



Ethnochemistry-Based E-Module: Does it Effect on Improving Students' Chemical Literacy

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Abstract: The low chemical literacy of students is caused by the lack of involvement of the socio-cultural environment in chemistry learning. Ethnochemistry is an exciting learning approach today because it can catalyze chemical literacy in chemistry education in the twenty-first century. This study aims to analyze the effectiveness of ethnochemistry using e-modules in improving students' chemical literacy competency. The research method used is quasi-experimental. The research subject is the chemistry education study program at two universities in West Nusa Tenggara. The sampling technique uses cluster random sampling to select the research sample. The sample consisted of two classes, namely class IIA (totaling 100 students), which served as the experimental group, and class IIB (which also consisted of 100 students), which served as the control group. Data collection was carried out using a chemical literacy essay test. Statistical tests, including the ANOVA and N-Gain, were used to evaluate students' chemical literacy. The results showed that 1) ethnochemistry-based e-modules have a significant effect on chemical literacy; 2) The use of e-modules in ethnochemistry can improve students' chemical literacy, especially in solving environmental problems. Thus, this research contributes to integrating E-module content with hybrid-based ethnochemistry as a 21st-century learning innovation. The implication of this study is that students' chemical literacy can be improved through ethnochemistry-based e-modules.

Keywords: green governance, local wisdom, TNBTS

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INTRODUCTION

Chemistry is the study of matter and the substances that compose it; it also involves identifying these substances, studying their properties, and using methods to synthesize new compounds. The knowledge of chemistry is essential to students in other fields of study, such as biology, geology, and physics, and therefore is central to studying science (Nwanze et al., 2018; Wardani et al., 2024). It is thus perceived as an ancient science and activity-oriented subject. Research has shown that chemistry is generally a complex subject for all students, although its study is closely associated with nature and the physical world around us (Chibuye & Singh, 2024; Childs et al., 2015). The chemistry study also requires students to possess good science process skills to experiment with natural phenomena. These challenges have been reflected in secondary school chemistry students' achievement, which has been greeted with several appalling remarks from Chief Examiners over the years.

A new chemistry education paradigm demands students to verbally comprehend conceptual stuff through memorization, formulas, and terms (Erman et al., 2020; Widarti et al., 2024). However, the instructor must still give students relevant, everyday chemistry examples (Putera & Hadi, 2024; Sumarni, 2018). Inspiring students to apply the scientific approach to studying natural phenomena (Rahmawati & Ridwan, 2017; Sarini et al., 2024). Students should also be able to respond responsibly to environmental issues related to chemistry in their communities, such as the depletion of the ozone layer, climate change, acid rain, the greenhouse effect, pollution, and so on (Celik, 2014; Syahmani et al., 2024). However, it reveals that chemistry classes can only meet those needs. According to Erman et al. (2020), What it means to be chemically "literate" does not correspond to what most Indonesians experience daily. Many people continue to demonstrate an inability to apply chemistry knowledge daily. The research conducted by (Dewi et al., 2019; Dewi et al., 2021; Rahmawati & Ridwan, 2017; Sumarni et al., 2017), most students need help with using their chemistry knowledge in the real world. Inadequate and incorrect knowledge of nominal and functional chemical literacy is a problem for 56% of aspiring chemistry teachers (Adesoji et al., 2019; Sumarni, 2018). A considerable portion of STEM needs to gain a greater understanding of the concept at the macroscopic level. Teachers give more points for learning formulas and using them than for conceptual, procedural, and multidimensional questions (Celik, 2014). The research of (Sumarni, 2018; Sumarni et al., 2017) demonstrates that many chemistry students need help

applying chemical concepts and relating them to external phenomena. A memory-based learning pattern with low critical thinking challenges and minimum memory access might cause the problem. This condition indicates that university learning outcomes must be improved to make their chemistry literate. This literacy reflects citizens' readiness to face global challenges (Archer-Bradshaw, 2017; Dewi et al., 2021).

The research findings above showed a big gap between students' knowledge and application. Most of what the students learned consisted of information that could be stored in their memories rather than used in their daily lives, such as facts, empirical data, and calculations. Therefore, an effort needs to be made to raise the literacy rates of chemical education students. The chemistry curriculum of the future needs to address real-world problems. Effective teaching methods exploit real-world examples, capitalize on regional benefits, and lead students to conclude intricate scientific and societal issues (Adesoji et al., 2019). The chemistry of social interactions centers on the maximization of contextual knowledge. Students might be inspired to learn by examining their own communities' abilities. Incorporating cultural competence into the various professions, including schooling, will become the deciding factor for professional service. Therefore, the lecturer needs to use local culture to meet the needs of the learning process (Ugwu, 2020).

One method to enhance the quality of education is to include cultural elements relevant to the target audience (Genc, 2015). Ethnochemistry is a process of translating community knowledge into chemistry knowledge. All chemistry related to environmental reality is considered pure chemistry (Wen et al., 2020). A refined understanding of society is reflected in local culture as a belief in nature and culture that exists in society (Sumarni, 2018). Generally, chemistry education in schools is only centered on the material provided in printed books as a guide. Chemistry learning must still reveal cultural facts in students' daily lives (Adesoji et al., 2019; Ugwu, 2020). The content of the material has yet to blend with the culture. The involvement of electronic media in the form of digital books as a source of learning to understand culture needs to be improved. Therefore, it is necessary to improve the learning process, one of which is by implementing existing strategies. Teachers must combine pure chemistry and chemistry by using an Ethnochemistry approach to teach chemistry (Dewi et al., 2022). A system has been successfully implemented. Culture lends credence to it, and a culture that endorses it is also connected with the correct approach (Archer-Bradshaw, 2017; Erna et al., 2021).

E-modules are one online learning medium that has been shown to successfully increase students' chemical knowledge. E-modules are online courses that can help students improve their understanding of chemistry, which is becoming increasingly vital in today's society (Dewi et al., 2022). E-modules can teach students about the media in various ways, including reducing travel time to relevant resources, teaching responsible ICT use, and providing a hub for independent study, news, and perspective-widening resources (Waluya et al., 2022). E-modules are a straightforward way to learn acid-base chemistry. This is because understanding chemical acid-base concepts is facilitated by their abstract nature. The process of creating chemical reactions as an example of an abstract idea can be taught more effectively through media in the form of an e-module (Khelifi & El-Sabagh, 2017; Purnamasari et al., 2020). The online course module is also quite (Sofyan et al., 2019; Waluya et al., 2022). E-modules can teach critical thinking skills and encourage independent study (Abidin & Walida, 2019; Zakiyah & Sudarmin, 2022). E-modules are an exciting and valuable addition to the educational landscape (Pratiwi et al., 2021). E-learning, in the form of digital electronics in the form of e-modules, has advanced to the point where professors must produce teaching materials that are compatible with the 4.0 era of the Industrial Revolution, making it more straightforward for students to absorb the material provided (Waluya et al., 2022; Zakiyah & Sudarmin, 2022). Students benefit from e-modules because they allow for flexible, independent learning that may be done from any device at any time (Awaliyah et al., 2022; Erna et al., 2021). Therefore, the originality of this study lies in testing how well an e-module-mechanochemistry approach may help students learn about acid-base chemistry.

Based on these facts and the fact that teachers are essential to the learning process, there needs to be a change in how teachers teach. Following the suggestion (Dewi et al., 2022; Dewi et al., 2022; Dewi et al., 2021; Sumarni, 2018), teaching institutions must improve future chemistry teachers' literacy by utilizing digital technology to support learning resources through ethnochemistry-based e-modules. Previous studies showed that there has yet to be research on using ethnochemistry-based e-modules to improve students' chemical literacy. This is an innovation in this research because it involves ethnochemical-based hybrid learning. Therefore, the author proposes a learning process using ethnochemistry-based e-modules to improve students' chemical literacy. This study aims to analyze the effect of using ethnochemistry-based e-modules on increasing students' chemical literacy. The following are the research questions (RQ): 1) Is there a significant effect of using ethnochemistry-based e-modules on students' chemical literacy?; 2) Is there an increase in students' chemical literacy using ethnochemistry-based e-modules?

METHODS

This study used a quasi-experimental design with a control group and pre- and post-study assessments (Creswell, 2014). The treated group was compared to a non-treated control group using a pre-and post-test method (Dimitrov & Rumrill Jr, 2003). Students' chemical literacy ability is the independent variable, and Ethnochemistry-based E-modules are the dependent variable. Students in the Ethnochemistry-based E-module group were compared with students in the control group who were familiar with ethnochemistry-based textbooks for eight meetings. Table 1 shows how the study was established as quasi-experimental before and after the test with the experimental and control groups (Creswell, 2014).

Table 1. Design of Pre-test and Post-test Control Groups

Group	Pre-test	Treatment	Post-test
Experimental	CLCT1	E-module-Ethnochemistry	CLCT2
Control	CLCT1	Conventional	CLCT2

The 200 participants came from the Chemistry Education Study Program at two universities in West Nusa Tenggara. The sampling technique uses cluster random sampling, where the samples taken come from only a list of cluster members without requiring representatives from all population members (Tanzeh & Arikunto, 2020). Classes IIA and IIB, each with 100 pupils, were the experimental and control groups. Students in both classes are of the same age, gender, and socioeconomic origin, and the same people teach them. The E-module-Ethnochemistry was used in the experimental group, while the Textbook-Ethnochemistry was used in the control group. Every student gets access to qualified educators. The research was conducted from July to September 2023, in the even semester of the 2022/2023 academic year.

The Chemical Literacy Competency Test (CLCT) was customized and created for this study using the PISA framework for science assessment (Thummathong & Thathong, 2018). CLCT has three levels: (a) scientifically explain a particular event, (b) evaluate and design scientific investigations, and (c) scientifically analyze facts and evidence. Chemical literacy instruments are tested on students who have taken introductory chemistry courses on acid-base materials. Furthermore, the validity and reliability of the tools that have been tested are analyzed. The results of instrument validation are shown in Table 2.

Table 2. Validity of the chemical literacy instrument

Item-Total Statistics					
Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Category
CL_1	22.0400	42.207	.707	.791	Valid
CL_2	22.2800	48.127	.883	.828	Valid
CL_3	22.0000	44.167	.484	.804	Valid
CL_4	21.9600	43.957	.573	.799	Valid
CL_5	21.9600	44.873	.525	.802	Valid
CL_6	21.8400	45.640	.427	.807	Valid
CL_7	21.6000	47.167	.397	.812	Valid
CL_8	21.9600	45.457	.516	.804	Valid
CL_9	21.6800	45.310	.595	.801	Valid
CL_10	21.9200	46.910	.550	.806	Valid
CL_11	22.0000	47.250	.793	.819	Valid
CL_12	21.9200	48.410	.408	.816	Valid
CL_13	21.9200	46.827	.425	.812	Valid
CL_14	21.9600	44.040	.517	.802	Valid
CL_15	22.3600	46.573	.357	.810	Valid

Furthermore, reliability tests were carried out on chemical literacy ability instruments, and the reliability test results are presented in Table 3. The reliability test results show a reliability value of 0.817, with high reliability.

Table 3. The Reliability of Chemical Literacy Instrument

Reliability Statistics	
Cronbach's Alpha	N of Items
.817	15

Eight sessions (8 x 50 mins = 400 mins) were devoted to the treatment, including two 50-minute sessions each for a pre-test and post-test panel and three 50-minute sessions each for studying acid-base characteristics at three conferences and acid-base titration at three sessions. At the outset of the intervention, the professor posed a perceptual question: "*If you accidentally swallowed soapy water when you showered, how would you feel??*". The lecturer then used one of the e-modules as an example. The instructor had the students break into smaller groups to discuss the problem and develop a solution. The instructor pushed for student presentations following group work. After the debate's conclusion (Figure 1), the professor emphasized its significance. The lecturer then had the students work in groups to devise and conduct acid-base experiments. The instructor assessed the class project. The last time we met, students performed experiments while the lecturer supervised and provided instruction on determining the acid-base strength of various substances. The normality test determines whether the data under consideration follows a normal distribution using the Kolmogorov-Smirnov test. In contrast, the homogeneity test determines the extent to which the population variants following the normal distribution are similar using the Levene test. The normality test results are presented in Table 4.

Table 4. Results of the Student Chemical Literacy Competency Normality Test

Tests of Normality			
Kolmogorov-Smirnov^a			
	Statistic	df	Sig.
Chemical Literacy	.095	131	.076

Table 4 shows the significance value of 0.076 (>0.05), so customarily distributed data can be inferred. Further homogeneity test is carried out; the homogeneity test results are presented in Table 5.

Table 5. Results of the Student Chemical Literacy Competency Homogeneity Test

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Chemical Literacy	Based on Mean	.125	1	132	.725
	Based on Median	.001	1	132	.979
	Based on the Median and with adjusted df	.001	1	81.815	.979
	Based on trimmed mean	.117	1	132	.733

Table 5 shows that the significance value is 0.733 (> 0.05), so it can be concluded that the data has a normal distribution. Furthermore, the Analysis of Variance (ANOVA) test was carried out to determine the effect of ethnochemistry-based e-modules on students' chemical literacy. Simultaneously, N-gain tests were performed to compare differences in pre- and post-intervention chemical literacy scores to determine how much change there was. The calculation for the value gives three sets of data, which can be understood in the following way.

Table 6. Classification of Value Gains (Dewi, 2019)

Average Gain	Criteria
0,00-0,30	Low
0,30-0,70	Medium
0,70-1,00	High

RESULT AND DISCUSSION

The first hypothesis was tested to test the impact of ethnochemistry-based e-modules on students' chemical literacy. This test compares chemical literacy scores between experimental classes using ethnochemistry-based e-modules and control classes with conventional learning. Comparison of experimental and control pre-test and post-test groups for chemical literacy are shown in Figure 1 below.

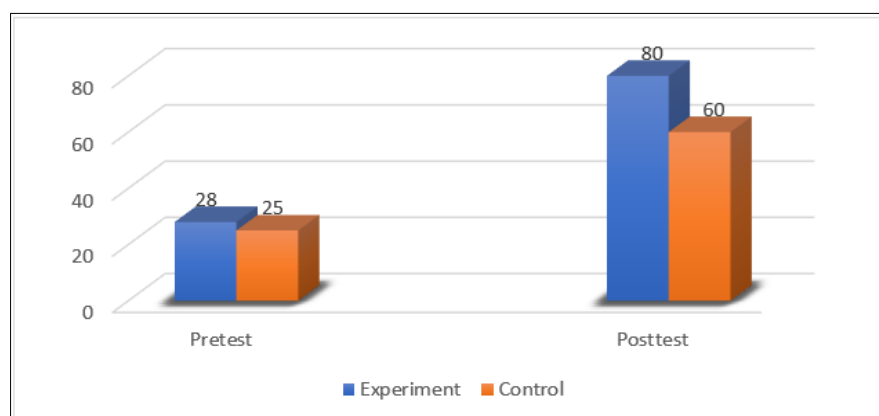


Figure 1. Pre-test and post-test scores of students' chemical literacy

Figure 2 shows that the average score of chemical literacy competence in the experimental class is higher than in the control class. This is reinforced by the results of the ANOVA test, which shows that the significance value is 0.000 (<0.05), which can be concluded that there is a significant influence on students' chemical literacy competence in experimental classes and dick. The following ANOVA test results are presented in Table 7.

Table 7. Anova Test Results on Chemical Literacy Ability

ANOVA					
		Sum of Squares	df	Mean Square	F
Experiment-Chemical Literacy	Between Groups	53779.766	2	26889.883	507.189.000
	Within Groups	6786.234	188	53.017	
	Total	60566.000	200		
Control-Chemical Literacy	Between Groups	340.129	2	170.064	2.013 .000
	Within Groups	10813.871	188	84.483	
	Total	11154.000	200		

The scores of the experimental and control groups were drastically different from each other. This shows that ethnochemistry-based e-modules positively impact students' chemical literacy competency, especially in helping students learn about chemistry. The experimental group's results were higher than those of the control group. Students in experimental groups contribute to improved learning by conducting, relating common problems and scientific concepts, and applying existing knowledge to new situations. Students can conduct experiments, record results, and conclude with the instructor's guidance. As stated in [Genc \(2015\)](#), ethnochemistry education raises students' chemical literacy. Students with a strong understanding of chemistry can structure their experiments and draw meaningful conclusions from the results ([Pebrianti & Suryani, 2024](#); [Wen et al., 2020](#)). Also, having teachers actively participate in the research has increased students' chemistry literacy ([Inayati et al., 2024](#); [Khaira et al., 2022](#)). Finally, it found that learning chemistry literacy increased students' enthusiasm for learning chemistry and active participation ([Lestari et al., 2024](#); [Shavlik et al., 2022](#)).

An electronic chemistry module with an ethnochemistry focus improved the experimental group's chemistry knowledge. Students learn science concepts in e-module-ethnochemistry during the intervention. In this setting, students are assigned to complete contextual projects, demonstrate a contextual understanding of scientific ideas, and defend their claims with evidence. To get better at chemistry, students need to be able to explain their thoughts with evidence, according to [Balgopal et al. \(2017\)](#) and [Pisa \(2015\)](#). Furthermore, according to ([BouJaoude, 2002](#)), In terms of scientific knowledge and experience, the quality of digital modules is essential. Applying scientific information effectively is at the heart of chemical literacy ([Fitri et al., 2024](#); [Schleicher, 2019](#)). As a result, students who understand chemistry will become chemically literate ([Fatihatussa'adah et al., 2024](#); [Kang, 2022](#); [Wijayanto et al., 2023](#)).

Students in the experimental group did better than those in the control group, with a considerable increase in chemical literacy after receiving the intervention, as determined by an independent t-test. E-module-Ethnochemistry outperforms module instruction to improve students' chemical literacy in this regard. The E-module-Ethnochemistry is an excellent platform for students to network, learn from, and critique one another's work. Students can form smaller groups, take on greater responsibility, and actively participate in problem-solving. Because of this, people learn more, gain confidence, and become more scientifically educated. Problem-solving and discourse in context-based learning can influence students' motivation, perspective, and scientific literacy ([McPherson & Johnston, 2022](#); [Mutiah et al., 2024](#)). In chemical literacy, students can better hone their

critical thinking and debating skills in an environment encouraging scientific thinking (Kamaludin et al., 2024; Shavlik et al., 2022). The increase in students' chemical literacy ability per indicator is shown in Figure 2 below.

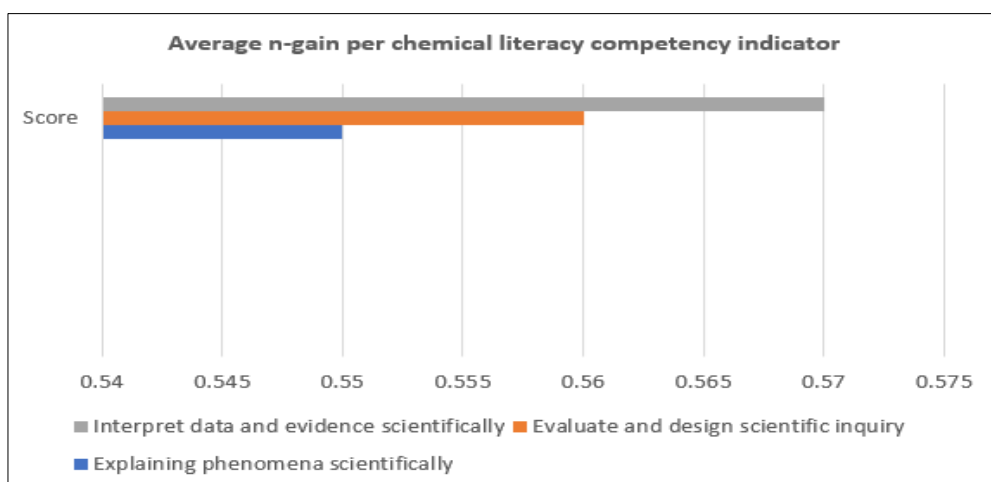


Figure 2. Average n-gain per chemical literacy competency indicator

Figure 2 shows that the competency aspect of chemical literacy in the indicator explaining the phenomenon scientifically has an N-gain score of 0.55, and the scientific inquiry indicator evaluating and designing has an N-gain score of 0.56. The hand-interpreting scientific data and evidence get an N-gain score of 0.57 in the medium category. This shows that students' chemical literacy competence increases after being taught using ethnochemistry-based e-modules. Students' chemical literacy competence increases after using ethnochemistry-based e-modules. This is because using ethnochemistry-based E-modules can provide detailed explanations and predict the results of scientific experiments. Students must understand their data, draw conclusions, reason logically, and present their findings and arguments throughout the curriculum. Students gain scientific knowledge about real-world problems by writing down their thoughts and communicating with their peers (Balgopal et al., 2017; Hasanah et al., 2024). The science context studied greatly influences chemical literacy (Guerrero & Torres-Olave, 2022; Hasanah et al., 2024). This aligns with the principle of context-based learning, which emphasizes using meta-cognitive skills and expects students to be scientifically literate (Mustafaoğlu, 2022; Sari et al., 2024). Students can indirectly learn about chemical changes, natural resources, and the digestive system through ethnochemistry lessons, including "Pudak." Through teaching ethnochemistry, such as "Pudak," students can indirectly learn about chemical changes, natural resources, and the digestive system. Furthermore, as students use natural resources in their environment, natural resources are studied. In other words, scientifically literate students can make connections between their classroom studies and nature (Rivera Gavidia & Marrero Galván, 2023; Young et al., 2024).

The E-module-Ethnochemistry successfully enhanced "explaining phenomena scientifically" in this study. The experimental group was given texts and videos regarding incidents in their daily life and asked to explain why the changes occurred. E-module-ethnochemistry can improve "assessment and design scientific questions" as well. As a result, schooling was redesigned to provide empirical proof of real-world events, with students encouraged to conduct small-group scientific research. The e-module-ethnochemistry also fostered "interpretation and scientific evidence" by arming students with empirical evidence on practical applications. This study's findings corroborate previous empirical evidence. For example, contextual learning was more effective than traditional teaching at increasing student scientific literacy (Genc, 2015; Hayati et al., 2024). Furthermore, according to Asadpour et al. (2022) and Cahyana et al. (2024), students engaged in context-based human experience learning performed better on science assessments and held more favorable attitudes toward the subject than their textbook-taught counterparts. Produced and evaluated a contextual science book in the Indonesian context, showing that a well-designed science book significantly improved eighth and ninth-grade students' scientific literature (Khaira et al., 2022; Sinaga et al., 2017). E-modules can teach students about the media in various ways, including reducing travel time to relevant resources, teaching responsible ICT use, and providing a hub for independent study, news, and perspective-widening resources (Khlifi & El-Sabagh, 2017).

E-modules are a straightforward way to learn acid-base chemistry. This is because understanding chemical acid-base concepts is facilitated by their abstract nature. Consider the process of creating chemical reactions as an example of an abstract idea that can be taught more effectively through media in the form of an e-module (Khlifi & El-Sabagh, 2017; Purnamasari et al., 2020). The online course module is also quite convenient (Saitong, 2022; Sofyan et al., 2019; Waluya et al., 2022). E-modules can help teach critical thinking skills and encourage independent study (Abidin & Walida, 2019; Zakiyah & Sudarmin, 2022). E-modules are an

exciting and valuable addition to the educational landscape (Alsabbagh & Azeez, 2023; Dewi et al., 2022; Lubis et al., 2023). E-learning, in the form of digital electronics in the form of e-modules, has advanced to the point where professors must produce teaching materials that are compatible with the Industrial Revolution 4.0, making it more straightforward for students to absorb the material provided (Waluya et al., 2022; Zakiyah & Sudarmin, 2022; Zulaeha et al., 2023). Students benefit from e-modules because they allow for flexible, independent learning that may be done from any device at any time (Abidin & Walida, 2019; Dewi et al., 2021; Erna et al., 2021; Hasanudin et al., 2022). The impact of this research is that the ethnochemistry-based E-module can support the independent learning process by directing students to independently research problems in everyday life related to the culture around them so that it significantly influences the improvement of students' chemical literacy because it helps students develop their ability to understand chemistry in various problems.

CONCLUSION

This study shows that ethnochemistry-based e-modules have a significant effect on chemical literacy, and the use of e-modules in ethnochemistry can improve students' chemical literacy, especially in solving environmental problems. That is, using ethnochemistry-based e-modules can improve students' chemical literacy. The impact of this research is that students' chemical literacy can be enhanced through ethnochemistry-based e-modules. The limitation of this study is the difficulty of implementing ethnochemistry-based e-modules in locations without extensive internet access. The recommendation for future researchers is that good internet access is needed to facilitate ethnochemistry-based e-modules in chemistry and science learning.

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