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Integrated Guided Inquiry Learning Model of Ethnochemistry on High School Students' Critical Thinking Skills and Learning Interest in Reaction Rate Material

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ABSTRACT

This study investigates the effect of the guided inquiry learning model integrated with ethnochemistry on senior high school students' critical thinking skills and learning interest in reaction rate. A quasi-experimental design with a pretest-posttest control group was employed, involving 60 students of class XI MIPA at SMAN 4 Lubuklinggau, selected through random sampling. Data were collected using a critical thinking test and a learning interest questionnaire, and analyzed with MANOVA. Findings revealed significant differences in critical thinking and learning interest between the two groups, with effective contributions of 65.7% simultaneously, 43.2% individually to critical thinking, and 44.3% to learning interest. These results demonstrate that guided inquiry integrated with ethnochemistry not only enhances students' cognitive and affective outcomes but also contributes to science education by contextualizing learning through local culture. It is therefore suggested that this model be applied to other chemistry topics and across broader student populations to strengthen its effectiveness and further enrich culturally grounded science learning.

ARTICLE INFORMATION

Keywords:
critical thinking skills; ethnochemistry; guided inquiry learning; learning interest; reaction rate

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INTRODUCTION

Education is the foundation for developing high-quality human resources capable of addressing global challenges in the 21st century. This era demands mastery of critical thinking, creativity, communication, and collaboration skills as core competencies that students must possess (Andrian & Rusman, 2019; Lestari & Hindun, 2023; Putra et al., 2018). These skills not only support academic abilities but also help prepare a generation that is adaptive and innovative. Aware of this, the Ministry of Education, Culture, Research, and Technology has implemented the Merdeka Curriculum, which focuses on project-based learning, character development, and the cultivation of soft skills to shape independent and critical Pancasila-based learners (Rihmahwati et al., 2024; Yamin & Syahrir, 2020).

Critical thinking skills play an important role in the science learning process, including chemistry, because they enable students to analyze information, evaluate arguments, and make logical decisions (Redhana, 2019; Agustin et al., 2018). However, several studies indicate that students' critical thinking skills remain low (Hasmarani et al., 2019; Khoirunnisa & Sabekti, 2020). One cause is that chemistry learning remains predominantly memorization-oriented, lacks active participation, and is challenging to understand due to its abstract nature (Rahmawati et al., 2019; Stocklmayer & Gilbert, 2002). The complexity of the relationships between chemistry concepts further exacerbates these difficulties (Kusumaningrum et al., 2018), necessitating learning strategies that are more effective in developing critical thinking skills.

In addition to critical thinking, learning interest also plays a crucial role in determining students' academic success (Rozikin et al., 2018). Unfortunately, chemistry is often perceived as a problematic and uninteresting subject, negatively impacting student motivation and participation (Andriani et al., 2019; Hemayanti et al., 2020). This low interest is exacerbated by monotonous, unvaried teaching methods and limited opportunities for students to explore concepts independently (Hasibuan et al., 2021; Metaputri & Garminah, 2016). To address these challenges, innovative, context-specific learning approaches are needed, including the integration of ethnochemistry into the chemistry curriculum. As a relatively new approach, ethnochemistry has been shown to stimulate students' curiosity not only about chemical concepts but also about the cultural traditions closely related to them. Through this integration, students demonstrate greater social awareness, sensitivity to others, and interdependence, particularly during collaborative discussions (Ridwan et al., 2025). Many students reported that their communication with peers increased, they became more comfortable expressing their ideas, and they developed a better understanding of their classmates' personalities, ultimately improving their ability to collaborate. In addition to increasing engagement, the integration of cultural content also fostered students' appreciation for Indonesian cultural heritage, encouraging them to internalize values such as loyalty, care, and respect for language, the social and physical environment, and broader cultural, economic, and national identities. In this way, integrating chemistry content into students' daily lives and culture not only provides academic benefits but also fosters character development and cultural identity, in line with the goals of chemistry education (Kelley, 2024).

One important but often challenging chemistry topic is reaction rate. This topic requires a deep conceptual understanding and mastery of mathematical calculations, making critical thinking skills essential (Dewi et al., 2020; Ramadhanti & Agustini, 2021). However, many students still face obstacles in understanding the factors influencing reaction rates, collision theory, and the application of mathematical equations (Muliaman, 2021). Lecture-based learning makes students less active, unmotivated, and unable to relate the material to real-world phenomena (Jamilla & Lazulva, 2020; Sandabunga et al., 2021). This situation underscores the need for a learning model that encourages active engagement while improving students' conceptual understanding.

The guided inquiry learning model is considered an effective alternative because it provides students with the opportunity to discover concepts through teacher-guided investigative activities (Puspaningtyas & Suparno, 2017). Previous research has demonstrated that implementing this model can improve learning outcomes, conceptual understanding, and critical thinking skills compared to conventional learning (Asni et al., 2020; Nisa et al., 2018). Furthermore, integrating ethnochemistry into ethnoscience is considered important for creating more meaningful chemistry learning. Ethnochemistry connects abstract concepts with local cultural phenomena, thereby not only enhancing understanding but also fostering appreciation for cultural values (Rahmawati et al., 2019; Sumarni, 2018). Students stated that learning became more interesting when ethnoscience was integrated into their curriculum (Sutrisno et al., 2020; Ugwu, 2020)

Although various studies have demonstrated the effectiveness of guided inquiry, its integration with ethnochemistry is still rarely implemented. Most teachers still use conventional approaches that rely on textbooks, while the integration of local culture has not been widely utilized (Aldiansyah et al., 2023). This indicates a research gap regarding the implementation of learning that can develop critical thinking skills and learning interest through the integration of scientific and cultural aspects. Therefore, this study was conducted to determine the effectiveness of the ethnochemistry-based inquiry learning model in improving students' critical thinking skills and learning interest in reaction rate material.

METHOD

This research used a quantitative approach. The research design was quasi-experimental with a pretest-posttest control group (Creswell, 2017). This study involved an experimental group and a control group. The experimental class implemented an integrated ethnochemical guided inquiry learning model, while the control class used a scientific approach. Prior to the study, ethical approval and permission were obtained from the school, and consent was also obtained from participating students to ensure compliance with ethical standards. The research design is presented in Table 1.

Table 1. Research Design

Group	*Pre-test*	Treatment	*Post-test*
Experiment	O_1, O_2	X_1	O_1, O_2
Control	O_1, O_2	X_2	O_1, O_2

This research aims to compare the effectiveness of two different learning strategies. The first treatment (X1) utilizes an integrated guided inquiry learning model of ethnochemistry, while the second treatment (X2) employs a standard scientific approach. The impact of these interventions is measured based on two dependent variables: (O1) students' critical thinking skills and (O2) students' learning interest, with data for the latter collected via a questionnaire. This study was conducted at SMA Negeri 4 Lubuklinggau, South Sumatra Province, during the second semester of the 2024/2025 academic year (January–February 2025) with reaction rate material. The study population consisted of all Grade XI MIPA students at accredited A-level public high schools in Lubuklinggau Selatan II District that follow the Merdeka Curriculum and have a balanced student population, with SMA Negeri 4 Lubuklinggau selected as the appropriate location. The sample was selected by random sampling from five Grade XI MIPA classes, after an ANOVA test on chemistry PAS scores showed no significant difference (sig. 0.135). Based on these results, Grade XI MIPA 2 was selected as the experimental class and Grade XI MIPA 3 as the control class, each with 30 students.

The data collection techniques used in this study included tests and non-tests. The tests consisted of essay questions measuring students' critical thinking skills in reaction rates, administered as pre- and post-tests in the experimental and control classes, with a grid compiled from critical thinking indicators by Ennis (2011). Non-test techniques were conducted through a learning interest questionnaire using a Likert scale adapted from several experts, administered at the beginning and end of the learning process. The instruments used included critical-thinking ability tests, learning-interest questionnaires, teaching modules, and worksheets designed according to the learning syntax of each class. All instruments were validated theoretically through expert judgment and empirically through pilot testing on students outside the sample, with results deemed valid. Reliability testing using Cronbach's Alpha yielded very high values, indicating that the research instruments were valid, reliable, and suitable for use.

The data analysis technique used in this study was MANOVA, with a significance level of 5%, to determine differences in critical thinking skills and learning interest between students who participated in guided inquiry learning integrated with ethnochemistry and those who used a scientific approach. Learning outcomes were analyzed using N-gain from pre-test and post-test scores, while the MANOVA prerequisite tests included normality, homogeneity, linearity, and multicollinearity, all of which were met. The analysis was conducted using SPSS, including multivariate and univariate significance tests, along with effect-size calculations using the Partial Eta Squared to determine the magnitude of the treatment's influence on the dependent variable.

RESULTS AND DISCUSSION

Well-prepared tables and or figures must be a significant feature of this section, because they convey the major observations to readers. Any information provided in tables and figures should no longer be repeated in the text, but the text should focus on the importance of the principal findings of the study. In general, journal papers will contain three to seven figures and tables. The same data can not be presented in the form of tables and figures. The results of the study are discussed to address the formulated problem, objectives, and research hypotheses. It is highly recommended that the discussion focus on the why and how of the research findings and extend to how they can be applied to other relevant problems.

This study was conducted in January–February 2025 at SMA Negeri 4 Lubuklinggau, involving students from classes XI MIPA 2 and XI MIPA 3 over six sessions. The primary objective of the study was to analyze differences in critical thinking skills and learning interest between students who participated in guided inquiry-based learning integrated with ethnochemistry and those who received instruction through a scientific approach on reaction rates, while also assessing the effectiveness of the guided inquiry model on both variables. Data on critical thinking ability were obtained through pre- and post-tests, while data on learning interest were collected through questionnaires. Prior to the study, a preliminary study was conducted, including obtaining permission, initial observations, and interviews with chemistry teachers. The observation results indicated that instruction was still dominated by lecture methods with textbooks as the primary learning resource, while students' critical thinking ability and learning interest were relatively low.

The research instruments, consisting of test questions and questionnaires, were developed through theoretical validation by experts in chemistry education and empirical validation with 12th-grade students outside the research sample. The validity and reliability tests were analyzed using IBM SPSS Statistics 26, and the instruments were found to meet the criteria for use in the primary research. The research was conducted over six sessions, each lasting 2 × 45 minutes, encompassing a pre-test phase, learning activities, and a post-test phase. The experimental class utilized Student Worksheets (SW) based on an integrated guided inquiry model incorporating ethnochemistry, while the control class used SW with a scientific approach. The material presented included the concepts of reaction rate, collision theory, factors affecting reaction rate, rate law, and reaction order. All learning activities were carried out according to the designed procedures, and the final session concluded with the administration of the post-test in both classes.

Research data on students' critical thinking skills and learning interests were obtained from pre- and post-test results in the experimental and control classes. The analysis included minimum, maximum, average, and n-Gain values for each variable. Critical thinking skills were measured through a written test on reaction rate material, while learning interest was assessed using a questionnaire administered before and after learning. In general, the data indicate differences in achievement between the experimental class, which used an integrated ethnochemistry-guided inquiry model, and the control class, which used a scientific approach. The details of the descriptive calculations for both variables are presented in Table 2.

Table 2. Descriptive Analysis and N-Gain Results

Variable	Treatment	Class	Minimum score	Maximum score	Average value	Average n-Gain
Critical Thinking Skills	Pre-test	Experiment	8	40	20.43	0,69
	Post-test	Experiment	59	87	75.6	
	Pre-test	Control	4	32	11.17	0,52
	Post-test	Control	44	69	57.1	

Interest in Learning	Pre-test	Experiment	45	102	73.8	0,84
	Post-test	Experiment	109	129	116.83	
	Pre-test	Control	40	96	67.1	0,57
	Post-test	Control	83	125	103.43	

The results of the data analysis show that the experimental class using the integrated ethnochemistry-guided inquiry model experienced a greater increase than the control class using the scientific approach. In terms of critical thinking skills, the experimental class's average score rose from 20.43 on the pre-test to 75.6 on the post-test, while the control class increased only from 11.17 to 57.1. A similar trend was observed in learning interest, where the experimental class increased from 73.8 to 116.83, while the control class increased from 67.1 to 103.43. The average n-Gain reinforced these findings, with 0.69 for critical thinking skills and 0.84 for learning interest in the experimental class, higher than the control class, which had 0.52 and 0.57, respectively. These results confirm that the guided inquiry model, integrated with ethnochemistry, is more effective than the scientific approach in improving students' critical thinking skills and learning interest.

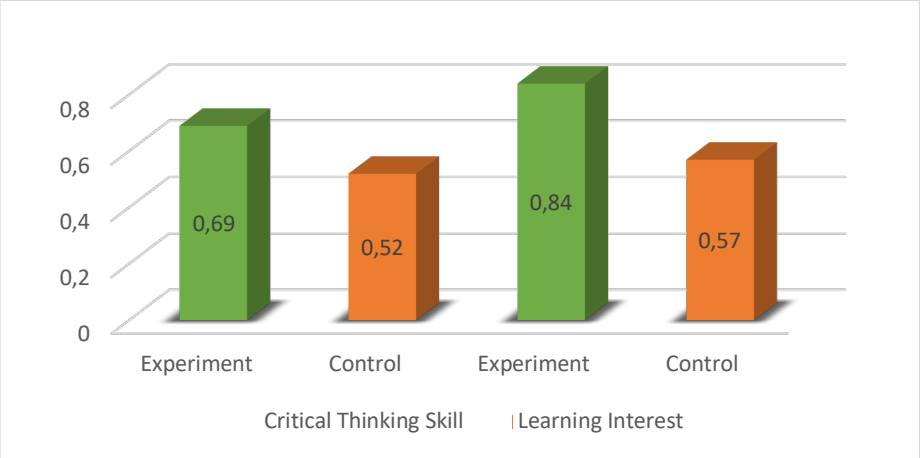


Figure 1. Comparison of Control and Experimental Classes

Prior to the main analysis, all MANOVA prerequisite tests were met, so MANOVA testing was continued. This analysis aims to identify significant differences in critical thinking skills and learning interests, both simultaneously and separately, between students who learn using the integrated ethnochemistry-guided inquiry model and those who learn using the scientific approach. The MANOVA was conducted using Pillai's Trace statistics in IBM SPSS Statistics 26.

Table 3. MANOVA Test Results

Effect	Value	Sig.	Partial Eta Squared	Description
Pillai's Trace	0,986	0,000	0,657	There is a difference

Based on the results of the MANOVA test with Pillai's Trace statistics, a significance value of 0.000 < 0.05 was obtained, so H_0 was rejected, and it can be concluded that there is a significant difference between the experimental and control classes in terms of students' critical thinking skills and learning interest simultaneously in reaction rate material. Furthermore, the partial eta squared analysis shows a value of 0.657, equivalent to an effective contribution of 65.7%, indicating that the guided inquiry learning model integrated with ethnochemistry has a strong impact on improving students' critical thinking skills and learning interest. The results of the first hypothesis test showed

a significant difference in critical thinking skills and interest in learning between students who used the integrated ethnochemistry-guided inquiry model and those who used the scientific approach. MANOVA with Pillai's Trace of 0.986 and p-value of 0.000 (<0.05) rejects H0 and indicates a fundamental difference between the two groups. These findings show that the application of the integrated ethnochemistry-guided inquiry model significantly improves students' critical thinking skills and learning interest in reaction rate material. This is in line with the research by (Kamal & Suyanta, 2021) which shows the effectiveness of the Pillai's Trace test in assessing differences in learning outcomes, as well as (Muharamiah et al., 2021) and Yasmansyah & Sesmiarni (2022), who confirm that the guided inquiry model can develop critical thinking skills by guiding students in discovering concepts through structured activities. Integration with ethnochemistry strengthens students' understanding because chemical concepts are directly linked to cultural values in society (Mashami et al., 2025; Rosyada et al., 2025; Ridwan et al., 2025).

The application of an integrated guided inquiry model involving ethnochemistry involves learning tools in the form of student worksheets structured according to inquiry syntax, from orientation to conclusion, while linking concepts to the local culture in Lubuklinggau. During the orientation stage, students are introduced to topics that connect chemistry material with local culture, such as durian batik, pindang patin, and tempoyak. This process helps students understand that cultural phenomena are related to chemical concepts, such as collision theory and factors affecting reaction rates (Aisyah & Nurhayani, 2023; Reli et al., 2017). Each stage of inquiry, from formulating problems and developing hypotheses to collecting data and testing hypotheses, encourages students to think critically, according to the indicators outlined by Indawati et al. (2021). Thus, students not only understand chemical concepts but also develop systematic, logical, and critical thinking skills through cultural studies that are closely related to their lives (Hasanatin & Rohaeti, 2021; Rahmawati et al., 2019). The implementation of this model also showed an increase in student participation in the learning process. At the beginning of the meeting, student involvement was still limited, but as the meeting progressed, all students became actively involved in formulating problems, developing hypotheses, conducting discussions, and presenting their group's findings (Hidayatussani et al., 2020). This involvement fostered curiosity, which in turn increased students' motivation to learn (Metaputri & Garminah, 2016; Singh & Manjaly, 2022). The growing interest in learning, along with increased curiosity, influenced the development of critical thinking skills (Kencanawaty, 2016; Mellysa, 2019). Other studies also confirm that guided inquiry-based learning using ethnochemistry is efficacious in improving students' learning outcomes, science literacy, and scientific process skills (Amijaya et al., 2018; Nisa et al., 2018; Sarwi et al., 2020). Thus, this model has a positive impact on both students' cognitive and affective aspects.

Conversely, in the control class, with a scientific approach, student involvement tended to be limited to observing, questioning, gathering information, associating, and communicating, with no connection to local culture. This condition led to suboptimal learning stimuli that failed to encourage critical thinking skills and interest in learning (Song & Cai, 2024). The absence of local cultural integration means students learn chemistry concepts only formally, thereby failing to provide a contextual learning experience. Amora et al. (2024) and Asna et al. (2024) confirm that integrating ethnochemistry into learning can train critical thinking skills and increase student interest because the material is presented in a contextually relevant form that is close to students' lives. Therefore, it can be concluded that the guided inquiry learning model integrated with ethnochemistry is superior to the scientific approach, as it can develop critical thinking skills while fostering students' interest in learning through meaningful integration of local culture. To determine whether there are differences in critical thinking skills between students in the experimental and control classes, as well as

differences in learning interest between the two groups, we can examine the results of the between-subjects effect analysis presented in Tables 4 and 5.

Table 4. Results of Tests of Between-Subject Effect on Critical Thinking Skills

Dependent Variable	df	Mean Square	F	Sig.	Partial Eta Squared
Critical Thinking Skills	1	0.439	44,063	0,000	0,432

The results of the Tests of Between-Subjects Effect showed a significance value of 0.000 < 0.05, so H_0 was rejected, and it can be concluded that there was a significant difference in critical thinking skills between the experimental and control classes regarding reaction rates. The partial eta-squared analysis yielded a value of 0.432 (43.2%), indicating that the guided inquiry learning model integrated with ethnochemistry contributes effectively at a moderate level to the improvement of students' critical thinking skills. The results of between-subjects tests show a significant difference in critical thinking skills between students in the experimental class using the integrated ethnochemistry-guided inquiry learning model and those in the control class using the scientific approach. A significance value of 0.000 (<0.05) indicates that the guided inquiry model integrated with ethnochemistry is superior in improving critical thinking skills. This difference is evident in the average pre-test and post-test scores, as well as the n-gain scores, where the experimental class achieved higher scores than the control class. The integration of ethnochemistry into learning through cultural discourse and the making of Lubuklinggau specialties has proven to provide cognitive stimuli that encourage students to reason when solving problems. These findings align with Sudarmin et al. (2019) and Hanum et al. (2023), who state that an ethnoscience-based approach is effective in developing critical thinking skills because it is contextual and culture-based, and encourages openness to challenges.

The guided inquiry learning model provides opportunities for students to be active and involved in problem-solving, thereby developing independent critical thinking skills. According to Amijaya et al. (2018) and Arifin et al. (2025), this learning method encourages students to use their full cognitive potential to systematically, critically, and logically examine phenomena, thereby enabling them to formulate their own findings. As a result, the learning process becomes more meaningful because students are not merely passive recipients of information but actively participate in investigation, decision-making, and conclusion. This reinforces the view that inquiry-based learning provides authentic learning experiences that integrate scientific skills while motivating students to be more active in the learning process. The n-gain analysis shows that the integrated ethnochemistry-guided inquiry model effectively improves students' critical thinking skills. This model emphasizes optimizing students' intellectual potential during the investigation process, so that the understanding gained comes directly from direct learning experiences. The results of this study are supported by Sofiannida et al. (2018), which show the effectiveness of guided inquiry based on local wisdom in improving critical thinking skills. The effective contribution of the integrated ethnochemistry-guided inquiry model to critical thinking skills is 43.2% (partial eta squared = 0.432), which falls within the moderate range. These results also align with Dewi et al. (2020), who found that guided inquiry learning positively affects students' critical thinking skills in reaction rate material. Thus, the significant difference between the experimental and control classes demonstrates that the guided inquiry learning model integrated with ethnochemistry has a real impact on improving students' critical thinking skills. The integration of local culture into chemistry learning not only enriches conceptual understanding but also strengthens critical thinking skills through contextual, meaningful learning experiences. Therefore, guided inquiry learning integrated with ethnochemistry can be an

effective alternative strategy for developing students' critical thinking skills compared to the application of the scientific approach, which tends to focus on formal aspects.

Table 5. Results of the Effect Test Between Subjects' Interest in Learning

Dependent Variable	df	Mean Square	F	Sig.	Partial Eta Squared
Interest in Learning	1	1,077	46,116	0,000	0,443

The results of the between-subjects effect test showed a significance value of 0.000 < 0.05, so H_0 was rejected, and it can be concluded that there was a significant difference in learning interest between the experimental and control classes on the topic of reaction rate. The partial eta-squared value of 0.443 (44.3%) indicates that the directed inquiry learning model, integrated with ethnochemistry, effectively increases students' learning interest at a moderate level. The results of the between-subjects analysis in Table 5 show a significant difference in learning interest between the experimental class that used the integrated guided inquiry learning model of ethnochemistry and the control class that used the scientific approach. The significance value of 0.000 confirms that the difference is statistically significant. Furthermore, the average n-Gain value for student learning interest in the experimental class is higher than that of the control class. This finding shows that the application of guided inquiry, integrated with ethnochemistry, significantly increases students' interest in learning.

One of the factors driving increased student interest in learning in the experimental class was a culture-based practical activity, namely the making of tempoyak, which was linked to the concept of factors affecting reaction rates. This practical activity attracted students' attention because it provided relevant, hands-on experience related to their daily lives. In line with the research by Putri et al. (2024), during the practical activities, students' interest and attention were reflected in their curiosity to understand the material and their high enthusiasm for learning. The combination of culture-based practical activities with a guided inquiry model created a more engaging and enjoyable learning atmosphere, reducing students' boredom during chemistry class. Additionally, the guided inquiry model provides students with the opportunity to make hypotheses and test assumptions through direct experiments, making learning more interactive and meaningful. The integration of local culture into learning makes the material more relatable to students' lives and fosters an emotional connection, thereby enhancing their interest in learning. This aligns with Widiantari (2025), who shows that learning grounded in local wisdom can foster students' interest in learning. Thus, integrating scientific and local cultural approaches can provide a more contextual and meaningful learning experience.

The partial eta-squared calculation yields a value of 0.432, or an effective contribution of 44.3%, which is classified as moderate. This figure indicates that the application of the integrated ethnochemistry-guided inquiry learning model has a positive, significant effect on students' interest in learning about reaction rates. Overall, the findings of this study confirm that the guided inquiry model integrated with ethnochemistry is more effective than the scientific approach because it positions students as active subjects in the learning process while linking chemical concepts to local cultures close to their daily lives. This study has several limitations that must be acknowledged. One is students' limited practical skills, particularly in operating laboratory equipment, which may have reduced the overall effectiveness of the learning process. Simultaneously administering a critical thinking test and a learning interest questionnaire could reduce the accuracy of student responses. This could affect the quality of the data obtained and, therefore, the findings of this study should be interpreted with this in mind. Nevertheless, the results of this study provide a substantive contribution to scientific discourse in chemistry education. Specifically, integrating guided inquiry with ethnochemistry demonstrates the potential to enhance students' critical thinking skills and

interest in learning, while also contextualizing abstract scientific concepts within a culturally relevant framework. This highlights the importance of culturally responsive pedagogical approaches in promoting meaningful learning and enriches existing knowledge about innovative learning models in science education. By empirically supporting the role of ethnochemistry as a pedagogical medium, this study not only strengthens the theoretical perspective on inquiry-based learning but also extends practical implications for developing context-sensitive learning designs in diverse educational settings. Based on these contributions, future research will expand the application of the guided inquiry model integrated with ethnochemistry to other chemistry topics. This also allows for evaluating its effectiveness across multiple learning domains. Furthermore, separating the cognitive and affective questionnaires is recommended to improve the accuracy of student responses. Further research could also examine the impact of this model on other variables, such as creative thinking skills or problem-solving abilities, thus providing a broader understanding of its potential in educational practice.

CONCLUSION

The results of this study indicate that the application of an integrated ethnochemistry-guided inquiry learning model significantly improves students' critical thinking skills and interest in learning about reaction rates. Consistent differences between the experimental and control classes show that this model is more effective than the scientific approach in developing higher-order thinking skills while also encouraging students' affective engagement. These findings also confirm that integrating ethnochemistry into learning not only provides a more meaningful understanding of concepts but also strengthens the connection between local culture and science, making the learning experience more contextual for students. Thus, this study contributes to the development of chemistry education by providing empirical evidence that an inquiry-based approach integrated with ethnochemistry can serve as a strategic alternative to enhance learning quality in secondary schools. The practical implication of this study is that chemistry teachers can adopt the guided inquiry learning model, integrated with ethnochemistry, as an effective pedagogical strategy to enhance students' cognitive and affective learning outcomes. This model also offers the potential to reinforce local cultural values within the framework of science education, thereby fostering greater relevance and contextualization of learning in relation to students' daily experiences. Moreover, the model demonstrates applicability across various chemistry topics, supporting the development of a more meaningful, contextually grounded, and student-centered learning environment. Recommendations for future research include testing this learning model on other chemistry topics, across different educational levels, or with a larger, more diverse student population. Furthermore, it is essential to examine the effects of this model on additional 21st-century skills, including creativity, collaboration, and scientific cultural literacy.

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