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The Effect of Applying Contextual Teaching and Learning in Problem-Based Learning on Students' Critical Thinking Skills in Chemical Equilibrium

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ABSTRAK

Keterampilan berpikir kritis merupakan kompetensi penting dalam pembelajaran kesetimbangan kimia yang membutuhkan kemampuan analisis mendalam. Penelitian ini bertujuan menganalisis pengaruh kombinasi Problem Based Learning dan Contextual Teaching and Learning (PBL-CTL) terhadap keterampilan berpikir kritis dan pengetahuan siswa dibandingkan dengan PBL tanpa CTL. Penelitian menggunakan metode kuasi-eksperimen dengan desain kelompok kontrol non-ekuivalen pascates. Kelompok eksperimen menerapkan PBL-CTL, sedangkan kelompok kontrol menerapkan PBL. Data diperoleh melalui lembar kerja, tes, dan observasi. Hasil uji Mann–Whitney U menunjukkan perbedaan signifikan pada keterampilan berpikir kritis (p = 0,010) dan pengetahuan (p = 0,038), dengan peringkat rata-rata kelompok PBL-CTL lebih tinggi. Ukuran efek berada pada kategori moderat untuk keterampilan berpikir kritis (r = 0,304) dan pengetahuan (r = 0,244). Dengan demikian, PBL-CTL lebih efektif dalam meningkatkan keterampilan berpikir kritis dan penguasaan materi kesetimbangan kimia dibandingkan PBL tanpa CTL.

ABSTRACT

Critical thinking skills are essential 21st-century skills that need to be developed, including in complex chemistry equilibrium material that requires in-depth analysis. Context-based learning and problem solving, such as a combination of Problem Based Learning (PBL) and Contextual Teaching and Learning (CTL), are expected to combine the strengths of both in improving critical thinking skills. This study aims to analyze the effect of applying PBL-CTL on critical thinking skills and compare it with non-CTL PBL. The type of research is a quasi-experiment – post-test non-equivalent control group design. The sample selection was conducted using a combination of purposive sampling and cluster random sampling after testing the normality and equality of variance in the population. This study was conducted by comparing two sample groups. The experimental group applied PBL-CTL, while the control group used PBL. Data were obtained from the completion of worksheets, post-tests, and observations. The Mann-Whitney U test results showed significant differences in critical thinking skills (p=0.010) and knowledge (p=0.038), with the experimental group having a higher mean rank. The effect size test indicated a moderate effect on critical thinking skills (r=0.304) and knowledge (r=0.244). These findings prove that PBL-CTL has a significant moderate effect on improving students' critical thinking skills and knowledge in chemical equilibrium material, with a greater effect on critical thinking skills. In addition, students in the PBL-CTL group consistently achieved higher scores on critical thinking indicators and mastery of material compared to the non-CTL PBL group.

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INTRODUCTION

21st century education requires students to have critical thinking, creative, communicative, and collaborative skills in order to face global challenges. However, in practice, classroom learning still tends to be theoretical and does not relate the material to real life, making it difficult for students to develop critical thinking skills. This situation is particularly evident in chemistry equilibrium material, which requires in-depth analysis, problem-solving, and connections to real-world phenomena in both the environment and industry.

One approach to address this need is the implementation of a learning model focused on real-world experiences and problem-solving. Problem-Based Learning (PBL) emphasizes learning through collaborative problem-solving of real-world issues, while Contextual Teaching and Learning (CTL) emphasizes the connection between subject matter and everyday life contexts. The combination of both (PBL-CTL) is believed to enhance the meaning of learning while simultaneously developing students' critical thinking skills. Previous studies support the effectiveness of both models. Ningsih *et al*. (2023) found that CTL is more effective in improving conceptual understanding than conventional learning, while Zahro & Lutfianasari (2024) showed that PBL has a significant effect on improving critical thinking skills. Other studies also confirm that integrating problem-based models with real-world contexts can enhance motivation, learning activities, and deep understanding of chemistry material (Maulana *et al.*, 2021; Sanova *et al.*, 2021). Thus, integrating CTL into PBL has the potential to become a relevant and innovative learning strategy.

Based on the above, this article discusses the effect of applying a combination of PBL-CTL on students' critical thinking skills in chemistry equilibrium material. The focus is on comparing critical thinking skill achievements between the group using PBL-CTL and the non-CTL PBL group. This theme is important to study because it can provide alternative solutions for teachers in delivering chemistry learning that is more meaningful, applicable, and in line with the demands of 21st-century skills. The main objective of this discussion is to analyze the extent to which the application of PBL-CTL can improve students' critical thinking skills and to describe the profile of critical thinking skill achievements in each learning group.

METHODS

This study used a quantitative approach with a quasi-experimental method and a post-test nonequivalent control group design. The research subjects were 11th grade students at SMA Negeri 1 Jakenan in the 2023/2024 academic year, with a population of 143 students in the science cluster. The sample was determined through a combination of purposive sampling and cluster random sampling, resulting in two classes being selected as the experimental and control groups. The experimental group

was given treatment using the Problem-Based Learning (PBL) model combined with Contextual Teaching and Learning (CTL), while the control group used the PBL non-CTL model.

The independent variable of the study was the learning model (PBL-CTL and non-CTL PBL), while the dependent variable was critical thinking ability. Control variables included chemistry equilibrium material, number of learning hours, curriculum, and the same teacher. The research instruments included Student Worksheets (SW), essay-type tests (post-tests), and observation sheets. SW were used to measure critical thinking skills, post-tests to measure post-treatment knowledge, while observations were conducted to assess the implementation of learning and students' critical thinking skills. All instruments were validated by experts and found to be highly valid, while test reliability was analyzed using the Rasch model with reliable results.

Data collection techniques included completing LKPD, tests (post-tests), and observations. Data were analyzed through prerequisite tests (normality and equality of variance) followed by hypothesis testing using the independent t-test or Mann-Whitney test according to the data distribution. If significant differences were found, effect size calculations (Cohen's d or r) were performed to determine the magnitude of the treatment effect.

RESULT AND DISCUSSION

Result

Critical Thinking Skills

Critical thinking skills were measured through the completion of worksheets. The results of the analysis showed that the experimental group had an average score of 76.44, which was higher than the control group's score of 69.98. The distribution of scores was also more varied in the experimental group.

Table 1. Critical Thinking Ability Scores

Group	N	Mark				
		Lowest	Highest	Average	Standard Deviation	Variance
E	36	43,37	96,39	76,44	13,14	172,68
K	36	54,22	93,98	69,98	11,50	132,30

Post-Treatment Knowledge

The students' knowledge after treatment was measured through a post-test on chemical equilibrium material. The average score for the experimental group was 73.89, while that for the control group was 65.28. The distribution of scores in the experimental group was more even than that in the control group.

Table 2. Post-Treatment Knowledge Score

Group	N	Mark				
		Lowest	Highest	Average	Standard Deviation	Variance
E	36	36,67	96,67	73,89	13,15	173,02
K	36	23,33	93,33	65,28	16,76	281,01

Hypothesis Testing

The results of the Mann Whitney U test show that there are significant differences between the experimental and control groups, both in critical thinking skills (p = 0.010) and post-treatment knowledge (p = 0.038).

Table 3. Results of the Influence The for Experimental and Control Groups

	Mean Rank		Significance
	E	K	
Ability Value, Critical Thinking	42,22	29,60	0,010
Post-Treatment Knowledge Score	40,99	30,87	0,038

The effect size test results show that the impact of implementing the PBL-CTL model is moderate, namely 0.304 for critical thinking skills and 0.244 for post-treatment knowledge.

Observation Results

The observation analysis is presented based on the assessment of each observer in the experimental and control groups and is used to observe trends in the development of students' critical thinking skills during lessons 1–3. The results of the observation of the critical thinking skills of students in the experimental group by observer 1 are presented in Table 4.

Table 4. Critical Thinking Achievements of the Experimental Group by Observer 1

Critical Thinking Indicators	Achievements in Learning Activities (%)		
	1	2	3
Provide a simple explanation	65,22	75,00	87,32
Build basic skills	66,85	69,57	84,24
Make inferences	68,48	71,01	79,71
Provide further explanation	62,50	65,76	72,83
Set strategy and tactics	63,04	71,74	83,70

The results of the observation of the critical thinking skills of the students in the experimental group by observer 2 are presented in Table 5.

Table 5. Critical Thinking Achievements of the Experimental Group by Observer 2

Critical Thinking Indicators	Achievements in Learning Activities (%)		
	1	2	1
Provide a simple explanation	64,74	76,92	87,18
Build basic skills	62,50	63,46	82,69
Make inferences	68,59	71,15	76,92
Provide further explanation	62,50	68,27	73,08
Set strategy and tactics	58,65	69,23	84,62

The results of the observation of the critical thinking skills of the control group students by observer 1 are presented in Table 6.

Table 6. Critical Thinking Achievements of the Control Group by Observer 1

Critical Thinking Indicators	Achievements in Learning Activities (%)		
	1	2	3
Provide a simple explanation	73,91	77,17	87,32
Build basic skills	63,59	64,13	85,33
Make inferences	69,20	72,46	74,28
Provide further explanation	60,87	65,76	73,37
Set strategy and tactics	70,11	72,28	83,70

The results of the observation of the critical thinking skills of the control group students by observer 2 are presented in Table 7.

Table 7. Critical Thinking Achievements of the Control Group by Observer 2

Critical Thinking Indicators	Achievements in Learning Activities (%)		
	1	2	3
Provide a simple explanation	68,06	75,69	81,94
Build basic skills	58,33	62,50	91,67
Make inferences	63,89	70,14	79,17
Provide further explanation	59,38	61,46	67,71
Set strategy and tactics	66,67	70,83	83,33

The results of the observation show an upward trend in the achievement of critical thinking indicators from learning activities 1 to 3 in the experimental group. The most significant improvement occurred in the indicators of providing simple explanations and organizing strategies and tactics. In the control group, improvements also occurred in all indicators, but not as strong as in the experimental group, especially in advanced indicators such as providing further explanations.

Discussion

The results of this study prove that the application of the Problem-Based Learning combined with Contextual Teaching and Learning (PBL-CTL) model has a positive effect on improving students' critical thinking skills and mastery of knowledge in chemical equilibrium material. This improvement is evident in the results of the LKPD analysis, observations, and post-test scores, which consistently show that the experimental group achieved higher scores than the control group. This finding also addresses the research

question that integrating real-world contexts into problem-based learning can strengthen students' critical thinking processes. The achievement of students' critical thinking skills is presented in Figure 1.

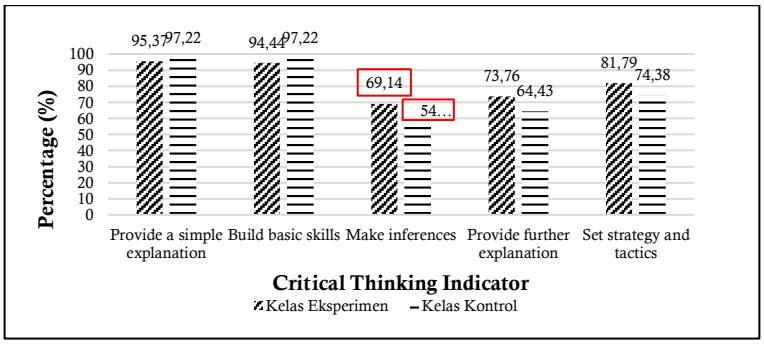

Figure 1. Critical Thinking Ability Indicator Achievement

In general, the critical thinking indicator scores show that students in the experimental group outperformed those in the control group on advanced indicators such as making inferences, providing further explanations, and organizing strategies and tactics. This indicates that the PBL-CTL syntax, which combines contextual problem formulation, group discussion, and individual reflection, successfully trained students to analyze phenomena in depth before making decisions. In contrast, the control group using the non-CTL PBL model tends to stop at procedural understanding and rarely connects concepts to real-world situations.

However, the achievement of the inference indicator in both groups is relatively low. This condition is in line with Ni'mah (2022) findings, which emphasize that the ability to draw conclusions is the most difficult indicator of critical thinking to achieve. Factors contributing to this low achievement include the complexity of the questions in the LKPD and the presence of ambiguous sentences that lead to different interpretations. However, despite this, the experimental group students still demonstrated more analytical and contextual answers compared to the control group.

The analysis of the observation results supports the findings of the worksheet achievement. Students in the experimental group showed an increase in critical behavior, such as actively discussing, asking questions, and connecting concepts with real phenomena. This behavior reinforces constructivism theory, which emphasizes the importance of meaningful experiences and social interaction in building knowledge. In contrast, the control group, although still showing improvement, experienced slower and inconsistent development, particularly in advanced thinking indicators.

The Mann Whitney U test results indicate a significant difference in critical thinking ability between the experimental and control groups. The significance value of 0.010 (<0.05) confirms that the PBL-CTL model is more effective than non-CTL PBL. These results align with previous studies, which similarly demonstrate that CTL is superior to pure PBL because it can provide more meaningful and contextual learning (Fitri *et al.*, 2024; Nurlinda *et al.*, 2024; Samsudin *et al.*, 2023). Thus, this study

reinforces the theory that problem-based learning is more effective when combined with contextual components.

In terms of knowledge mastery, the experimental group also achieved higher and more consistent results compared to the control group. The lower standard deviation of post-test scores in the experimental group indicates better mastery of the material. These findings support the results of Samsudin *et al*. (2023), who stated that CTL not only enhances creativity but also improves the evenness of learning outcomes. The analysis of achievement on each item of the chemical equilibrium questions is presented in Figure 2.

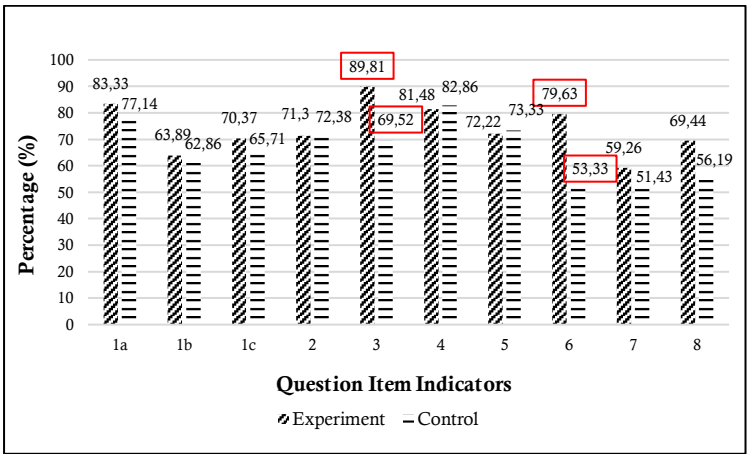

Figure 2. Post-Treatment Knowledge Achievement

Analysis of the achievement of each question item shows that questions requiring higher analytical skills, such as calculating K_p values and designing experimental procedures, were better mastered by the experimental group. This indicates that contextual learning not only helps students understand concepts but also trains them to apply these concepts in real-life situations.

Theoretically, the results of this study integrate the PBL and CTL models into a more comprehensive approach. PBL provides space for developing problem-solving skills, while CTL adds a contextual dimension so that the thinking process becomes more meaningful. This combination results in a modification of the theory that problem-based learning will be more optimal if enriched with real experiences and relevant to the lives of students. Thus, this research not only strengthens existing theory but also contributes to the modification of the PBL-CTL syntax, which can serve as an alternative model for science education.

CONCLUSION

The application of PBL-CTL has been proven to significantly impact the improvement of critical thinking skills and knowledge mastery among students in the subject of chemical equilibrium. The experimental group consistently showed higher achievements than the control group, particularly in advanced critical thinking and analytical questions, with moderate to strong effects on critical thinking

aspects. These findings confirm that PBL-CTL is effective not only in improving critical thinking quality but also in equalizing mastery of the material.

Recommendations are provided for teachers to apply PBL-CTL to topics that require critical thinking and the application of real-world concepts. Further research should expand the study with longer durations and more valid instruments, while educational institutions are encouraged to support the implementation of this innovative model through teacher training and the provision of adequate learning resources.

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