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The Effect of Problem-Based Learning with A Culturally Responsive Teaching Approach on Understanding the Concept of Acids and Bases

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ABSTRAK

.Pembelajaran kimia pada materi asam-basa perlu dikaitkan dengan konteks budaya lokal agar lebih bermakna bagi peserta didik. Penelitian ini bertujuan untuk mengetahui pengaruh pembelajaran berbasis masalah berpendekatan CRT (CRT) terhadap pemahaman konsep asam-basa. Salah satu implementasi pembelajaran dilakukan melalui kegiatan identifikasi pH pada limbah pewarnaan batik sebagai bagian dari budaya lokal di sekitar SMA Negeri 1 Juwana. Penelitian menggunakan desain quasi experiment dengan model Nonequivalent Control Group Design. Subjek penelitian adalah peserta didik kelas XI, dengan kelas XI-4 sebagai kelas eksperimen yang mendapatkan perlakuan berupa pembelajaran berbasis masalah berpendekatan CRT, dan kelas XI-5 sebagai kelas kontrol dengan pembelajaran berbasis masalah tanpa pendekatan CRT. Hasil penelitian menunjukkan bahwa pembelajaran berbasis masalah berpendekatan CRT memberikan pengaruh yang signifikan terhadap pemahaman konsep asam-basa. Hal ini dibuktikan melalui hasil uji statistik yang menunjukkan adanya perbedaan pemahaman konsep secara signifikan antara kelas eksperimen dan kelas kontrol. Besar pengaruh pembelajaran berbasis masalah berpendekatan CRT berdasar nilai uji effect size sebesar 0,778 (kategori sedang). Berdasarkan hal tersebut pendekatan CRT dalam model PBL terbukti efektif berdampak terhadap pemahaman peserta didik pada konsep asam-basa.

ABSTRACT

Chemistry learning on acid-base material needs to be associated with the local cultural context to make it more meaningful for students. This study aims to determine the effect of problem-based learning with the CRT approach on the understanding of acid-base concepts. One of the implementations is done through the activity of identifying pH in batik coloring waste as part of the local culture around SMA Negeri 1 Juwana. The research used a quasi-experimental design with a Nonequivalent Control Group Design model. The research subjects were grade XI students, with grade XI-4 as the experimental class that received treatment in the form of problem-based learning with the CRT approach, and grade XI-5 as the control class with problem-based learning without the CRT approach. The results showed that problem-based learning with the CRT approach had a significant effect on the understanding of the acid-base concept. This is demonstrated by the results of statistical tests that show a significant difference in concept understanding between the experimental and control classes. The influence of problem-based learning with the CRT approach, based on the effect size test value, is 0.778 (medium category). Based on this, the CRT approach in the PBL model is proven to have an effective impact on students' understanding of the acid-base concept.

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INTRODUCTION

Learning is a process of behavior change that includes improving thinking skills, attitudes, and skills through learning experiences (Septryanesti & Lazulva, 2019). As times change, education in Indonesia continues to transform to keep pace with technological advancements. Currently, Indonesia is striving for quality education, as evidenced by the annual revision of the curriculum, including the implementation of the Merdeka Curriculum, which emphasizes literacy and the development of the Pancasila Student Profile (Wardani et al., 2024). This curriculum requires teachers to apply learning models that are in accordance with the characteristics of the material and students, and are oriented towards 21st-century skills, namely 4C: Critical Thinking, Collaboration, Communication, and Creativity (Mahrunnisya, 2023).

One of the relevant models is Problem-Based Learning (PBL), which encourages students to actively solve problems collaboratively (Nurhamidah, 2022). In chemistry education, this model can be integrated with the Culturally Responsive Teaching (CRT) approach, which connects learning materials with students' cultural (Lasminawati set al., 2023). The CRT approach is used to help students understand the material, especially in chemistry, by connecting the material used with their existing culture. This aligns with Ki Hajar Dewantara's philosophy that education should incorporate cultural elements into children's lives. Therefore, teachers, as facilitators, are required to design engaging learning activities that encourage students to actively think critically by incorporating cultural concepts (Salma & Yuli, 2023).

Acid-base material in chemistry is known to be complex because it includes macroscopic, microscopic, and symbolic aspects (Andriani et al., 2019). Unfortunately, conventional learning is still dominant, causing low understanding of students' concepts. At SMA Negeri 1 Juwana, learning still focuses on lectures and has not utilized contextual worksheet. Even though this area has local cultural potential, such as batik Bakaran, which can be integrated into chemistry learning based on the cultural context.

Therefore, it is important to apply the PBL model with the CRT approach to improve understanding of acid-base concepts, as supported by the findings of Wahyuningsih (2022), which showed the effectiveness of the approach in chemistry learning. In addition, this research needs to be conducted because there have not been many studies examining the integration of the CRT approach in problem-based learning, especially in acid-base material in high schools.

METHODS

This study used a quasi-experiment design with a nonequivalent pre-test post-test control group design approach, as explained by Sugiyono (2019). This design involves two groups, namely experimental and control classes, that are not randomly selected. Both classes were given a pre-test and

post-test, but only the experimental class received treatment in the form of problem-based learning with a Culturally Responsive Teaching approach. The pre-test was conducted before learning to measure students' initial understanding of the acid-base concept. Ideally, the pre-test results between the two classes are not significantly different. Furthermore, the experimental class followed problem-based learning with a cultural approach, while the control class received problem-based learning without this approach. After the learning is complete, a post-test is conducted to measure the improvement of students' concept understanding. In this study, the considerations used in determining the sample were that the classes to be used as the control class and the experimental class had the same variance, with the same teacher and the same number of teaching hours, namely 5 hours of lessons per week.

The teaching materials include test and non-test instruments, teaching modules, and student worksheets used in the learning process, which are instruments and teaching materials that have been validated by expert validators. Then, for the test instruments used, the questions have been tested in class XII-3 and analyzed for validity, reliability, discriminating power, and level of difficulty.

RESULT AND DISCUSSION

The research was conducted at SMA Negeri 1 Juwana in a span of time, starting from February 3, 2025, to March 31, 2025. The research was conducted using two classes, namely class XI - 4 and class XI - 5, in the academic year 2024/2025. This study provides an explanation of the data on the results of the effect of problem-based learning with the CRT approach on understanding the concept of acid-base. The data in this study were obtained through the results of the initial test (pre-test) and the final test (post-test) regarding understanding the concept of acid-base. Pre-test data is data used to determine the initial ability of students before learning, while post-test data is data used to determine the final ability of students after the implementation of problem-based learning with the CRT approach.

Result

Initial Data Analysis

At the beginning of the study, a pre-test was conducted on students from both classes to determine the initial ability of students. The pre-test results from both classes were then analyzed using the IBM SPSS Statistics 27 application, with the statistical test results presented as follows.

In this study, the normality test was carried out using the IBM SPSS Statistics 27 application using the Saphiro Wilk column, because the sample used was a small sample. If the data tested has a significant value more than 0.05 (sig. > 0.05), then the data can be declared normally distributed. Meanwhile, if the data tested has a significant less than 0.05 (sig. <0.05), then the data can be declared not normally distributed.

Table 1. Results of Pre-test Data Normality Test

Class	Data			Conclusion
	N	Sig.	α	
Experiment	36	0,095	0,05	Sig. > 0,05 (Normally distributed data)
Control	36	0,112	0,05	

Based on the table of normality test results for the pre-test and post-test data above, it can be seen in the Shapiro-Wilk section that the normality test analysis results show that the data is normally distributed with significance values for the experimental class and control class of 0.095 and 0.112, respectively.

The variance equality test in this study was conducted to determine whether the pre-test data obtained from the control and experimental classes had the same variance or not. This test was conducted using IBM SPSS 27, and decisions were made based on the significance value in the SPSS output. If the significance value for Based on mean is greater than 0.05 (sig. > 0.05), then the data is considered to have the same variance, and if the significance value for Based on mean is less than 0.05 (sig. < 0.05), then the data is considered to have different variances.

Table 2. Results of the Variance Equality Test for Pre-test Data

Statistics	Data	Conclusion
α	0,05	Sig. > 0,05 (homogeneous data)
Sig.	0,759	

Based on the results of the variance similarity test on the pre-test data of the control class and the experimental class, a significance value of 0.759 was obtained, where the significance value obtained was greater than 0.05 (sig. > 0.05), so the data could be declared to have the same variance or it could be said that the pre-test data from both classes was homogeneous.

This test was conducted to determine whether there were differences between the experimental class and the control class before problem-based learning using the CRT approach was implemented. The mean difference test was conducted using an independent sample t-test using IBM SPSS Statistics 27. The decision-making in the independent sample t-test was as follows:

1) H_a: If the Sig. (2-tailed) value obtained is less than 0.05 (Sig. (2-tailed) < 0.05), then there is a significant difference between the pre-test results of the experimental class and the control class.
2) H_0: If the Sig. (2-tailed) value obtained is greater than 0.05 (Sig. (2-tailed) > 0.05), it is stated that there is no significant difference in the pre-test results between the experimental class and the control class.

Table 3. Results of the Pre-test Data Mean Difference Test

Data		Conclusion
Sig. (*2-tailed*)	**α**	Sig. > 0,05
0,808	0,05	(H_0 accepted)

Based on the results of the independent sample t-test that was conducted, a sig. (2-tailed) A value of 0.808 was obtained. This sig. (2-tailed) The value is greater than 0.05, so H0 is accepted, and H_a is rejected, which means that there is no significant difference between the experimental class and the control class. Thus, it can be concluded that both classes started from the same initial conditions

Final Data Analysis Results (*Post-test)*

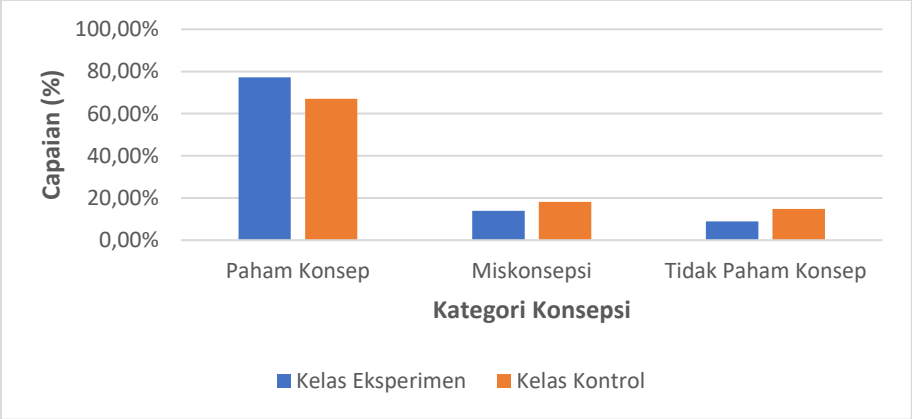

Figure 1. Graph of Student Concept Achievement

Based on the results of the post-test, the level of conceptual understanding of students in the experimental class was 77.22%, while in the control class it was 67.04%. Misconceptions in the experimental class were 13.89% and in the control class 18.15%. Furthermore, for the category of not understanding the concept, the experimental class scored 8.89% and the control class scored 14.81%. This difference in percentages indicates that the experimental class had a better understanding of the concept of acids and bases than the control class.

A normality test was also conducted on the post-test data to determine whether the post-test data for the experimental class and control class were normally distributed or not.

Table 4. Results of Post-test Data Normality Test

Class	Data			Conclusion
	N	**Sig.**	**α**	
Experiment	36	0,055	0,05	Sig. > 0,05
Control	36	0,185	0,05	(Normally distributed data)

Based on the results of the normality test that has been conducted, the significance values of the post-test for the experimental class and control class were 0.055 and 0.185, respectively. The significance values obtained from the post-test data of both classes were greater than 0.05, so the data can be declared to be normally distributed.

A variance test was conducted to determine whether the post-test data of the experimental class and the control class had the same variance or not.

Table 5. Results of the Post-test Data Variance Similarity Test

Statistics	Data	Conslusion
α	0,05	Sig. > 0,05
Sig.	0,337	(homogeneous data)

Based on the results of the variance equality test that has been conducted, the results of the post-test variance equality test for the control class and the experimental class obtained a significance value based on the mean of 0.337, which means that the significance value obtained is greater than 0.05 (sig. > 0.05), so it can be concluded that the post-test data from both classes have the same or homogeneous variance.

The mean difference test in this study was conducted using post-test data from the experimental class and control class to determine whether there was a significant difference between the two classes after the treatment was administered. The mean difference test was conducted using the independent sample t-test with IBM SPSS Statistics 27. The decision-making in the independent sample t-test was as follows:

1) H_a: If the Sig. (2-tailed) value obtained is less than 0.05 (Sig. (2-tailed) < 0.05), then there is a significant difference between the post-test results of the experimental class and the control class.
2) H_0: If the Sig. (2-tailed) value obtained is greater than 0.05 (Sig. (2-tailed) > 0.05), then it is stated that there is no significant difference in the post-test results of the experimental class and the control class.

Table 6. Results of Post-test Data Mean Difference Test

Data		Conclusion
Sig. (2-tailed)	**α**	Sig. < 0,05
0,002	0,05	(H_0 rejected)

Based on the independent sample t-test that was conducted, the result obtained was Sig. (2-tailed) of 0.002, where the Sig. (2-tailed) value obtained was less than 0.05 (Sig. (2-tailed) < 0.05). Based on the formulated hypothesis, it can be concluded that H0 is rejected and Ha is accepted. Furthermore, based on the results of the independent sample t-test, it can be stated that at a 95% confidence level, there is a significant difference in the mean post-test scores between the experimental class and the control class.

The effect size test in this study was conducted to determine the magnitude of the effect of CRT-based problem-based learning on the understanding of acid-base concepts between the experimental class and the control class.

Table 7. Effect Size Results

d (effect size)	Effect Size Value	Conclusion
$\frac{(77,17 - 67,39)}{12,565}$	0,778	77,8% (moderate effect)

Based on the results of the effect size test that has been conducted, an effect size value of 0.778 was obtained. Referring to Cohen's Standard table, the effect size value obtained is in the moderate category.

This study was conducted in an experimental class (XI-4) and a control class (XI-5) over seven sessions with a total of 18 teaching hours (1 teaching hour = 45 minutes) to analyze the effect of problem-based learning with the CRT approach on acid-base material. In the experimental class, problem-based learning with the CRT approach was applied, while in the control class, problem-based learning without the CRT approach was used. The material taught in both classes included the definition and theory of acids and bases, pH calculations, and acid-base indicators, with the learning process referring to teaching tools that had been prepared, such as teaching modules, test and non-test instruments, and worksheets.

In the first meeting, a pre-test was conducted to determine the initial ability of students using two-tier multiple-choice questions, and the questions used were the same for both classes. The pre-test results showed low scores in classes XI-4 and XI-5 because most students did not work on the questions seriously due to their limited understanding of acid-base material. Following the pre-test, instruction continued with the concept and theory of acids and bases through group discussions using a worksheet. Activities for this subtopic continued until the second meeting, which included group presentations and a review of the material.

In the third meeting, students continued learning about pH calculations through group discussions using a worksheet and teacher guidance. In the fourth meeting, several groups presented the results of their discussions, followed by a discussion of pH calculation questions with the teacher. After all questions were discussed, the teacher reviewed the material and helped students formulate conclusions from the learning that had taken place.

In the fifth meeting, students learned about pH indicators and conducted a practical experiment as part of individual and group investigation steps in the worksheet using the PBL syntax. The practical experiment involved testing pH and solution properties using indicators such as litmus paper, universal indicators, and natural indicators (roses and turmeric) with solution samples from everyday materials. Students then recorded the results of the laboratory experiment and drew conclusions in the worksheet. At the sixth meeting, they presented the results of the laboratory experiment along with the conclusions

they had drawn. The seventh meeting concluded with a post-test to measure understanding of acid-base concepts, which was then analyzed to assess the effectiveness of problem-based learning using the CRT approach.

Results of Supporting Data Analysis

Results of Psychomotor and Affective Observation Data Analysis

This study also analyzed the psychomotor and affective abilities of students through observations in the experimental class. The observations were conducted by two observers using assessment sheets that had been validated by experts. The psychomotor aspect included presentation and collaboration skills, with eight assessment indicators for each skill. Presentation skills were assessed based on the systematic presentation, division of material, completeness, intonation, and articulation when presenting the results of problem-solving. Meanwhile, collaboration skills were evaluated through a discussion activity, responsibility, and participation in helping group members during problem-solving in the WORKSHEET.

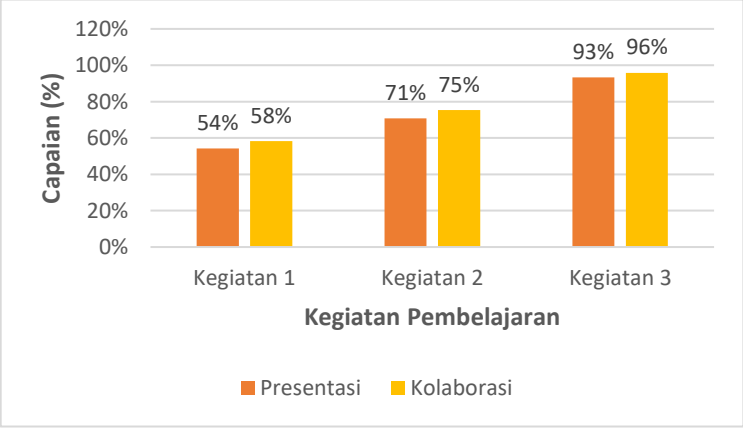

Figure 2. Results of Psychomotor Learning Achievement

Observations were conducted three times in accordance with the number of worksheet's completed by the students. In the first lesson (covering the concepts and theories of acids and bases), the students' collaboration and presentation skills were still low because they were not yet accustomed to solving problems in groups and presenting their results, with a presentation score of only 54%. In the second lesson (on acid-base pH calculations), the students' presentation skills improved as they had understood the presentation methodology and appeared more confident, although the collaborative participation of some students was still suboptimal. In the third lesson (on acid-base indicators), collaboration and presentation skills showed a significant improvement. All students actively participated in discussions, problem-solving, and presenting practical results with good systematic organization and confidence.

Furthermore, the affective assessment in this study covered three aspects of student attitudes, namely responsibility, honesty, and discipline. Responsibility was assessed through student involvement in group discussions, honesty was measured when completing assignments and tests, while discipline was observed from the timeliness of students in completing and submitting assignments.

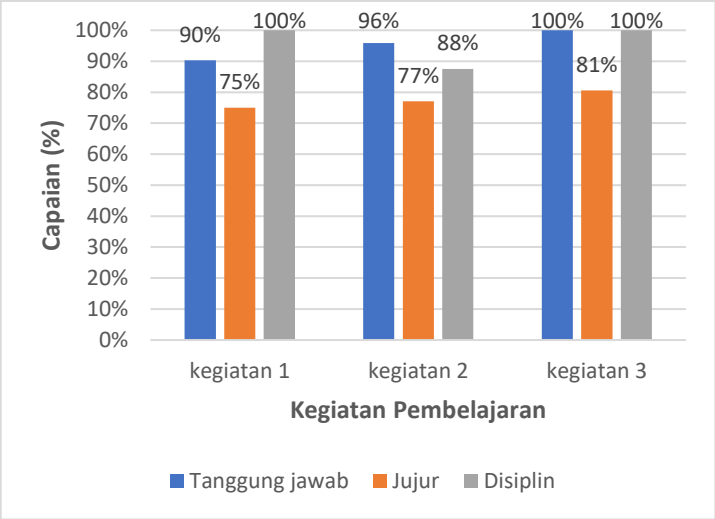

Figure 3. Results of Affective Learning Achievement Analysis

In the first learning activity, students still seemed confused by the model being applied, but they still tried to complete the tasks in the worksheet on time, even though their participation in group discussions was not optimal. In the second learning activity, student engagement increased with active participation in group discussions. In the third learning activity, all students contributed to the investigation activity to solve problems in the WORKSHEET. Overall, students responded positively, especially when solving problems relevant to culture and daily life, thereby improving their understanding of the material.

Results of Student Response Questionnaire

A student response questionnaire was used to determine perceptions of problem-based learning using a Culturally Responsive Teaching (CRT) approach. The questionnaire, consisting of 18 statements, was completed by students in the experimental class (XI-4) using a scale of 1–4. The results of the analysis showed an average percentage of 62%, indicating a positive response to learning. On specific items, such as items 15, 16, 17, and 18, most students agreed and strongly agreed that the learning was closely related to daily life and local culture, motivated them to study more diligently, and helped connect acid-base material to real-life situations, making the learning more engaging and meaningful.

DISCUSSION

This study shows that problem-based learning using the CRT approach is more effective in improving understanding of acid-base concepts than learning without the CRT approach. This can be seen in the graph (Figure 1), which shows a higher percentage of concept understanding in the experimental class. The independent t-test conducted yielded a Sig. (2-tailed) value of 0.002 ($p < 0.05$), indicating a significant difference between the post-test results of the experimental class and the control class. Thus, problem-based learning using the CRT approach has been proven to have a positive effect on students' understanding of acid-base concepts. The significant difference in post-test results between the experimental and control classes is attributed to the differing instructional approaches employed. The results of the independent sample t-test indicate that problem-based learning using the CRT approach is more effective in improving students' understanding of acid-base concepts. This is evident from the average post-test score of the experimental class, which was 77.17, higher than that of the control class, which was 67.39. Thus, problem-based learning using the CRT approach has been proven to have a greater impact on students' understanding of acid-base concepts.

The application of the CRT approach enables students to recognize and appreciate cultural diversity in their environment, making learning more contextual and meaningful. This is in line with the research of Noviarini et al. (2024) and Rochaminah et al. (2024), which shows that integrating local culture into learning makes it easier for students to understand concepts. At SMA Negeri 1 Juwana, the CRT approach is integrated with the process of making batik, brassware, shrimp paste, and bandeng presto as a contextualization of acid-base material. For example, students identify chemicals in the batik dyeing process to understand acid and base concepts, and conduct pH experiments with natural samples such as terasi solution and lime juice using natural indicators (rose petals and turmeric).

The application of problem-based learning using the CRT approach provides enjoyable learning activities by integrating local culture into the learning process. The material presented can be easily understood by students because it is related to their real-life experiences and is relevant to their daily lives (Sari et al., 2023). The learning model applied in this instruction is implemented through group collaboration, where learning in groups results in better learning and understanding, thereby improving students' learning outcomes (Nurrohma & Adistana, 2021).

Psychomotor and affective observations have shown an improvement in students' collaboration and presentation skills during learning. Initially, these skills were still low because students were accustomed to individual learning. However, through group discussions and contextual problem solving, students became more active and confident. These results align with Gay (2018), who states that CRT enhances student engagement through cultural connections, as well as the research by Becerra-Labra et al. (2022), which demonstrates that PBL is effective in developing conceptual understanding through inquiry-based problem-solving.

Overall, the integration of the CRT approach into the PBL model has proven to create enjoyable, relevant, and empowering learning experiences for students. This finding is supported by studies by Ladson-Billings (2021), which emphasize the importance of culturally responsive learning approaches to reduce comprehension gaps and improve learning outcomes for students from diverse backgrounds. Furthermore, in line with research by Carter et al. (2023), which shows that when students are encouraged to explore chemical concepts through cultural contexts they are familiar with, there is a significant increase in concept retention and critical thinking skills. Additionally, a study by Alvarado et al. (2022) demonstrated that the implementation of CRT in science classrooms directly impacts the strengthening of students' identities and positive perceptions of science as part of their lives. Therefore, it can be concluded that the combination of PBL and CRT enhances concept retention, critical thinking, and positive attitudes toward science. Thus, this approach is effective for developing more meaningful conceptual understanding in chemistry education.

CONCLUSION

Based on the research results, problem-based learning using the Culturally Responsive Teaching (CRT) approach was proven to have a significant effect on the understanding of acid-base concepts among 11th-grade students at SMA Negeri 1 Juwana. The results of the independent sample t-test showed a significance value of 0.002 ($p < 0.05$), which means that there was a significant difference between the post-test results of the experimental class and the control class. The average post-test score for the experimental class was 77.17, which was higher than that of the control class at 67.39. Additionally, the effect size test results showed a value of 0.778, which falls into the moderate category. These findings indicate that problem-based learning using the CRT approach has a positive impact on students' understanding of acid-base concepts.

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