagogical factors, the current curriculum is also an obstacle. The demand for universal academic competency and the dense learning material limit teachers' space for in-depth exploration of the local context. As a result, despite awareness of the importance of a local wisdom-based approach, its implementation in the classroom is still sporadic and not yet systematically structured.

Interviews with two chemistry teachers reinforced these findings. Teachers with more than ten years of teaching experience expressed interest in the ethnoscience approach but acknowledged difficulties in linking chemistry material to local cultural practices due to the lack of concrete examples in textbooks and the absence of specific training related to ethnoscience integration. This teacher assessed that chemistry learning has been heavily dependent on national textbooks that are theoretically oriented, so opportunities to link chemistry concepts with local phenomena have not been optimally utilized.

A teacher with approximately five years of teaching experience demonstrated a more adaptable attitude towards the ethnoscience approach. This teacher has tried to integrate sago processing practices into learning, particularly in fermentation material, by inviting students to identify the stages of the traditional process and relate them to the chemical concepts being studied. This approach is considered capable of increasing student interest and engagement in learning. However, these teachers also emphasized that time constraints and a dense curriculum are major obstacles to implementing ethnoscience in a more in-depth and sustainable manner.

The perspectives of students in the Chemistry Education Study Program at Cenderawasih University reinforce the findings from the perspective of

student learning experiences. The first student revealed that during secondary education, chemistry learning was rarely linked to local cultural practices, making chemical concepts feel abstract and difficult to understand. Awareness of the connection between traditional practices, such as sago processing, and scientific concepts only emerged when the student entered higher education. This observation shows that the absence of an ethnoscience approach at the secondary school level has the potential to hinder students' conceptual understanding.

The second student highlighted that ethnoscience-based chemistry learning has the potential to change students' perceptions of chemistry as a difficult and abstract subject. According to him, the connection between chemistry concepts and cultural practices that are familiar to students can improve conceptual understanding while creating a more intriguing and interactive learning atmosphere. These findings emphasize the importance of the teacher's role in designing learning that focuses not only on knowledge transfer but also on contextual learning experiences.

The third student, who comes from a family of sago processors, revealed a gap between his empirical experience and chemistry learning at school. The cultural practices that had been familiar since childhood were never explicitly linked to the chemical concepts studied in class. Awareness of the scientific dimension of these practices only developed when entering college. These findings indicate that chemistry learning that ignores the local cultural context has the potential to waste the cognitive and cultural capital that students already possess.

Overall, the results of this study indicate that the ethnoscience approach has significant potential in improving conceptual understanding, learning interest, and student appreciation of local culture. However, its implementation is still constrained by teachers' limited understanding, a lack of contextual teaching materials, and a curriculum structure that does not fully support the integration of local wisdom. Therefore, strengthening teachers' capacity through ethnoscience-based training, developing contextual teaching materials, and adjusting the curriculum to be more flexible are strategic steps to optimize the application of ethnoscience in chemistry learning.

Ultimately, collaboration between educational institutions, academics, local communities, and educational authorities is an important prerequisite in building a learning ecosystem that supports the sustainable integration of ethnoscience. This collaboration is expected to produce innovations in chemistry learning that are not only oriented towards academic achievement but also towards strengthening cultural identity and the relevance of chemistry in people's lives, especially in Jayapura City.

Challenges Faced by Teachers in Implementing Ethnoscience in Chemistry Education in Senior High Schools

The implementation of ethnoscience in chemistry education in senior high schools in Jayapura City presents substantial challenges related to teachers' professional capacity, curriculum structure, and the availability of contextual learning resources. These findings are consistent with previous studies reporting

that teachers' understanding of the relationship between chemistry concepts and local cultural practices is still weak, resulting in teaching that tends to be oriented toward conventional methods emphasizing memorization of theory without connection to students' daily experiences (Alfiana & Fathoni, 2022; Andayani et al., 2021a). This context is reinforced by interviews with chemistry teachers who expressed difficulty in formulating teaching strategies that connect local cultural phenomena such as sago processing with abstract chemistry concepts.

These findings are consistent with other studies that identify teachers' lack of knowledge and skills to utilize local wisdom in chemistry teaching due to the lack of contextual teaching materials relevant to local culture (Marpaung et al., 2024). As a result, teachers are in a position where they recognize the potential of ethnosience but face practical obstacles in pedagogical literacy that support real integration with cultural practices. In addition, a curriculum structure that is highly focused on achieving national standard academic competencies and further learning time constraints reduces teachers' flexibility to explore ethnosience approaches. As found in the literature review, the narrow focus of the curriculum and the pressure to meet national education standards often hinder the integration of local contexts into chemistry learning, especially in high schools (Yuendita & Rohaeti, 2025).

The limited professional training that specifically addresses the design and implementation of ethnosience-based learning is also a major obstacle. Field findings note this phenomenon: many teachers lack in-depth training or workshops on ethnosience as a pedagogical approach. Literature studies support this, stating that inadequate professional development can hinder teachers' ability to develop holistic and contextual learning experiences (Yuendita & Rohaeti, 2025).

Opportunities and Supporting Strategies for Ethnosience Implementation

Although significant challenges remain, the results of the study show that the application of ethnosience opens up strategic opportunities to improve the quality of chemistry learning in high schools. Findings from teacher interviews show that when learning is linked to local cultural practices such as sago processing, students show higher engagement and a deeper understanding of concepts. These findings are in line with the literature, which emphasizes that the integration of local cultural knowledge in chemistry learning can bridge the gap between abstract theory and students' real-life experiences, thereby improving chemistry literacy and the relevance of learning (Yuendita & Rohaeti, 2025).

One strategy that emerges in the literature is the development of ethnosience-based learning modules that focus on local contexts and case studies relevant to students' daily lives. Such modules have been shown to strengthen the understanding of chemistry concepts in a more contextual and meaningful way than conventional modules (Nugraheni & Pratomo, 2025). The creation of these modules also enhances students' chemistry literacy by integrating elements of their familiar local culture, as advocated by numerous ethnosience literature studies in chemistry education (Alia, 2024; Yuendita & Rohaeti, 2025).

Teacher training and professional development on ethnosience design and practice are some of the key strategies. Continuous and ethnosience-specific

training can help teachers build the ability to design learning experiences that are not only oriented towards academic content but also towards understanding local culture and context.

Support from schools and education authorities is also important for providing resources, such as books, teaching aids, and ethnosience-based teaching materials, to encourage implementation. In addition, the use of digital technology as an innovative learning medium can help teachers and students explore the relationship between chemical concepts and cultural practices in a more interactive and engaging format (Djarwo et al., 2025).

Finally, cross-stakeholder collaboration between educational institutions, academics, local communities, and the government needs to be strengthened to create a learning ecosystem that supports ethnosience in a sustainable manner. This collaboration will enrich learning resources and help formalize the ethnosience approach in education policy and curriculum implementation in the field.

This study significantly helps improve chemistry education based on ethnosience by showing the real challenges teachers face when trying to include local knowledge in their lessons, especially related to Papuan culture in secondary schools. The findings of this study add to existing knowledge by showing that the challenges in using ethnosience come not just from teachers not fully understanding it, but also from a lack of relevant teaching materials, the demands of a packed curriculum, and insufficient hands-on training support. Additionally, this study shows that using sago processing as a teaching method can connect difficult chemistry ideas with students' cultural backgrounds, which helps them understand better and become more involved in learning. So, this study helps provide evidence for creating chemistry teaching models based on ethnosience, designing teaching materials that relate to real-life situations, and developing educational policies that better include local culture in science education.

CONCLUSIONS AND RECOMMENDATIONS

This study shows that using the ethnosience approach can greatly enhance how relevant and understandable chemistry is for high school students, especially by including local cultural practices like sago processing. This approach is able to bridge abstract chemistry concepts with students' cultural experiences, thereby increasing learning engagement and appreciation of local wisdom. However, the implementation of ethnosience still faces significant challenges, particularly teachers limited pedagogical understanding, a lack of contextual teaching materials, the pressure of a dense curriculum, and a lack of professional training oriented toward ethnosience practices.

To optimize the application of ethnosience in chemistry learning, it is necessary to strengthen teachers' capacity through structured training, develop teaching materials based on local cultural contexts, and provide policy support that allows for curriculum flexibility. Further research is recommended to empirically develop and test ethnosience-based chemistry learning models, including exploring cultural practices from various regions. In addition, teacher education needs to instill awareness that science can be taught contextually and

responsively to culture so that chemistry learning becomes more meaningful and sustainable.

FURTHER STUDY

This study has limitations in terms of the scope of informants and the local context, which is focused on the city of Jayapura, so the findings cannot be generalized widely. In addition, the qualitative approach used did not allow for empirical measurement of the impact of ethnoscience-based chemistry learning on student learning outcomes, science literacy, and cultural awareness. Therefore, further research needs to use a mixed or experimental research design, as well as develop and validate ethnoscience-based chemistry teaching models and materials supported by curriculum policy and teacher professional development.

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