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The Influence of a PBL Learning Model Supported by Zeep Quiz on Students' Critical Thinking Skills in the Subject of Chemical Equilibriumat State Senior High School 1 Bolaang Uki

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Abstract

This research is motivated by the importance of critical thinking skills in chemistry learning, particularly in the topic of chemical equilibrium, which is abstract in nature and requires conceptual understanding and in-depth analysis. The Zeep Quiz-assisted Problem-Based Learning (PBL) model is implemented as a solution because it emphasizes contextual problem-solving, active discussion, and interactive feedback. This research project aims to determine the effect of the PBL model assisted by Zeep Quiz on students' critical thinking skills in the subject of chemical equilibrium at State Senior High School 1 Bolaang Uki. The research method used is quantitative with a quasi-experimental design of the non-equivalent control group pretest-posttest type. The research population includes all students of Senior High School 1 Bolaang Uki for the 2025/2026

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academic year, with a sample of 66 students selected thru cluster sampling technique (evenly divided into experimental and control classes). The research instrument consists of 10 essay test items based on critical thinking indicators (interpretation, explanation, analysis, evaluation, and inference) which are declared reliable with a Cronbach's Alpha value of 0.706. The research results show that the PBL model assisted by Zeep Quiz significantly enhances students' critical thinking skills. Improvements occurred in all indicators in the experimental class, namely interpretation (84.8%), explanation (70.7%), inference (68.2%), analysis (59.1%), and evaluation (58.0%). Effect size analysis shows a score of 0.87 (very large category), indicating a strong influence on post-test achievement. The hypothesis test yielded a significance value of 0.001 (< 0.05), leading to the conclusion that the application of the PBL model assisted by Zeep Quiz significantly affects students' critical thinking skills on the topic of chemical equilibrium.

Keywords: Problem-Based Learning; Zeep Quiz; Critical Thinking; Chemical Equilibrium

INTRODUCTION

Chemistry is a branch of Natural Sciences that studies the structure, properties, and changes of matter along with the accompanying energy thru three levels of representation, namely macroscopic, submicroscopic, and symbolic. A comprehensive understanding of chemistry concepts requires students to simultaneously connect the three representations. However, in school learning practices, chemistry concepts are often considered difficult because they are abstract, hierarchical, and require high-level reasoning, which frequently leads to misconceptions among students (Farizal et al., 2024). Critical thinking skills are one of the main competencies that must be developed in 21st-century learning because they play a role in helping students analyze information, evaluate evidence, construct arguments, and make decisions based on logical reasoning. However, various studies show that students' critical thinking skills in chemistry learning are still categorized as low due to teacher-centered learning that focuses on material delivery and problem-solving exercises (Setiawan et al., 2020; Antara, 2022). This condition causes students to tend to memorize concepts without understanding the relationships between concepts or their application in solving contextual problems.

One of the learning models considered effective in enhancing critical thinking skills is Problem Based Learning. This model places contextual problems as the starting point of learning, encouraging students to investigate, discuss, process information, and formulate solutions based on scientific evidence. Various studies report that the implementation of PBL is capable of

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enhancing students' critical thinking skills, problem-solving abilities, and conceptual understanding (Fareza et al., 2024; Karvandi et al., 2024). On the other hand, the development of educational technology encourages the use of gamification-based learning media to enhance student motivation and engagement. One of the media that has started to be used is Zeep Quiz, which is a metaverse-based learning platform that provides interactive quiz activities, a real-time feedback system, and a virtual environment that supports active student participation (Wijayanto et al., 2023).

Various studies show that high school students still experience significant difficulties in understanding the concept of chemical equilibrium. Common misconceptions include the belief that equilibrium occurs when the reaction stops, errors in writing and interpreting equilibrium constant equations (Kc and Kp), and the inability to explain shifts in equilibrium based on Le Chatelier's Principle (Khairunnisa, 2020). Additionally, students also experience difficulties in connecting macroscopic phenomena with submicroscopic processes and mathematical symbolism, especially at the submicroscopic level which requires the ability to visualize particle dynamics (Proksa et al., 2018). Conceptual difficulties in the topic of chemical equilibrium directly impact the low levels of Higher Order Thinking Skills (HOTS), particularly the critical thinking abilities of students. Students tend to have difficulty analyzing changes in equilibrium systems, solving non-routine problems, and drawing conclusions based on data and scientific evidence. In fact, critical thinking skills are one of the main competencies that must be developed in 21st-century learning, especially in science and chemistry education, which require logical and analytical reasoning (Peperkorn & Schwedler 2024).

Along with the development of educational technology, the integration of gamification-based learning media has become one of the solutions to enhance motivation and critical thinking skills. Gamification is the application of game elements, such as challenges, points, and feedback, in the context of learning to create a more interactive and enjoyable learning experience (Utami et al., 2025). One of the emerging gamification platforms is Zeep Quiz, a metaverse-based learning media that offers an immersive learning experience thru avatar interactions, three-dimensional virtual environments, and real-time automatic feedback. Compared to other digital quiz platforms, Zeep Quiz has advantages in enhancing the sense of presence, active participation, and critical thinking skills in the learning process (Wijayanto et al., 2023).

Based on the results of an interview with the chemistry teacher at High School Senior 1 Bolaang Uki, it was found that the understanding of class XI students regarding the topic of chemical equilibrium is still relatively low. This is reflected in the daily evaluation results, where

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around 55–60% of students scored below the Minimum Completeness Criteria of 75. Therefore, this research was conducted with the aim of analyzing "The Influence of the PBL Learning Model Assisted by Zeep Quiz on Students' Critical Thinking Skills in the Subject of Chemical Equilibrium at State Senior High School 1 Bolaang Uki"

RESEARCH METHOD

Research Design

This study employs a quantitative approach with an experimental method to test the effect of implementing the Problem Based Learning model integrated with gamification elements on critical thinking skills. The research design used is a quasi-experimental non-equivalent control group design with pretest and posttest administration, allowing the researcher to compare changes in abilities between the two groups before and after the implementation of the learning model.

Table 1. Research Design

Pre-Tes	Treatment	Post-Tes
O_1	X	O_2
O_3	-	O_4

X = Treatment (Problem Based Learning Model assisted by Zeep Quiz)
O1 = pre-test experimental class
O2 = post-test experimental class
O3 = pre-test control class
O4 = post-test control class

The group of research participants consists of all 11th-grade students who chose the Chemistry Major at High School Senior 1 Bolaang-Uki for the 2025/2026 academic year, and is made up of 4 classes. The sample in this study was determined using the Cluster Sampling method, which is a sampling technique conducted on a specific group or cluster, where all members of the selected group are used as the research sample (Mandiri, 2022). Therefore, the sample determined in this study is XI-A as the experimental class and XI-B as the control class.

Research Instruments This study uses two types of instruments: treatment instruments and test instruments. The treatment instrument used in this study is a teaching module developed

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based on the Merdeka Curriculum Phase F, following the learning steps and syntax of the Problem Based Learning model assisted by Zeep Quiz. The test instrument consists of ten essay questions that represent indicators of critical thinking ability.

Before use, all instruments undergo a preliminary trial to evaluate their feasibility. The validation procedure includes content validity assessment and empirical validation thru instrument trials. To assess students' critical thinking skills before and after the implementation of the PBL model assisted by Zeep Quiz, descriptive analysis in the form of percentage scores was used. This analysis aims to present the data in percentage form, thereby providing a clear picture of the changes and results obtained from the collected data.

Data Analysis

The data obtained from the pretest and posttest results were then calculated using effect size (Widyastuti & Airlanda, 2021). The formula used to calculate effect size is as follows:

$$r = \frac{Z}{\sqrt{N}}$$

Explanation:
r = Effect Size
Z = Z value in the Wilcoxon test
N = Sample size

Tabel 2. Interpretasi Effect Size

Effect Size	Interpretation
0 < d < 0,2	Small
0,2 < d ≤ 0,5	Moderate
0,5 < d ≤ 0,8	Besar
d > 0,8	Very Large

RESULTS AND DISCUSSION

Results

The students' critical thinking skills were assessed thru the implementation of pretest and posttest. The pretest measured the students' initial knowledge before the application of the PBL model assisted by Zeep Quiz, while the posttest measured their thinking ability after the learning process. Based on data analysis, the average pretest and posttest scores for each critical thinking

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indicator in the control class and the experimental class are presented in Table 3.

Table 3. Percentage (%) of Critical Thinking Ability Indicators of Students' Pre-test and Post-test Results in Control Class and Experimental Class

No	Critic Thinking Indicators	Question Number	Percentage of Student's Critical Thinking Score (%)			
			Control Class		Experimental Class	
			Pretest	Posttest	Pretest	Posttest
1.	Interpretation	1	26,5%	62,9%	36,4%	84,8%
2	Explanation	2	36,4%	54,5%	31,8%	72,0%
		4	8,3%	47,0%	24,2%	55,3%
	Average Pecentage Score		23,7%	54,8%	30,8%	70,7%
3	Analysis	3	10,6%	40,2%	22,7%	65,2%
		5	12,1%	49,2%	22,7%	53,0%
		6	9,8%	47,7%	23,5%	53,8%
		8	3,8%	50,0%	24,2%	64,4%
	Average Pecentage Score		9,1%	46,8%	23,3%	59,1%
4	Evaluation	7	8,3%	46,2%	24,2%	53,8%
		9	5,3%	48,5%	25,8%	62,1%
	Average Pecentage Score		6,8%	47,4%	25,0%	58,0%
5	Inference	10	3,8%	51,5%	22,0%	68,2%

The influence of the application of the Problem Based Learning model assisted by Zeep Quiz on students' critical thinking skills was analyzed using a t-test. Before conducting the hypothesis test, prerequisite analysis tests, including normality and homogeneity tests, were first carried out to ensure that the data met the necessary assumptions for the application of the t-test. Based on the results of the prerequisite analysis tests, the critical thinking ability scores of the students in the pre-test and post-test were not normally distributed but were homogeneous. Therefore, statistical analysis was conducted using the nonparametric Wilcoxon Signed-Rank test as a paired sample test in accordance with the characteristics of the research data. It can be seen in Table 4.

Table 4. Ikhtisar Wilcoxon Signed Rank

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Test of Statistics

	posttest-pretest
Z	-5.020
Asymp.sig.(2-tailed)	<0,001

Based on the results of the prerequisite analysis, in the sample of unpaired data, the critical thinking ability scores of students in the experimental class and the control class are normally and homogeneously distributed. Therefore, further statistical analysis was conducted using the parametric Independent Samples t-test. It can be seen in Table 5.

Tabel 5. Independent Sample T-Test

Independent Sample t-test			
Hypothesis	Test Criteria	Test Result	Decision
H0 = there is no difference in the average critical thinking ability of students in the experimental class and the control class	H0 is rejected if the significance value < 0,05 $T_{count} > t_{table}$ 7,041 > 1,998.	Significant value = 0,001 T_{count} = 7,041	H0 is rejected, there is a difference in the average between the critical thinking skills of the experimental and control class students.

Effect size analysis was conducted to measure the extent of the influence of the PBL model assisted by Zeep Quiz on students' critical thinking skills in the topic of chemical equilibrium. because the main analysis used is the Wilcoxon Signed Rank Test, the formula used can be seen in the analysis data. The calculation of the effect size influence shows a value of r = 0.87. Based on the effect size calculation results, it shows a value of 0.87, which falls into the very large category. Thus, the implementation of the Problem Based Learning model assisted by Zeep Quiz has proven to have a very significant impact on students' critical thinking skills.

DISCUSSION

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The research results show that the application of the Problem Based Learning (PBL) model assisted by Zeep Quiz has a significant effect on students' critical thinking skills in the subject of chemical equilibrium. These findings were proven thru hypothesis testing results that showed a significant impact of the application of the learning model on students' critical thinking skills. The magnitude of the influence was then analyzed using the effect size test. Based on the calculations, an effect size value of 0.87 was obtained, which exceeds the threshold of 0.80, thus falling into the very large category. These results indicate that the implementation of the Problem Based Learning model assisted by Zeep Quiz has a strong impact on students' critical thinking skills.

Based on the research results, on the interpretation indicator, the experimental class obtained a pre-test score percentage of 36.4% which increased to 84.8% on the post-test, while the control class increased from 26.5% to 62.9%. These results indicate that the improvement in critical thinking skills in the experimental class was higher compared to the control class. On the second indicator, namely explanation, there is an increase in students' abilities after the implementation of the Problem Based Learning model assisted by Zeep Quiz. In the experimental class, the average percentage of pre-test scores increased from 30.8% to 70.7% in the post-test. In the control class, the average percentage of pre-test scores increased from 23.7% to 54.8% in the post-test. On the third indicator, analysis, there is an increase in the experimental class from 23.3% to 59.1%. In the control class, the average percentage of pre-test scores increased from 9.1% to 46.8% in the post-test. Next, on the fourth indicator, evaluation, the experimental class average pre-test score of 25.0% increased to 58.0% in the post-test. Meanwhile, in the control class, the average pre-test score of 6.8% increased to 47.4% in the post-test. Then, the students' critical thinking skills on the inference indicator showed improvement after the learning process. In the control class, the average pre-test score of 3.8% increased to 51.5% in the post-test. Meanwhile, in the experimental class, the average pre-test score of 22.0% increased to 68.2% in the post-test. The increase in the experimental class was higher compared to the control class.

This improvement occurs because the Zeep Quiz-assisted PBL model provides students with the opportunity to actively engage in the learning process thru problem-based activities. At the problem orientation stage, at this stage, students are presented with contextual problems related to the topic of chemical equilibrium, which encourages them to understand the situation, identify the core issues, and interpret information before determining the appropriate solution. These findings are also supported by Pikoli's (2019) research, which shows that the ability to understand chemical concepts can develop optimally when students are able to connect various chemical representations, whether at the macroscopic, submicroscopic, or symbolic level. The

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ability to connect these representations helps students interpret information and build a deeper understanding of a chemical phenomenon. In this study, students not only observed the condensation phenomenon occurring on window glass but also attempted to connect it with the chemical equilibrium concepts being studied. These conditions indicate that the interpretation process carried out by the students becomes more meaningful because it is based on the connection between real phenomena and relevant scientific concepts.

Next, at the stage of Organizing Students for Learning, students are divided into study groups to discuss the given problems, identify the necessary information, and determine appropriate resolution strategies. Group discussion activities become an important part of the learning process because they allow students to exchange ideas, consider various perspectives, and construct arguments based on the concepts being studied. Thru group interactions, students not only gain individual understanding of concepts but also learn to evaluate opinions, compare information, and logically determine relationships between concepts. These findings are also supported by Sari's (2022) research, which explains that interaction and cooperation in study groups can help students develop critical thinking skills, particularly in the aspects of analysis and systematic problem-solving. Thus, the stage of organizing students for learning in the application of Problem Based Learning assisted by Zeep Quiz can create more active and collaborative learning, as well as support the development of students' critical thinking skills in the analysis indicator.

Next, in the stage of guiding group investigations, students actively search for information, study concepts, and conduct inquiries to solve the given problems. The teacher acts as a facilitator who guides students in finding relevant information and helps direct the thinking process without providing direct answers. The results of this study are supported by the findings of Djafar et al. (2024), which state that students not only strive to gather relevant information to solve problems but also examine various alternative solutions and consider the scientific basis that supports the chosen option. These conditions indicate that the investigative activities carried out thru the Problem Based Learning model play a role in developing students' evaluation skills thru the processes of assessing, considering, and making decisions based on available evidence and information.

The stage of developing and presenting work, The stage of developing and presenting work in the Problem Based Learning model provides students with the opportunity to present the results of group discussions thru presentation activities in front of the class. At this stage, students are required to communicate their thoughts clearly, coherently, and logically to the teacher and

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classmates. The presentation activity not only serves as a means of conveying the results of the discussion but also becomes a platform for students to justify their answers based on relevant scientific concepts. During the presentation process, students are given the opportunity to explain the reasoning behind the solutions obtained and to respond to questions or feedback from other groups. The academic interaction that takes place during class discussions encourages students to think more deeply in defending the arguments presented. This condition helps students understand that an answer is not only determined by the final result but must also be supported by logical and systematic scientific reasoning. These findings are in line with Dewi's (2020) research, which states that presentation activities in the Problem Based Learning model can enhance students' critical thinking skills because they are trained to explain problem-solving results and defend arguments scientifically.

Then the stage of analyzing and evaluating, At this stage, the teacher together with the students reflect on the solutions obtained and the thinking process that has been carried out during the learning process. Students are directed to identify conceptual errors, examine the weaknesses of problem-solving strategies, and consider alternative solutions based on the scientific concepts that have been learned. The reflection process helps students understand that a problem can be viewed from various perspectives, requiring logical and in-depth consideration before drawing conclusions. In addition, evaluation activities provide a more meaningful learning experience because students not only know the correct answer but also understand the scientific basis that supports that answer. Thru these activities, students are encouraged to evaluate the accuracy of solutions while also drawing conclusions based on the analysis conducted. Research by Syahraini et al. (2022) also shows that analysis and evaluation activities in problem-based learning can enhance students' ability to assess the accuracy of information, consider various alternative solutions, and draw conclusions based on logical scientific reasoning.

The improvement in students' critical thinking skills in this study is also suspected to be influenced by the use of Zeep Quiz as a supporting medium in the implementation of the Problem Based Learning model. The use of Zeep Quiz is able to create a more interactive learning atmosphere and encourage active student participation during the learning process. Thru this media, students have the opportunity to engage directly in answering questions, analyzing problems, and reinforcing their understanding of chemical equilibrium concepts thru quiz-based evaluations. Additionally, the immediate feedback feature on Zeep Quiz helps students quickly identify answer errors, allowing them to reflect on and correct their understanding of concepts that are still inaccurate. The questions presented also encourage students to think logically,

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analyze information, provide scientific reasoning, and draw conclusions based on the concepts they have learned. This condition shows that Zeep Quiz not only functions as a medium for evaluating learning but also as a tool that supports the development of students' critical thinking skills.

This research aligns with the study by Indriani & Gularso (2022), which shows that the application of the Problem Based Learning model assisted by Quizizz media has a significant impact on improving students' critical thinking skills. The study emphasizes that the combination of the Problem Based Learning model and interactive quiz media can encourage students to think more actively in solving learning problems. The results of that study are relevant to this research because Zeep Quiz is used as a supporting medium that helps improve critical thinking skills, strengthen concept understanding, and train analytical abilities during the learning process.

CONCLUSION

The application of the Problem-based Learning (PBL) model assisted by Zeep Quiz has a significant impact on improving students' critical thinking skills in the topic of chemical equilibrium. This improvement occurred across all indicators of critical thinking (interpretation, explanation, analysis, evaluation, and inference), with the experimental class consistently achieving higher than the control class. Statistically, the Wilcoxon Signed Rank test produced an Asymp. Sig. (2-tailed) value of <0.001 (H_o rejected), indicating a significant difference in critical thinking skills before and after the intervention. The Independent Sample t-test reinforces this finding with a Sig. (2-tailed) value of 0.0001<0.05 and $t_{count} < t_{table}$ (7,041<1,998), which confirms a significant difference between the experimental class and the control class. Supported by an effect size of 0.87 (very large category), it can be concluded that the PBL model assisted by Zeep Quiz not only has a statistically significant impact but also has a strong effectiveness in enhancing students' critical thinking skills.

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