

Analyzing the Potential and Challenges of Ethnoscience-Based Chemistry Learning in Madrasah Aliyah

Sri Wahyuni¹, Mega Novita², Muhammad Syaipul Hayat³, Feny Roshayanti⁴

^{1,2,3,4}Universitas PGRI Semarang, Indonesia

¹yunieffin@gmail.com

Abstract

This study aims to analyze the potential and challenges of ethnoscience-based chemistry learning in Madrasah Aliyah. The approach used is a quantitative survey type with participants being Madrasah Aliyah chemistry teachers in Surakarta Residency who were taken randomly. The method used is descriptive-quantitative. The data collection tool used is a questionnaire containing statements related to chemistry learning and the ethnoscience approach. Based on the data analysis carried out, both survey results and interviews, that although there is high enthusiasm from chemistry teachers, namely 92.3%, to implement ethnoscience-based learning, their knowledge of ethnoscience is still limited. As many as 50% of teachers admitted to having difficulty integrating ethnoscience with chemistry material, and 57.7% of teachers had never implemented it. The main obstacles in the implementation of ethnoscience include lack of teacher understanding and limited supporting infrastructure. Nevertheless, the ethnoscience approach offers great potential to improve scientific literacy, understanding of local culture, and student learning outcomes. Policy and infrastructure support in madrasahs, including Madrasah Aliyah Negeri Wonogiri, is ready to facilitate further development of ethnoscience-based learning. With increased training and resources, ethnoscience can be effectively integrated to enhance student engagement and understanding in chemistry learning.

Keywords: potential, learning, chemistry, ethnoscience, Madrasah Aliyah

Introduction

Education in the 21st century faces major challenges in preparing students to face a rapidly changing world. This era is marked by the need for 4C skills — critical thinking, communication, collaboration, and creativity — which are considered essential for students' future success (Septikasari & Frasandy, 2018). In the Indonesian context, the development of these skills is becoming increasingly relevant to improving the competitiveness of human resources at the global level. The Merdeka Curriculum, as a national educational innovation, aims to create a flexible learning process that is oriented towards student needs, including emphasizing mastery of 21st-century competencies (Nugrohani et al., 2022). The concept of an independent learning curriculum initiated by the Indonesian Minister of Education Nadiem Makarim is a solution in answering problems in Indonesian education today and is the right step in facing the challenges of the 21st century (Gumilar et al., 2023; Manalu et al., 2022). According to Nugrohani et al. (2022) there are three major competencies in the 21st century, namely thinking competencies (including critical thinking, creative thinking and problem solving), acting (including communication, collaboration, digital literacy and technological literacy), while living in the world competencies are initiative, self-direction, global understanding and social responsibility. In line with this opinion, students in the 21st century are equipped with four skills or what are usually called 4Cs, namely critical thinking, communication, collaboration, creativity (Wiguna & Tristaningrat, 2022). Schools in the 21st century require creative thinking skills,

critical thinking and problem solving, as well as communication and collaboration, commonly referred to as 4C (Septikasari & Frasandy, 2018). 4C skills can be combined with science learning, so that students are expected to be able to solve various problems encountered in their daily environment (Monica et al., 2021).

Science learning in the independent curriculum aims to direct students to be able to integrate learning with the environment, including the cultural potential of local wisdom or ethnoscience. Ethnoscience functions to introduce students to the surrounding environment through learning as an effort to foster scientific literacy as an essential skill in the 21st century (Haspen et al., 2021). Local culture-based learning approaches, such as ethnoscience, can be an effective solution for increasing students' awareness of their cultural values (Nahak, 2019; Yoga Agustin, 2011). Culture-based learning is a strategy for creating a learning environment and designing learning experiences that integrate culture as part of the learning process (Fahrozy et al., 2022). Culture-based learning is a strategy for creating a learning environment and designing learning experiences that integrate culture as part of the learning process (Susim et al., 2019). Ethnoscience relates to knowledge originating from culture which can act as a basis for building a reality that emphasizes the relationship between culture and current scientific knowledge (Abonyi et al., 2014). Ethnoscience teaches students to relate learning material to local wisdom around the community in their area which can be tested for truth, so that students can know the direct impact of the material they have studied (Rosyidah et al., 2013). Ethnoscience encourages students to recognize and study natural science through the use of the surrounding environment (Novia et al., 2015). In the results of research conducted by Sari et al. (2021), it is stated that ethnoscience-based science learning is proven to be able to develop students' ability to think critically, therefore the use of ethnoscience-based science learning can be used to support students in developing their abilities in responding to information received while still considering all related aspects with this information, meanwhile Rosyidah et al., 2013 relates traditional and typical Indonesian food in the study of additives. Teaching materials based on local wisdom have been proven to be effective in increasing learning activities and outcomes) research (Rahmawati et al., 2018). Furthermore, Nisa' et al., 2015 shows that students who are taught using an integrated model of ethnoscience in problem-based learning have higher scientific literacy abilities. According to (Parmin, 2015), science learning is not limited to studying concepts, but also strengthens the identity of a nation that has cultural diversity and the goal of science learning that has been set in Indonesia is that students are able to apply science wisely, maintain and preserve cultural sustainability.

Learning with ethnoscience is more effective than conventional learning in terms of science process skills and increasing mastery of chemical material (Trianah, 2020). Ethnoscience cannot be separated from science, especially in chemical material. Chemistry is a part of science that does not only solve problems but must also understand the interpretation of facts, chemical laws and chemical material that is abstract in nature (Amelia, 2017). Chemistry is always considered something that is not closely related to everyday life because it is considered complicated, abstract and dangerous (Sutrisno et al., 2020). This assumption makes chemistry seem not to be part of social life even though many branches of chemistry are used to support social life. Knowledge about the use of chemistry in society can be an implementation of chemical concepts into a simpler context that is easier for the community to understand (Priyambodo & Wulaningrum, 2017). One real picture of the concept of chemistry can be presented in a contextual form that can be done in the learning process. Majid & Rohaeti (2018) added that contextual chemistry learning has a positive influence on student learning achievement and attitudes. Ethnoscience offers a way to make learning more relevant and interesting when viewed from the context of Chemistry Education. By connecting chemical

concepts with local wisdom, students can understand the application of chemistry in real life. For example, the study of chemical reactions can be linked to the process of making traditional foods, such as tempeh fermentation or salt making. This approach helps students see the relationship between science and everyday life, while appreciating local culture (Rosyidah et al., 2013).

Despite its great potential, the application of ethnoscience in chemistry learning in Madrasah Aliyah faces various challenges. The main challenges include teachers' limited knowledge of ethnoscience integration, lack of supporting resources, and difficulties in connecting local culture with modern chemistry concepts (Andayani et al., 2021). Therefore, teacher training, development of learning resources, and policy support are needed to overcome these obstacles.

This study aims to analyze the potential and challenges of implementing ethnoscience-based chemistry learning in Madrasah Aliyah especially at Madrasah Aliyah in the former Surakarta Residency. The main focus of the study includes analyzing teachers' attitudes, their knowledge of ethnoscience, and the obstacles faced in implementing this approach in the classroom.

Method

This study uses a quantitative-descriptive survey approach to describe phenomena related to the application of ethnoscience in chemistry learning. The method used is descriptive-quantitative to analyze the response of Chemistry teachers to the potential for ethnoscience-based chemistry learning. In addition, this approach was chosen because it allows for systematic data analysis related to the attitudes and understanding of chemistry teachers at Madrasah Aliyah (Sugiyono, 2022).

The study involved 26 chemistry teachers from Surakarta Residency who were selected through simple random sampling technique. Respondents covered various backgrounds of age, gender, and teaching experience, thus providing a comprehensive picture of the population studied. Data were collected using a questionnaire that had been validated by experts, focusing on aspects of teachers' knowledge of ethnoscience, integration of ethnoscience in learning, and barriers to its implementation. The respondents in this study were consisting of various age groups, gender, educational qualifications, teaching experience, madrasah background, and employment status. Most of the respondents were over 45 years old (57.9%), while the rest were under 45 years old (42.1%). In terms of gender, 84.2% of respondents were female and 15.8% were male. In terms of education, the majority of respondents had a background in chemistry (57.9%), pure chemistry (36.8%), and 5.3% others. Respondents who had teacher certification were 78.9% and the rest were not yet certified teachers. Of the 26 respondents, 80.8% had teaching experience of over ten years while 19.2% had teaching experience of less than ten years. In terms of the status of the madrasah of origin, the majority of respondents came from State Madrasah Aliyah, namely 73.7% and 26.3% from private madrasahs.

The data collected came from e-questionnaires (google form). The data collection instrument used in this study was questionnaire 3 with aspects, namely, teacher knowledge of ethnoscience, integration of ethnoscience in learning, ethnoscience-based learning and obstacles to its implementation. The instruments used have been validated by experts. Descriptive data analysis techniques are used to describe or depict data obtained, where data analysis is presented in the form of graphs, percentage calculations (Sugiyono, 2022).

The data analysis technique was carried out by calculating and presenting the results of the teacher questionnaire and then describing them based on supporting literature. The research

data analysis used the interactive analysis method proposed by Miles & Huberman (1994), in the form of data collection, data condensation, data presentation, drawing conclusions and verification. The data examination technique used the degree of trust/credibility by (a) determining the research period and schedule until the saturation point appeared, (b) conducting consistent observations, (c) using the data/source triangulation method to test the truth of the data collected by comparing the observation data with the data obtained through interviews with informants. While the data analysis technique is by collecting, reducing, presenting, and drawing conclusions from data (Puspasari et al., 2019).

Results

In the context of Indonesian education, the Independent Curriculum emphasizes the integration of local culture into learning to improve the relevance of education and student competencies in the 21st century. National education standards direct learning to not only be oriented towards the transfer of knowledge, but also to be able to improve students' scientific literacy as well as critical thinking, collaboration, communication, and creativity (4C) skills (Ministry of Education and Culture, 2022).

The results of this study indicate that 92.3% of chemistry teachers at Madrasah Aliyah have a high interest in ethnoscience-based learning. However, only 46.2% have an adequate understanding of this approach. This indicates a gap with national standards that target the implementation of ethnoscience-based learning widely in the Merdeka Curriculum. Previous studies support that ethnoscience-based learning can improve students' scientific literacy by up to 30% compared to conventional methods (Wibowo & Ariyatun, 2020). For example, the ethnoscience-based problem-based learning model has been shown to significantly improve students' understanding of chemical reaction material (Basit et al., 2023). Unfortunately, in this study, the main obstacles faced by teachers were limited training and infrastructure, which caused the implementation of this approach to be less than optimal. Previous studies support that ethnoscience-based learning can improve students' scientific literacy by up to 30% compared to conventional methods (Wibowo & Ariyatun, 2020). For example, the ethnoscience-based problem-based learning model has been shown to significantly improve students' understanding of chemical reaction material (Basit et al., 2023). Unfortunately, in this study, the main obstacles faced by teachers were limited training and infrastructure, which caused the implementation of this approach to be less than optimal.

The results of the questionnaire completed by the teacher show the results described for each aspect as follows:

Ethnoscience Integration in Learning

From the results of a questionnaire to teachers related to the ethnoscience approach in learning, the results obtained are as in Figure 1

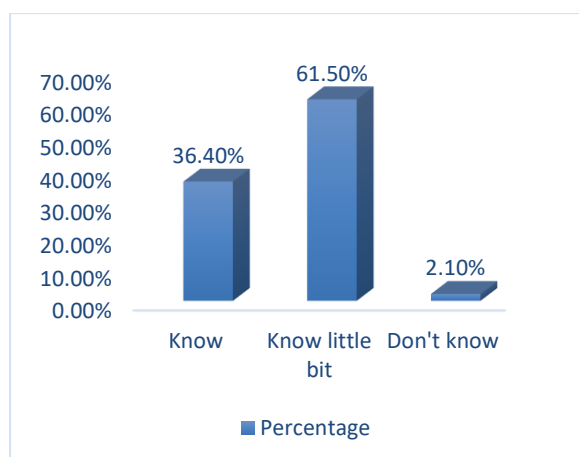


Figure 1. Integration of Ethnoscience Approach to Learning

The implementation of learning based on teacher knowledge of ethnoscience, while specifically in chemistry subjects can be seen in Figure 2

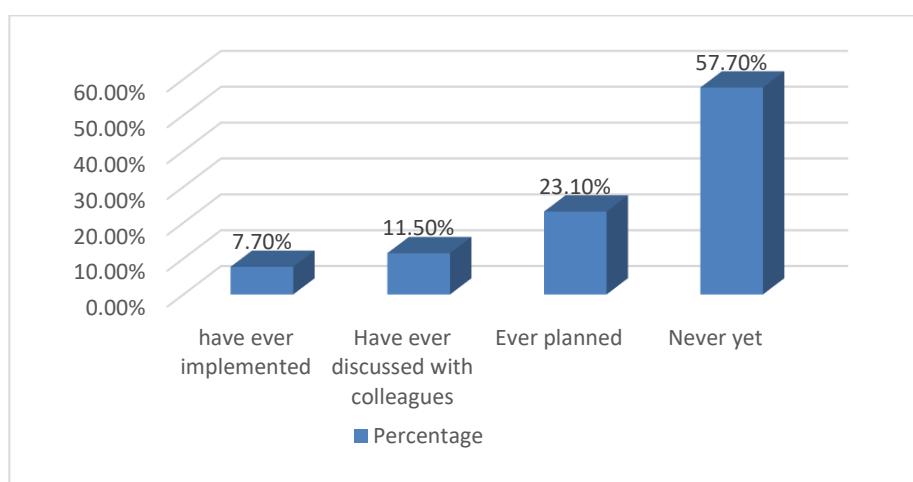


Figure 2. Implementation of Chemistry Learning with an Ethnoscience Approach

Potential of Implementing Ethnoscience-Based Learning in Chemistry Learning

The teacher interest in implementing ethnoscience-based learning and teachers' knowledge level on ethnoscience as shown in Figures 3 and 4.

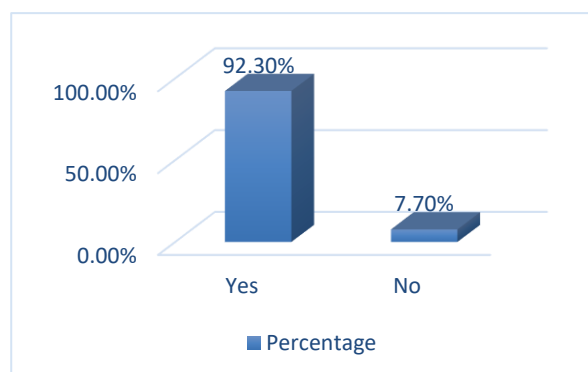


Figure 3. Teachers' Interest in Implementing Ethnoscience-Based Learning

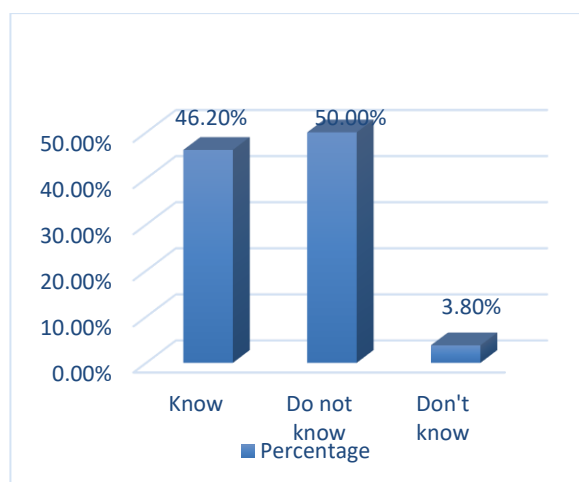


Figure 4. Teachers' Knowledge Level on Ethnoscience

The graphs in Figures 3 and 4 show something opposite, on the one hand, teachers' interest in ethnoscience-based learning is very high but is not balanced by teachers' knowledge of ethnoscience. Teachers' interest in ethnoscience is high because they realize its relevance and potential to improve contextual and meaningful learning for students. However, their level of knowledge may be limited due to the lack of specific training that integrates ethnoscience into chemistry learning. In other words, limited access to training or resources keeps their level of knowledge about ethnoscience low.

Obstacles in Implementing Ethnoscience-Based Learning

Constraints in implementing ethnoscience-based learning as shown in Figure 5. Selain faktor lain yang tidak kalah pentingnya adalah kurang eksplisitnya kurikulum dan lingkungan yang kurang memadai. Selain itu faktor dari dalam yaitu kurangnya pengetahuan guru tentang etnosains

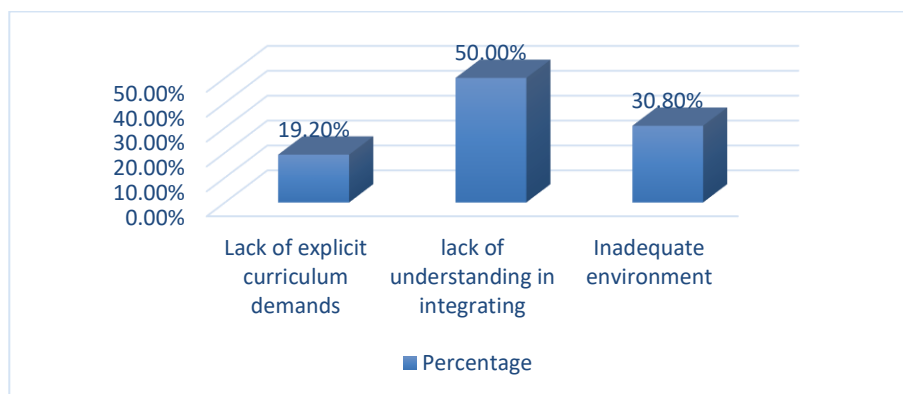


Figure 5. Constraints in Implementing Ethnoscience-Based Learning

Apart from that, another factor which is no less important is the lack of explicitness of the curriculum and the inadequate environment, in addition to internal factors, namely the lack of teacher knowledge about ethnoscience. In addition that the facilities and infrastructure supporting ethnoscience-based learning in their madrasahs are inadequate, as shown in Figure 6.

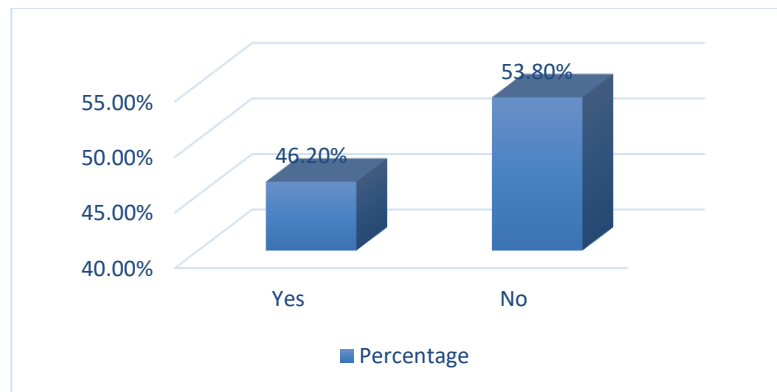


Figure 6. Supporting Facilities and Infrastructure for Ethnoscience Learning

Ethnoscience learning offers many benefits, but in terms of facilities and infrastructure, there are several weaknesses that can hinder its optimal implementation.

Discussion

Knowledge is a fundamental skill that teachers must have in order to succeed in learning. Knowledge is not just a set of facts, concepts, laws or rules that are ready to be remembered, transferred from one person to another, and used, but as a continuous formation that will change at any time due to new understanding (Woro Sumarni, 2018). As an important part of learning, teachers must have a variety of knowledge, including ethnoscience knowledge. According to research conducted by Dewi *et al.* (2021) there is a major gap between students' scientific literacy before and after implemented CCLBE model and scientific literacy ability has increased in the medium category on capacity of students in content, process and attitude aspects. The uniqueness of contextual collaboration learning based ethnoscience (CCLBE) model is that students can integrate their knowledge with cultural competences in a different profession so that become the key determinants in improving students' scientific literacy in terms of content, context and attitude (Dewi *et al.*, 2021). Other studies have shown that project-based learning with an Ethno-STEM approach enhances critical, creative, and collaborative thinking skills. For example, chemistry learning that integrates ethnoscience such as traditional essential oil processing can strengthen students' understanding of chemical concepts while promoting cultural conservation and entrepreneurship skills in the 21st century. This model encourages students to apply chemistry to local contexts, providing hands-on experiences that are relevant to their daily lives (Sumarni *et al.*, 2022).

Previous research on the effectiveness of ethnoscience-based learning conducted by Rahmawati *et al.* (2018), showed that local wisdom-based teaching materials can improve students' activities and learning outcomes. In addition, Wibowo & Ariyatun (2020) revealed that ethnoscience-based chemistry learning improves students' scientific literacy skills through an approach that is relevant to everyday life. Regarding the limited understanding of teachers, Andayani *et al.* (2021) found that although teachers understand the importance of ethnoscience, its implementation is still limited due to the lack of training and practical guidance for integration into the curriculum. Meanwhile, Sari *et al.* (2021) proved that ethnoscience-based learning improves students' critical thinking skills, especially in connecting scientific concepts with their local cultural experiences.

Ethnoscience Approach in Chemistry Learning

Chemistry learning based on ethnoscience offers a great opportunity to increase the relevance and involvement of students in the learning process. The concept of ethnoscience introduces students to local wisdom contained in the culture of the local community, and

connects it with modern scientific concepts. This not only strengthens students' scientific understanding but also builds awareness of their own cultural values. Through the integration of ethnoscience, students are invited to get to know their surroundings better and understand that science is inseparable from everyday life. In addition, students have the opportunity to get to know and appreciate local wisdom better. Ethnoscience can increase students' knowledge and understanding of the potential and culture of a region (Ulya et al., 2023). The same thing was stated by Andayani et al. (2021) that the integration of ethnoscience into science learning makes learning is more meaningful and can instill the values of wisdom local. The same thing was stated by Andayani et al., 2021.

Another study showed that Application of the Chemistry Learning Model Based on Ethnoscience (MPKBE) can improve cognitive abilities and critical thinking because the learning model links classroom learning to what students encounter in everyday life and also encourage students to play an active role in the learning process (Arfianawati et al., 2016). This study used daily activities related to local culture such as making antor crackers and salted eggs in Brebes as examples of teaching the concept of organic compounds. The results showed that students became more active in the learning process and were able to connect chemical concepts with their real lives. The learning approach that combines ethnoscience with the inquiry-creative method has proven effective in improving students' critical thinking skills (CT).

Some chemistry materials that can be integrated with ethnoscience include reaction rate materials. According to Basit et al. (2023) there is an influence of ethnoscience-based problem-based learning models on student learning outcomes in reaction rate materials. In addition, according to research results from Amini et al., (2021) the problem-based learning model provides a learning experience that makes students active and more focused in solving problems that are closely related to culture and daily life in chemistry learning, especially colloid materials. From the results of a questionnaire to teachers related to the ethnoscience approach in learning, the results obtained are as in Figure 1.

Based on Figure 1, 61.5% of teachers are less aware that learning can use an ethnoscience approach, 34.6% know and 3.9% do not know. The implementation of learning based on teacher knowledge of ethnoscience, while specifically in chemistry subjects can be seen in Figure 2. Regarding the implementation of chemistry learning with an ethnoscience approach, information was obtained that most teachers do not know that learning with an ethnoscience approach can be implemented, namely 57.7% of teachers have never implemented chemistry learning with an ethnoscience approach, 23% have planned, 11.5% have discussed with colleagues, as shown in Figure 2

Potential of Implementing Ethnoscience-Based Learning in Chemistry Learning

Teachers who are interested in implementing ethnoscience-based learning because they consider the importance of ethnoscience integration in chemistry learning. This is in line with research conducted by Putri et al. (2022) that the integration of ethnoscience in learning can improve learning outcomes obtained when compared to conventional learning. The ethnoscience-based learning model is closely related to everyday life so that it can help students understand learning materials (Wibowo & Ariyatun, 2020).

Based on the results of a study involving chemistry teachers at Madrasah Aliyah in Surakarta, there was high enthusiasm for implementing ethnoscience-based learning, with 92.3% of teachers showing great interest. However, only about 46.2% of teachers had adequate knowledge of ethnoscience, and 50% of them found it difficult to integrate ethnoscience into chemistry materials, as shown in Figures 3 and 4

This high interest indicates that there is great potential to develop ethnoscience-based learning at the Madrasah Aliyah level, especially in the Surakarta Residency area. Research by

Wibowo & Ariyatun (2020) supports this finding, where they found that students who learned using an ethnoscience-based approach showed significant improvements in their science literacy compared to students who learned using a conventional approach. This suggests that there is an urgent need for increased training and support for teachers, so that they are better able to connect local culture with the chemistry concepts being taught. Therefore, although there are still limitations in terms of teacher knowledge, the potential for implementing ethnoscience remains great, especially if supported by proper training and guidance.

Obstacles in Implementing Ethnoscience-Based Learning

One of the main obstacles in implementing ethnoscience-based learning is the lack of teacher understanding on how to integrate ethnoscience concepts with chemistry materials. As many as 50% of teachers stated that they were not interested in implementing ethnoscience in learning because they felt they did not understand how to connect ethnoscience with chemistry concepts, as shown in Figure 5. The main reason why many teachers lack understanding of ethnoscience is related to several factors. One is the lack of training or understanding of the integration of local knowledge and modern science in the formal curriculum. Many teacher education programs still emphasize science in general without accommodating cultural perspectives or traditional knowledge held by local communities. Another contributing factor is the lack of adequate resources to support ethnoscience-based learning, such as relevant textbooks or teaching materials, especially in rural or remote areas. In addition, in some countries, ethnoscience has not been widely discussed in the formal science education curriculum. As a result, teachers are not familiar with how to incorporate local knowledge into science lessons. They may also feel unsure about the credibility of local knowledge compared to modern science taught through textbooks and formal education standards. Research conducted Andayani et al. (2021) revealed that although chemistry teachers in West Nusa Tenggara (NTB) understand the importance of ethnoscience, they have not been able to implement it optimally in the classroom. This obstacle is caused by the lack of specific training on how to integrate ethnoscience into the chemistry curriculum. In addition, 53.8% of teachers stated that the facilities and infrastructure supporting ethnoscience-based learning in their madrasahs are inadequate, as shown in Figure 6. This is in accordance with the findings of research by Puspita et al. (2022), which shows that adequate infrastructure is very important in supporting ethnoscience-based learning. Infrastructure such as laboratories equipped with local materials and adequate technological devices are needed to ensure that learning can run smoothly and relevantly.

Compared to previous research this study specifically measures the level of interest and knowledge of chemistry teachers in Madrasah Aliyah towards ethnoscience-based learning. The results show that although 92.3% of teachers have high interest, only 46.2% have adequate knowledge, and 57.7% have never implemented it. Not only does it identify the limitations of teachers' understanding, this study also highlights structural barriers, such as the lack of infrastructure and supporting facilities. This includes the absence of laboratory equipment relevant to ethnoscience and learning modules based on local wisdom. This article focuses on the unique context of madrasahs by emphasizing the importance of ethnoscience integration to improve students' understanding of chemistry while maintaining local cultural values. This study suggests that supportive madrasah policies can be an important step in overcoming implementation barriers. This study provides specific recommendations, including the need for structured training for teachers, the development of ethnoscience-based learning modules, and improving laboratory facilities that support local culture-based experiments. This study goes beyond previous studies by providing in-depth contextual data on the conditions of Madrasah Aliyah, as well as practical recommendations to overcome challenges in implementing

ethnoscience. This makes this article an important reference for the development of local wisdom-based education policies.

Based on an interview with the Head of Wonogiri State Islamic Senior High School, the madrasah policy is very supportive if teachers want to implement ethnoscience-based learning. This statement is supported by the Deputy Head of Madrasah for Curriculum who is related to the curriculum structure and learning devices. In addition, the results of the interview with the Deputy Head of Madrasah for Facilities and Infrastructure are very supportive of ethnoscience learning, and there will continue to be improvements to facilities and infrastructure. Regarding students, the Deputy Head of Madrasah added that students at Wonogiri State Islamic Senior High School come from all over Wonogiri and even from outside Wonogiri, which allows for heterogeneity in the conditions of students in terms of culture, habits and local wisdom.

In addition to support from the stakeholders above to optimally implement ethnoscience-based learning, madrasahs need to develop policies that support the creation of an inclusive, relevant, and contextual learning environment in accordance with local culture, including curriculum integration. For example, by identifying natural phenomena related to local community traditions, conducting workshops or In House Training for teachers to prepare teaching modules and integrated ethnoscience learning media, as well as student science projects based on culture, such as making environmentally friendly local products, simple research on local wisdom, or science and culture exhibitions. Madrasah needs to ensure that ethnoscience-based learning policies are evaluated periodically. This is important to identify the challenges faced by teachers and students and to improve the implementation of these policies. Through these policies, schools can create learning that not only teaches modern science, but also instills a love for local culture, increases environmental awareness, and forms students' characters who value diversity. Thus, ethnoscience-based learning can be an important means of preserving local wisdom while preparing the younger generation to face global challenges.

Madrasah Aliyah Wonogiri as part of Madrasah Aliyah Se Karesidenan Surakarta has the potential to implement ethnoscience-based chemistry learning by considering the results of a survey indicating that not many have developed ethnoscience-based learning and interviews with policy makers and stakeholders of Madrasah Aliyah Wonogiri. Learning with an ethnoscience context plays an important role in efforts to improve student learning outcomes in the aspects of knowledge, attitudes, and skills. Therefore, the integration of ethnoscience in science learning needs to be continuously developed.

Conclusion

This study shows the great potential of ethnoscience application in chemistry learning in Madrasah Aliyah, although significant challenges such as limited teacher knowledge and lack of facilities need to be overcome. With proper training and policy support, this approach can improve the quality of chemistry learning while preserving local wisdom.

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