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Cultural Awareness Through the Integrated PBL Model of Malay Cultural Ethnochemistry on Chemical Kinetics

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ABSTRACT
Culture, as a nation's invaluable asset, must continuously be introduced and preserved in alignment with the progress of time. Integrating cultural studies with scientific knowledge through education fosters the development of cultural awareness attitudes. A generation trained in cultural sensitivity will recognize the significance of heritage and innovate its presentation to suit contemporary developments. This study explores the use of a Problem-Based Learning (PBL) model integrated with the ethnochemistry of Malay culture—specifically utilizing traditional curd milk—in teaching chemical kinetics to enhance students' cultural awareness. The research employed a quasi-experimental method with a nonequivalent pre-test–post-test control group design, conducted at SMAN 2 Siak Hulu, Kampar, Riau Province, involving Grade XI Science students. Cultural awareness attitudes were assessed using indicators adapted from Wunderle, including data and information gathering, cultural consideration, cultural knowledge, cultural understanding, and cultural competence. The results demonstrated that the experimental group achieved an average cultural awareness score of 81.85 (categorized as Very Good), whereas the control group attained an average of 60.84 (Fairly Good). The learning model contributed significantly to enhancing cultural awareness attitudes, with a contribution rate of 56.1%. These findings suggest that integrating ethnochemistry within PBL effectively cultivates both scientific and cultural competencies in students.

Keywords: *cultural awareness, ethnochemistry, malay culture, PBL*

INTRODUCTION

Indonesia's rich cultural diversity represents the nation's true beauty. However, rapid globalization and shifts in human thinking patterns have led to a significant degradation of both regional and national cultures (Hildigardis, 2019). This erosion of cultural values has had a profound impact on the younger generation, who are increasingly detached from nationalist values (Pujasmara et al., 2021). Research by Safitri et al. (2018) highlights that a major factor contributing to this phenomenon is the pervasive influence of Western culture, which has rapidly infiltrated Indonesian society.

Zafi (2018) emphasized that education and culture are intrinsically linked, both revolving around core societal values. Tepayakul (2021) further asserted that cultural awareness, embedded within the affective domain, is not innate but developed through cognitive processes. According to Sariata (2022), cultural awareness fosters open-mindedness towards diverse perspectives, while Bisri et al. (2016) noted that it enhances individuals' abilities to analyze cultural contexts critically, considering the norms, values, and customs that shape perceptions and behavior. Consequently, fostering cultural awareness is crucial for the preservation and progressive adaptation of culture in an era of rapid change. Ramdani et al. (2020) identified several systemic issues in Indonesia's educational landscape, including limited innovation in learning, a lack of emphasis on critical thinking, and a predominant focus on rote memorization. Cultural integration in science education remains minimal. Interviews with chemistry teachers at SMAN 2 Siak Hulu, SMAN 3 Siak Hulu, and SMAN 2 Tambang revealed that the application of the Problem-Based Learning (PBL) model is often unstructured, rarely integrated with cultural contexts, and typically still teacher-centered. Moreover, students' daily assessments in reaction rate material only reached a 65% passing rate.

To address these challenges, implementing student-centered learning models that incorporate cultural elements is vital. Rahmadani (2019) noted that the PBL model promotes student engagement by presenting real-world problems at the onset of learning. Yulianti and Gunawan (2019) also stressed that PBL encourages students to formulate and investigate their own questions within relevant cultural contexts, thus enhancing active learning. Ethnochemistry, an approach that frames chemistry through cultural perspectives (Rahmawati et al., 2020), emerges as a promising strategy. Dewi et al. (2021) explained that integrating local knowledge—rooted in traditional beliefs and practices—into science education increases students' engagement and comprehension. Previous studies show that culture-based chemistry learning enhances student interest and connects abstract scientific concepts to everyday life (Rahmawati & Ridwan, 2017).

Malay culture, with its profound interaction between human activities and nature (Ilhami et al., 2021), offers rich opportunities for integration into ethnochemistry-based learning. Instilling Malay cultural values through education is essential to counteract cultural erosion amid globalization. Sunyono (2009) highlighted that chemistry is often perceived as difficult, which diminishes student engagement, while Sunyono et al. (2005) pointed out students' struggles with reaction-related calculations and concepts. Therefore, innovative models that link chemistry to daily life are necessary to overcome learning barriers.

Chemical kinetics, a core topic in Grade XI Chemistry, is crucial for developing critical thinking skills (Wangge, 2021), yet remains challenging for students (Muliaman & Mellyzar, 2020; Oktaviani & Mahidin, 2017). Despite its real-life relevance, many students fail to grasp its concepts due to the complexity of calculations and the emphasis on memorization over understanding. In light of these challenges, there is a critical need for a well-designed learning model that promotes active engagement and cultural awareness. This study thus proposes the integration of the Problem-Based Learning (PBL) model with Malay ethnochemistry to enhance students' cultural awareness within the context of chemical kinetics. This approach is supported by findings from Amora et al. (2024), which demonstrated that ethnochemistry-based PBL effectively enhances students' cognitive and cultural competencies.

METHODOLOGY

This study aims to examine the effect of the Problem-Based Learning (PBL) model integrated with the ethnochemistry of Malay culture on enhancing students' cultural awareness in the context of chemical kinetics. The research employed a quasi-experimental method with a nonequivalent pre-test–post-test control group design, where samples were selected through non-random procedures (Hastjarjo, 2019). The research subjects consisted of all Grade XI Science students at SMA Negeri 2 Siak Hulu, totaling 306 students distributed across 9 classes. The sample selection utilized purposive sampling techniques, meaning participants were chosen based on specific criteria aligned with the research objectives.

Two groups were established for the study: an experimental class and a control class. The experimental group received instruction using a Problem-Based Learning (PBL) model integrated with elements of Malay ethnochemistry, while the control group was taught using a conventional scientific approach. Prior to the intervention, both groups completed a pre-test to assess the normality and homogeneity of their initial cultural awareness levels. Following this, the experimental treatment was implemented, culminating with a post-test to measure any changes. The research design framework is illustrated as follows Table 1.

Table 1. Research Design Nonequivalend Control Group Design

Group	Pretest	Treatment	Posttest
E	Y_1	X	Y_2
K	Y_1	-	Y_2

Information:
E : Experimental Class
K : Control Class
X : The experimental class group was given treatment with an integrated PBL model of Malay ethnochemistry
\- : Class groups with a scientific approach
Y_1 : Pre-test experimental class group and control class
Y_2 : Post-test experimental class group and control class

The instrument used to measure students' cultural awareness was a questionnaire developed based on five indicators proposed by Wunderle (2006), namely: data and information, cultural consideration, cultural knowledge, cultural understanding, and cultural competence. The distribution of cultural awareness indicators is presented in Table 2.

Table 2. Indicator *Cultural Awareness*

No.	Indicator	Description	Statement
1.	Data and information	Measuring how students obtain cultural data and information	1-6
2.	Culture consideration	Measures the extent to which students consider an acquired culture	7-13
3.	Cultural knowledge	Measuring the extent to which students know their own culture and that of other people	14-19
4.	Cultural understanding	Measuring the extent to which students understand their own culture and that of others	20-26
5.	Cultural competence	Measuring the extent to which students understand cultural preservation	27-33

The questionnaire was administered to assess students' cultural awareness attitudes and was previously validated by experts and through field testing. To interpret the percentage data obtained from the questionnaire results, the interpretation guidelines outlined in Table 3 and Table 4 were employed.

Table 3. Categorization of Questionnaire Results

Value Scale	Standard Score	Information
81-100	A	Very good
66-80	B	Good
56-65	C	Pretty good
41-55	D	Less Good

Value Scale	Standard Score	Information
≤ 40	E	Not good

(Arikunto, 2005)

Table 4. Interpretation of Questionnaire Scores

Percentage	Category
3,68 – 5,00	High
2,34 – 3,67	Currently
1,00 – 2,33	Low

(Arikunto, S., 2019)

An initial phase of research was conducted to develop the cultural awareness instrument, which was then validated by subject matter experts. After the instrument was deemed valid, a trial was performed to assess its reliability. Following this, the questionnaire, based on the validated cultural awareness instrument, was distributed to the students. The experimental class received treatment using the Problem-Based Learning (PBL) model integrated with the ethnochemistry of Malay culture, while the control class was taught using a conventional scientific approach. To test the effect of the PBL model integrated with Malay ethnochemistry on students' cultural awareness attitudes, a Multivariate Analysis of Variance (MANOVA) was conducted using IBM SPSS Statistics 22 for Windows.

RESULT AND DISCUSSION

Data collection for this study was conducted across two classes within the same school: the experimental class (which received the integrated PBL model of Malay cultural ethnochemistry) and the control class (which followed a scientific approach). Before administering the cultural awareness instrument to the students, it was first validated by experts and tested for reliability. The validity and reliability analysis showed that each item in the cultural awareness questionnaire had a Cronbach's alpha value ranging from 0.953 to 0.956, with an overall value of 0.958. Furthermore, the item correlation values exceeded 0.3, indicating that all items were reliable and acceptable. In both classes, data on students' cultural awareness attitudes were collected using a pre-test and post-test mechanism. The pre-test results were used to assess the normality and homogeneity of the sample. The results of these normality and homogeneity tests are presented in Table 5 and Table 6.

Table 5. Normality Test Results Pre-test Attitude Cultural Awareness

Class	X_{min}	X_{max}	$\bar{x}$	SD	Shapiro Walk			Conclusion
					Statistic	Df	Sig.	
XI_2	43	68	55,82	6,373	0,965	36	0,297	Normal
XI_3	44	67	54,04	6,093	0,996	36	0,329	Normal

Table 5 presents the results of the sample normality test, with the obtained significance (sig) value exceeding 0.05. This indicates that the pre-test data for cultural awareness is normally distributed.

Table 6. Homogeneity Test of Results Pre-test Attitude Cultural Awareness

Levene	df1	df2	Sig.	Conclusion
0,059	1	70	0,809	Homogen

Table 6 presents the results of the sample homogeneity test. The analysis yielded a significance (sig) value greater than 0.05, which indicates that the pre-test data for cultural awareness is homogeneously distributed. After the treatment was applied to the sample group, a post-test was administered at the end of the study sessions. The results of the post-test on cultural awareness attitudes are presented in Table 7.

Table 7. Results Post-test Attitude Cultural Awareness

No	Class	N	X_{max}	X_{min}	$\bar{x}$	SD
1	Experiment	36	97,7	64,4	81,85	10,228
2	Control	36	75	44,7	60,82	8,041

Based on the data presented in Table 7, the average post-test cultural awareness score of the experimental class, which applied the PBL model integrated with Malay ethnochemistry, was higher than that of the control class, which utilized a scientific approach. The experimental class had an average score of 81.85, categorized as "Very Good," while the control class had an average score of 60.84, categorized as "Fairly Good." The use of the integrated PBL model of Malay cultural ethnochemistry positively impacted students' cultural awareness. In the experimental class, the integration of culture with chemical kinetics involved discussing elements of Malay culture from students' everyday lives, such as durian acid, green sticky rice, mangrove charcoal, curd milk, and sour cream. These cultural elements were connected to the chemical kinetics material, fostering a deeper curiosity among students.

According to Rahmawati and Sastrapraja (2017), learning with an ethnochemical context—integrating culture and chemistry—not only makes chemistry learning more meaningful for students but also contributes to preserving the nation's cultural heritage. The ethnochemistry of Malay culture is included in the LKPD, which serves as a guide for students' learning. A comprehensive discussion of Malay ethnochemistry can be found in Table 8.

Table 8. Ethnochemistry of Malay Culture on Chemical Kinetics Material

Meeting	Speed Material	Ethnochemistry Based on Malay Culture
1	Temperature Factor	**Dadih (Kampar)**: milk fermented spontaneously with lactic acid bacteria produced from new bamboo. In this fermentation, if the temperature is too high the microbes produced in the bamboo can die and at low temperatures the microbes are inactive so they cannot ferment the milk. The required temperature is 27-33^{0}C.
	Catalytic Factors	**Kapur sirih of kulit kerang:** CaO produced from shells is used as a catalyst in making biodiesel.
2	Surface Area Factor	**Arang Bakau Indragiri Hilir**: Mangrove charcoal with a smaller size or wider surface area so it burns quickly.
	Collision Theory	**Asam durian (Kampar)**: Fermentation for making tempoyak durian has two methods, namely first using additional salt to the durian flesh and second using yeast which has a faster fermentation time.
	Reaction Mechanism	**Tape ketan hijau (Tembilahan)**: fermentation of green sticky rice tape with the addition of yeast which can speed up the fermentation process with a soft and slightly watery texture. The natural dye used is from katuk leaves (Sauropus Androgynus).
3	Concentration Factor	**Pekasam (Kampar)**: fermentation of river fish with lactic acid bacteria resulting from the addition of salt. Different salt concentrations can affect fermentation speed. **Kue Apam kukus:** Yeast obtained from sweet potato tape water actively consumes simple sugars and produces carbon dioxide (CO_2). The formation of CO_2 causes the dough to expand and produces a soft and hollow texture in the cake. The yeast will eat the sugar in the dough and turn it into gas and other byproducts, including alcohol.

Meeting	Speed Material	Ethnochemistry Based on Malay Culture
4	Reaction Order	**Minyak Kelapa Indragiri Hilir:** Utilization of coconut in making cooking oil.

According to research by Siwale et al. (2020), the application of models within an ethnochemical context has a significant impact on the learning process, such as enhancing students' understanding of phenomena relevant to ethnochemistry within a local context. This approach indirectly helps develop critical thinking skills. The integration of ethnochemistry in education not only improves students' cognitive learning outcomes but also fosters scientific attitudes and enhances critical thinking skills. Additionally, it can be used to integrate ethnochemistry with learning models, strategies, or as a resource for scientific inquiry (Wahyudiati & Fitriani, 2021). Presenting Malay culture within scientific knowledge can stimulate students' curiosity and cultural awareness. As Rahmawati et al. (2019) noted, presenting ethnochemistry in a meaningful context connects chemistry content to real-life situations and phenomena. This approach encourages students to think critically, develop open-mindedness, and cultivate an interest in culture, ultimately increasing their awareness and responsibility toward their cultural heritage.

Students are encouraged to engage actively in learning by searching for scientific information within cultural contexts and expressing their opinions during group discussions. These activities are reflected in the stages of idea generation and learning issues in the integrated PBL model of Malay cultural ethnochemistry. During the "idea generation" stage, students work in groups to find solutions to problems related to ethnochemistry, such as the effect of curd milk on temperature. In the "learning issues" stage, students present their group findings. The PBL model is a learning process based on a constructivist approach, which enhances students' abilities by promoting the construction of their chemistry attitudes, knowledge, and learning experiences (Wahyudiati, 2022). The cultural awareness profile is assessed based on the achievement of indicators in the experimental class. The scores obtained for each indicator are categorized according to the ideal assessment. The cultural awareness profile, based on the percentage of each indicator, is presented in Figure 1.

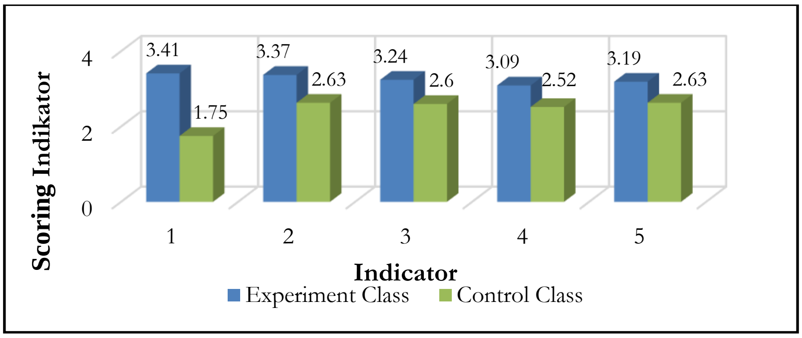

Figure 1. Profile Cultural Awareness Per Indicator

Information:

1. Data and Information
2. Culture Consideration
3. Cultural Knowledge
4. Cultural Understanding
5. Cultural Competence

Based on the analysis of Figure 1, it was found that in the experimental class, the highest percentage of category scores was in the "Data and Information" indicator, while the lowest category score was observed in the "Cultural Understanding" indicator. The complete results for each indicator category can be seen in Table 9.

Table 9. Category of Each Indicator Cultural Awareness

No	Indicator ***Cultural Awareness***	Experiment Class		Control Class	
		$\bar{x}$	Category	$\bar{x}$	Category
1	Data and information	3,41	Currently	1,75	Low
2	Culture consideration	3,37	Currently	2,63	Currently
3	Cultural knowledge	3,24	Currently	2,6	Currently
4	Cultural understanding	3,09	Currently	2,52	Currently
5	Cultural competence	3,19	Currently	2,63	Currently
	Average	3,26	Currently	2,43	Currently

The categories of each cultural awareness indicator were assessed based on an ideal assessment model. Based on the analysis of Figure 9, the highest average cultural awareness score in the experimental class was found in the "Data and Information" indicator. This indicator reflects how students acquire information about Malay culture, one example being the LKPD (Student Worksheet) provided by the teacher, which contains ethnochemistry content.

According to research by Azizah & Shidiq (2021), learning within an ethnochemical context—integrating culture and chemistry—not only makes chemistry learning more meaningful for students but also helps preserve the nation's culture. Students are provided with opportunities to formulate, negotiate, and make decisions related to the ethnochemistry presented during the learning process. The ethnochemical concepts introduced are sometimes unfamiliar to students in the context of chemical knowledge, sparking curiosity. This curiosity, in turn, encourages students to pursue further learning, such as by searching for related articles or books. Ethnochemistry, as the application of chemical ideas in daily life, is reflected in customs, symbols, value systems, social structures, and cultural items relevant to chemical concepts or practices in all cultures. Cultural objects add meaning to learning and enhance student outcomes, making their inclusion in chemistry education a valuable resource for improving the understanding of chemical concepts (Wahyudiati, 2021).

To assess the impact of the learning model, the post-test data on students' cultural awareness attitudes from both the experimental and control classes were analyzed. The effect of the univariate learning model can be observed in the "Test of Between-Subject Effects." The results of this test are presented in Table 10.

Table 10. Results Test of Between Subject Effects

Variabel Dependen	Df	F	Sig.	Partial Eta Squared
Cultural Awareness	1	89,345	0,000	0,561

Table 10 shows that there are significant differences in students' cultural awareness attitudes through the application of the integrated PBL model of Malay cultural ethnochemistry and the scientific approach, with an F-value of F(89.345) = 0.000 ($p<0.05$). This indicates that there are differences in cultural awareness attitudes between students who were taught using the integrated PBL model of Malay cultural ethnochemistry and those who were taught using a scientific approach.

The integrated PBL model of Malay cultural ethnochemistry has a notable impact on students' cultural awareness, particularly in learning chemical kinetics. This model can be effectively applied in schools to improve the quality of education by increasing students' interest in chemistry and simultaneously preserving local culture. The integration of ethnochemistry benefits chemistry students by providing them with a framework to sequence their learning through prior cultural knowledge or indigenous knowledge. This approach offers them the opportunity to gain deeper insights into reality, culture, society, and science (Izondeme, B., & Chinelo, O. 2021; Ajayi et al., 2017).

The significant contribution of the learning model to students' cultural awareness attitudes is reflected in the partial eta squared value. With a partial eta squared value of 0.561, the learning model contributes 56.1% to the improvement of cultural awareness attitudes. Preserving local culture in education is critical. Researchers are particularly interested in ethnochemistry because, through the integrated PBL model with Malay cultural ethnochemistry, students can be introduced to and participate in the preservation of Malay culture in an era where much of it is at risk of being lost. Additionally, the integration of Malay cultural ethnochemistry can increase students' interest in understanding chemistry, making learning more engaging and culturally relevant.

CONCLUSION

This study has demonstrated that the integration of the Problem-Based Learning (PBL) model with Malay cultural ethnochemistry significantly influences students' cultural awareness attitudes towards the topic of Chemical Kinetics. The key findings are summarized as follows. First, **High Level of Cultural Awareness** the implementation of the PBL model, coupled with the integration of Malay cultural ethnochemistry, resulted in a notable enhancement of students' cultural awareness. The average score for cultural awareness was 81.85, placing it in the "Very Good" category. Each of the five cultural awareness indicators—data and information, cultural consideration, cultural knowledge, cultural understanding, and cultural competence—fell within a moderate to high range ($2.34 < x < 3.67$), indicating effective development of these aspects among students. Second, **Statistical Significance of Cultural Awareness Differences** a comparison of students in the experimental class (PBL integrated with Malay cultural ethnochemistry) and the control class (scientific approach) revealed significant differences in cultural awareness, with students in the experimental class showing greater improvements. This was supported by statistical analysis, confirming the effectiveness of the integrated learning model in fostering cultural awareness. Third, **Contribution to Cultural Awareness** the PBL model integrated with Malay cultural ethnochemistry accounted for a substantial 56.1% of the variance in students' cultural awareness attitudes. This high contribution highlights the effectiveness of this integrated approach in enhancing students' awareness and understanding of both chemistry and their cultural heritage. Finally, **Fostering Interest and Cultural Preservation** the integration of cultural elements into chemistry lessons through ethnochemistry not only increased students' interest in the subject of chemical kinetics but also facilitated the preservation and promotion of Malay culture. By contextualizing scientific concepts within local cultural frameworks, this approach contributed to a more meaningful and engaging learning experience, while simultaneously fostering a sense of cultural responsibility among students.

In conclusion, the results of this study suggest that integrating cultural elements, particularly Malay cultural ethnochemistry, into the PBL model can serve as an effective pedagogical strategy for enhancing cultural awareness and improving chemistry education. Further research is recommended to explore the long-term impact of this approach on students' academic and cultural development across various subjects and educational contexts

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