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The Effect of an Ethnochemistry-based Culturally Responsive Teaching Approach to Improve Cognitive Learning Outcomes on Green Chemistry Material in High School

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Abstract: Culture has an important role in realizing sustainable education. An Ethnochemistry-based Culturally Responsive Teaching Approach has the potential to integrate students' cultural and chemical concepts into classroom learning. However, this approach has not been widely implemented in schools. Therefore, this research aims to determine the effect of implementing an tthnochemistry-based culturally responsive teaching approach on improving cognitive learning outcomes in green chemistry material in high school. A quasi-experimental design involving 36 students in the experimental class and 36 students in the control class was used, utilizing a post-test with ten multiple choice questions to measure cognitive learning outcomes. The Kruskal-Wallis test was then applied to evaluate the effectiveness of the treatment. The research results show that the application of the Culturally Responsive Teaching approach which is integrated with ethnochemistry has an effect on increasing cognitive learning outcomes in green chemistry material.

Keywords: Culturally Responsive Teaching; Ethnochemistry; Green Chemistry; Learning Outcomes

Introduction

Indonesia is known as a country rich in cultural diversity. Culture has an important role in the sustainability of a nation, one of which is education (Budi & Widodo, 2019). As stated by Gay (2002), character and cultural education is an important aspect of the educational process. In education, students who come from different cultures have values, beliefs and characters that influence the learning process in the classroom. Generally, students who gain knowledge and skills from western knowledge are considered the most correct at every level of education. This makes students increasingly unfamiliar with their cultural background. For example, the application of chemistry learning material tends to be about chemistry in modern industrial western countries, where students rarely encounter this in their daily lives. Because of this, students do not really understand the learning material they are studying, just based on theory alone does not achieve meaningful learning goals (Sulaiman & Neviyarni, 2021). Aikenhead stated that the stages for creating meaningful learning are by linking culture-based learning (Aikenhead, 2017). The educational process can play a role in reconstructing culture, where learning must be linked to the background and phenomena that are often encountered (Aminullah, 2022).

In Indonesia, currently implementing the "Merdeka/independent" curriculum, namely learning patterns that adopt student learning experiences that adapt to the student's background, characteristics and initial abilities (Purnawanto, 2022). An educational approach that can connect subject matter with students' cultural backgrounds is the Culturally Responsive Teaching approach (Rahmawati et al, 2020). The Culturally Responsive Teaching approach is a learning method that requires students to have the same rights to receive learning regardless of their cultural background. The goal of Culturally Responsive Teaching is to ensure diverse students achieve achievement through support such as respect for their cultural background, meaningful relationships with the curriculum so that it can lead to meaningful learning experiences (Bonner et

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al, 2018). According to Ladson-Billings (1995) the result of this approach is to ensure students gain academic success and cultural competence through instilling cultural values in learning (Akcan, 2022). Instilling cultural values in learning can be done by integrating ethnochemistry (Wahyudiati & Fitriani, 2021). Ethnochemistry is a branch of science that studies the relationship between human culture and chemistry (Nirmalasari, 2020). Thus, this lesson will explore cultural practices in Indonesia that are related to students' daily lives. This ethnochemistry integration can be an interesting zone to explore in chemistry learning. Ethnochemistry is a branch of science that studies chemistry based on a cultural perspective. The learning process with ethnochemistry nuances can increase the dimensions of students' knowledge not only in theory but also in preserving local wisdom (Pertiwi et al., 2021). According to Asda (2023) and Singh & Chibuye (2016) this is because ethnochemistry is knowledge based on local culture in everyday life from a chemistry perspective.

In learning chemistry subjects, one of the approaches that is widely applied in schools today is the scientific approach which refers to scientific methods and principles (Umar, 2016). The implementation of an independent curriculum emphasizes creating learning experiences that are more inclusive, relevant, and combine student empowerment with concern for students' background/culture (Wahyuni, 2022). The implementation of the independent curriculum is continuous with the CRT approach, but this approach has not been widely implemented in schools (Prihatini, 2022). Meanwhile, learning that applies CRT can foster students' attitudes that are more active and respect each other's backgrounds (Khasanah, 2023). Previously, several studies had been carried out applying the Culturally Responsive Teaching (CRT) approach. Research conducted by Shabrina (2023) on reproductive system material and Khasanah (2023) in elementary schools opens up opportunities to apply this approach to green chemistry material at the high school level. Then, research applying an ethnochemistry-integrated CRT approach was carried out by Arif et al. (2021) regarding hydrolysis materials also opens up opportunities to apply it to green chemistry materials. So far, there has been no application of the ethnochemistry-integrated CRT approach to green chemistry material at the secondary school level. This learning method can be applied to green chemistry material, where the main concepts in green chemistry material are the principles of green chemistry (Suci, 2023). The application of green chemistry principles is something that is often found and even done in everyday life. When ethnoscience is integrated with green chemistry material that is relevant to everyday life, this will open up opportunities to increase students' understanding of this material in everyday life (Sari et al., 2023; Wati et a., 2021). This research focuses on finding out the effect of implementing an ethnochemistry integrated Culturally Responsive Teaching approach on improving students' cognitive learning outcomes in green chemistry material in high school. It is important to carry out this research to contribute significantly to chemistry learning that is more relevant, sustainable, and empowers local wisdom.

Method

This research uses quasi experimental research with Posttest Only Equivalent Control Group Design (Zakariah & Afriani, 2021). A quasi-experimental design is used to test the hypothesis whether the treatment has an impact on the sample by controlling variables that are adapted to conditions in the field (Priadana & Sunarsi, 2021). The sample in this study was determined using Random Sampling techniques. This technique is used because every sample in the population has the same opportunity to become a sample (Firmansyah, 2022). The sample to be selected for research consists of two classes: experimental and control classes. The class X population consists of 12 classes. Then, of the twelve, homogeneity and normality tests were carried out using the results of the initial assessment values for green chemicals.

This research was conducted at a high school in the Surakarta area, Central Java. The research design is shown in Table 1, where the experimental group in one class (36 students) uses an Ethnochemistry-based Culturally Responsive Teaching Approach. Meanwhile, the control group in one class (36 students) used a scientific approach without integrating ethnochemistry. Table 2 shows that 72 students from two classes were selected as research subjects.

Table 1. Research design

Group	Treatment (X)	Posttest (O)
Experiment	X_1	O_1
Control	X_2	O_2

Note: X_1 = Treatment in the experimental group (Culturally Responsive Teaching approach); X_2 = Treatment in the control group (Scientific approach); O_1 = Posttest in the experimental class; and O_2 = Posttest in the control class.

Table 2. Research Participant Data

Experimental class	Control class
36 people	36 people

This research uses a posttest on students as a guide to determine the success of treatment on learning outcomes. Quantitative data is obtained from data collected with this instrument. Posttest questions consist of ten complex multiple-choice questions with five answer indicators. This research uses SPSS computer statistical software, namely the T-Test, for data analysis. The instruments used for further research are explained in Table 3. Then, the hypothesis used in this research is in Table 4.

Table 3. Research Instrument

Measured indicators	Question type	Number of posttest questions
Learning outcomes	Complex multiple choice	10
Total	5 answer indicators	10

This research was conducted in 4 meetings lasting 90 minutes. The learning model used is Problem-Based Learning (PBL) with a Culturally Responsive Teaching (CRT) approach. At the first meeting, learning was carried out by delivering green chemistry material and discussing problems provided on media and power points. At the second meeting, learning was carried out in the form of discussions on group assignments based on the differentiation groups that had been created; each group worked on Student Worksheets-presentation-discussion of student worksheets answers. At the third meeting, green chemistry principles were applied to the practice of making Eco print batik, then the results of this practice were presented. A Posttest on green chemistry material was carried out at the fourth meeting. The learning syntax used in the research is explained in Table 5. The learning syntax refers to the principles of the Culturally Responsive Teaching approach (Yuli Rahmawati, 2017).

Table 4. Research Hypothesis

H_0	H_1
There is no influence of the ethnochemistry-based culturally responsive teaching approach approach in improving learning outcomes in green chemistry material	There is an influence of the ethnochemistry-based culturally responsive teaching approach approach in improving learning outcomes in green chemistry material

Table 5. Research Learning Syntax

Meeting	PBL syntax	CRT principles
1	Introduction	Content integration, facilitating knowledge construction
	Student orientation toward problems	Content integration, facilitating knowledge construction
	Organizing students toward problems	Prediction reduction, social justice, academic development
	Guide individual and group investigations	Prediction reduction, social justice, academic development
	Presenting the results of the work	Academic development
	Analyze and evaluate	Academic development
	Closing	Academic development
2	Introduction	Content integration, facilitating knowledge construction
	Student orientation toward problems	Content integration, facilitating knowledge construction
	Organizing students toward problems	Prediction reduction, social justice, academic development
	Guide individual and group investigations	Prediction reduction, social justice, academic development
	Presenting the results of the work	Academic development
	Analyze and evaluate	Academic development
	Closing	Academic development
3	Introduction	Content integration, facilitating knowledge construction
	Student orientation toward problems	Content integration, facilitating knowledge construction
	Organizing students toward problems	Prediction reduction, social justice, academic development
	Guide individual and group investigations	Prediction reduction, social justice, academic development
	Presenting the results of the work	Academic development
	Analyze and evaluate	Academic development
	Closing	Academic development
4	Introduction	Content integration, facilitating knowledge construction
	Student orientation toward problems	Facilitating knowledge construction
	Guiding individual investigations	Academic development
	Analyze and evaluate	Academic development
	Closing	Academic development

Results and Discussion

Results

Data Description

This study collected research data as learning outcomes data in the cognitive domain. Data on learning outcomes in the cognitive domain are in the form of post-test scores. Learning outcome data was obtained from experimental and control group samples. The experimental group carried out learning activities using a Culturally Responsive Teaching (CRT) approach integrated with ethnochemistry, while the control group used a Scientific approach without integration with ethnochemistry. Research data on the learning outcomes of experimental and control class students in the cognitive domain are shown through post-test scores and can be seen in Figure 1 as a histogram. A histogram is a graphic representation that shows the distribution of values in different colors, showing the intensity of each data (Ratna, 2020).

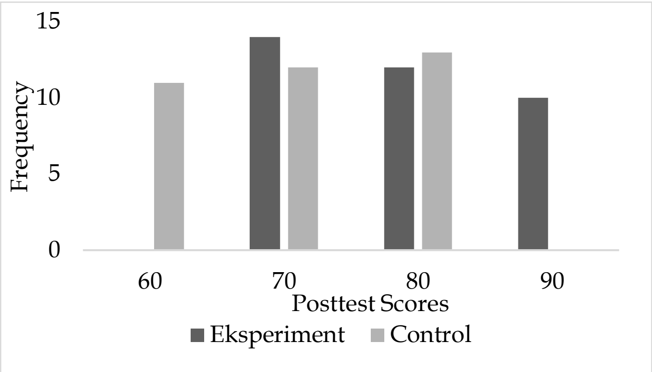

Figure 1. Posttest Score Distribution Data

Based on Figure 1, it can be seen that the smallest frequency of learning outcomes in the cognitive domain (post-test scores) in the experimental class was a score of 70 for 14 students, and the largest (post-test score) was a score of 90 for 12 students. Meanwhile, the smallest frequency of learning outcomes in the cognitive domain (Posttest score) in the control class was 60 with 11 students and the largest (Posttest score) with 13 students with a score of 80. In the experimental class, the average learning outcome in the cognitive domain (post-test score) was 78.89. Meanwhile, in the control class, the average learning outcome in the cognitive domain (post-test score) was 70.56. Based on Figure 1, it can be seen that the learning outcomes in the cognitive domain in this study are different.

Analysis Prerequisite Test

Normality test

The normality test is a statistical test that aims to determine whether data distribution is normally distributed. Many methods can be used to test normality with different decision results (Sintia et al., 2022). This study used the Shapiro-Wilk test method to compare the results of testing the normal data distribution. The Shapiro-Wilk test is a method or formula for calculating data distribution created by Samuel Stanford Shapiro and Martin Wilk. The Shapiro-Wilk method is a normality test method that is effective and valid for small samples. The test statistic is obtained by dividing the square of the appropriate linear combination of the ordered statistical sample by the usual symmetric variance estimate. According to Razali & Wah (2011), the Shapiro-Wilk test was initially limited to samples of less than 50.

This normality test was calculated with the help of SPSS version 26 software. Data on learning outcomes in the cognitive domain (post-test) from the experimental and control classes were checked to determine whether the data was normally distributed. The sample is normally distributed if it has a significance level (Sig. > 0.05) and is not normally distributed if it has a significance level (Sig. < 0.05). If the data is normally distributed, it will continue with parametric hypothesis testing using MANOVA. Meanwhile, if the data is not normally distributed, it will be continued with non-parametric hypothesis testing using the Kruskal-Wallis Test. One of the causes of abnormally distributed data can be caused by research data having very large (extreme) disparities.

Table 6 shows the results of the Shapiro-Wilk normality test from the experimental and control classes' post-test scores. Based on the normality test results, it can be seen that the learning outcomes data in the experimental and control classes' cognitive domains are not normally distributed. In the experimental class, the significance value was 0.000 (Sig. < 0.05) and in the control class, the significance value was 0.021 (Sig. < 0.05). Therefore, the H_0 test decision is rejected, or the data is not normally distributed.

Table 6. Normality Test Results

Class	Normality test	Sig.	Decision	Conclusion
Experiment	Cognitive Domain (Posttest)	0.00	H_0 is rejected	Abnormal data
Control		0.02		

Homogeneity Test

The homogeneity test is a statistical test that aims to show that two or more groups of data samples are taken from a population with the same variance (Sianturi, 2022). Several methods can be used to test homogeneity of variance, one of which is used in this research, namely the Levene test (Usmadi, 2020). Levene's test is a test used to test whether populations have the same variance or not. Levene's test is an alternative test to Bartlett's test. If there is strong evidence that the data is normally or near-normally distributed, then the Bartlett test is better to use (Aprilina et al., 2018). This homogeneity test was calculated with the help of SPSS version 26 software. The learning outcomes data in the cognitive domain (post-test) were checked to see whether the data was homogeneous. The sample is known to be homogeneous if it has a significance level (Sig. > 0.05) and not homogeneous if it has a significance level (Sig. < 0.05).

Table 7 shows the results of Levene's homogeneity test results of the posttest scores for the experimental and control classes. Based on the results of the homogeneity test, it can be seen that the learning outcomes data in the cognitive domain (post-test) are homogeneous. The cognitive domain homogeneity test (Posttest) obtained a significance value of 0.150 (Sig. > 0.05). Therefore, the H_0 test decision is accepted, or the data is homogeneous.

Table 7. Homogeneity Test Results

Homogeneity test	Sig.	Decision	Conclusion
Cognitive domain (posttest)	0.15	H_0 is accepted	Homogeneous data

Hypothesis testing

Hypothesis testing is a process of drawing scientific conclusions which is carried out in stages, so that it can be accounted for by all parties (Rahayu, 2021). In this study, the Kruskal-Wallis test method was used, equivalent to the Mann-Whitney test. The Kruskal-Wallis test is to see significant differences between two groups, and the Mann Whitney test is to see the difference in values between two groups, indicating that the treatment has an influence. The Kruskal-Wallis test is a non-parametric statistical test used to test the initial hypothesis. The Kruskal-Wallis test determines whether the groups of independent and dependent variables are significantly different (Jamco, 2022). Hypothesis testing decisions are made based on comparing the significance value (Asymp. Sig) with a probability of 0.05. The conditions are (1) If the value of Asymp. Sig > 0.05, then H_0 is accepted, Ha is rejected or there is no difference between groups; (2) If the value of Asymp. Sig < 0.05, then H_0 is rejected, Ha is accepted or there are differences between groups.

Table 8 shows the results of the Kruskal-Wallis non-parametric hypothesis test. From the results of the Kruskal-Wallis test, Asymp Sig. of 0.014 (Asymp Sig. < 0.05). Therefore, the test decision H_0 is rejected, Ha is accepted, or there is a significant difference between the experimental and control classes. Based on the results of the hypothesis test, it can be seen that the cognitive domain learning outcomes data in the experimental and control classes have significant differences in results.

Table 8. Hypothesis Test Results

Kruskal-wallis test	Asymp sig.	Test decision
Cognitive domain learning outcomes	0.01	H_0 is rejected, H_a is accepted

The Mann-Whitney test is a non-parametric statistical test used to determine the difference in medians of 2 independent groups. This test requires data on an ordinal, interval, or ratio scale (Cantica et al., 2023). This test is used to determine the effect of the Culturally Responsive Teaching (CRT) integrated ethnochemistry approach on students' cognitive learning outcomes. Hypothesis testing decisions are made based on comparing the significance value (Asymp. Sig) with a probability of 0.05. The conditions are (1) If the value of Asymp. Sig > 0.05, then H_0 is accepted, H_a is rejected, or there is no difference between groups; (2) If the value of Asymp. Sig < 0.05, then H_0 is rejected, H_a is accepted or there are differences between groups.

Table 9 shows the results of the Mann-Whitney non-parametric hypothesis test. From the results of the Mann-Whitney test, Asymp Sig was obtained. as big as. from the results of the Kruskal-Wallis test, Asymp Sig. of 0.000 (Asymp Sig. < 0.05). Therefore, the test decision H_0 is rejected, H_a is accepted, or there is a significant difference between the experimental and control classes. Based on the results of the hypothesis test, it can be seen that in the cognitive domain learning outcomes data in the experimental class and control class, there are differences in cognitive domain learning outcomes scores between students in the experimental class and students in the control class. Thus, it can be concluded that the Culturally Responsive Teaching approach integrated with ethnochemistry affects students' cognitive learning outcomes (Posttest). Based on the results of hypothesis testing, it can be seen that the cognitive domain learning outcomes data in the experimental class and control class have different results.

Table 9. Advanced Hypothesis Test Results

Mann-whitney test	Asymp sig.	Test decision
Cognitive domain learning outcomes	0.00	H_0 is rejected, H_a is accepted

Discussion

The findings in this research show that there is an influence of applying the Culturally Responsive Teaching (CRT) approach which integrates ethnochemistry in green chemistry material, where this approach is quite effective in improving student learning outcomes (cognitive domain). This is also supported by integrating green chemistry with ethnochemistry. The results of this study are in line with several previous research results. Previous research, among others, was conducted by Khasanah (2023), Arif et al. (2021), and Shabrina (2023). Khasanah (2023) implemented a Culturally Responsive Teaching approach in class II elementary school, which resulted in effective learning and improved student learning outcomes. Then Arif et al. (2021) implemented a Culturally Responsive Teaching approach integrated with ethnochemistry on hydrolysis material, where this research can help students more easily understand what researchers are conveying and learning appears more meaningful. Then Shabrina (2023) implemented ethno-bioedugame-based learning with a Culturally Responsive Teaching approach to reproductive system material, where this research resulted in increased activity and student learning outcomes. This is in line with research conducted also by Hikmawati, et al (2021), where this research applies ethnoscience-based science learning. The results of the research were also positive, finding a scoring system that was suitable for test assessment. This proves that culture has a positive role in supporting improved learning outcomes in a lesson

(Amtu et al., 2020). This is because with local culture learning becomes more contextual and meaningful so that the learning process will be effective and enjoyable (Lestari et al., 2022). The Culturally Responsive Teaching approach has principles that can create meaningful learning. In this research, an ethnochemistry integrated Culturally Responsive Teaching approach was developed referring to Hernandez et al. (2013) which consists of five basic principles, namely content integration, facilitation of knowledge construction, prejudice reduction, social justice, and academic development. These learning activities can develop students' abilities supported by exploration, concentration, investigation from various perspectives (scientific, sociocultural, historical), elaboration and affirmation (Suastra et al, 2021). The application of Culturally Responsive Teaching stimulates students' awareness of the role of chemistry in their daily lives, especially in their culture which also influences their cultural understanding (Rahmawati & Ridwan, 2017).

The novelty in this research lies in an interdisciplinary approach that integrates the principles of Culturally Responsive Teaching and ethnochemistry concepts in green chemistry learning. The results of this research identify teaching methods that are more effective in creating inclusive and culturally centered learning environments for students, while increasing their understanding of green chemistry applications in their cultural contexts. These findings provide a new framework for curriculum development and teaching practices that can better meet student needs, while creating cultural awareness and supporting a deeper understanding of green chemistry.

The benefits of implementing a culturally responsive teaching approach integrated with ethnochemistry in green chemistry material show an increase in learning outcomes during the learning process. In line with the research results, the application of this research can also provide various useful contributions in the context of education and research. Some potential contributions from implementing this approach include increasing student involvement and providing space for cultural expression. This approach takes into account students' cultural backgrounds and can increase student involvement and reveal aspects of their culture (Kea & Trent, 2013), especially in learning green chemistry. This can make the material more relevant and interesting for students with diverse cultural backgrounds (Antika et al., 2023). It is also possible to develop cultural awareness, where students can develop better cultural awareness and greater tolerance towards other cultures through this Culturally Responsive Teaching approach (Amirin, 2012). In understanding the material, this approach can certainly increase understanding of green chemistry concepts and increase interest in chemistry. The integration of ethnochemistry in green chemistry teaching can help students understand chemical concepts better, because they can relate to situations and examples that are more familiar to their culture. By introducing students to the applications of green chemistry in their cultural context, this approach can improve student interest in chemistry and potential scientific careers. Lastly, this approach can improve critical and analytical skills, and encourage systemic thinking. This approach encourages students' critical and analytical thinking as they consider the impact of green chemistry in their cultural context. This can help students develop better problem-solving skills. Then, ethnochemistry in the Culturally Responsive Teaching approach can help students see a greater connection between green chemistry and cultural, social, economic and environmental aspects (Rahmawati, 2018).

Conclusion

The conclusion of this study is that an Ethnochemistry-based Culturally Responsive Teaching approach is needed to improve the learning outcomes of students' cognitive domains and make learning more meaningful. The learning process with a Culturally Responsive Teaching approach makes learning encourage students to be more active because they feel valued. The integration of ethnoscience into chemicals (ethnochemistry) makes students better understand and learn more efficiently. However, this approach requires extra attention from teachers to understand and appreciate the cultural diversity of students, as well as take into account the differences that exist in the planning and implementation of learning.

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Author Contributions
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Conflict of Interest
The authors declare no conflict of interest.

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