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The Influence of the Application of Problem-Based Learning Models on Critical Thinking Skills and Science Learning Outcomes

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A B S T R A C T
This research aims to examine the impact of the problem-based learning (PBL) approach on the critical thinking abilities and academic performance of seventh-grade students at MTsN 7 Bulukumba. The study employed a pretest-posttest control group design, with participants chosen through simple random sampling. Class VIIA, consisting of 27 students, served as the experimental group using PBL, while class VIIB, comprising 28 students, functioned as the control group with traditional direct instruction. Data were gathered via assessments of critical thinking skills and academic achievement, and were analyzed using IBM SPSS Statistics 26. The findings indicated that PBL was more effective than direct instruction in enhancing both critical thinking skills and academic performance regarding the science topics of substances and their transformations.

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INTRODUCTION

Learning is a multifaceted process that encompasses cognitive, affective, and psychomotor elements. The primary goal of education is to fully develop students' potential, both academically and personally. In the context of globalization and the Fourth Industrial Revolution, the challenges facing education are becoming increasingly intricate, demanding the enhancement of 21st-century skills. As noted by Trilling and Fadel (2009), essential skills for the 21st century include critical thinking, creativity, communication, collaboration, and empathy skills that are crucial for students' future professional and social lives.

The Independent Curriculum introduced in Indonesia offers greater flexibility and autonomy for teachers in tailoring lessons to meet the needs of students. This curriculum underscores the significance of fostering 21st-century skills, particularly critical thinking. With this increased autonomy, educators can implement various teaching methods such as discussions, debates, and case studies, which are designed to promote critical thinking among students.

Critical thinking refers to the ability to analyze and assess information thoroughly and solve problems based on logical reasoning. This skill is essential for nurturing advanced cognitive abilities necessary to tackle future challenges (Simatupang et al., 2022). Siahaan et al. (2022) suggest that critical thinking can be enhanced through constructivist learning approaches, which provide students with the opportunity to explore concepts through direct experience and inquiry.

However, traditional, teacher-centered learning environments often restrict students' opportunities to engage with the material in a deeper, more meaningful way. Such approaches can hinder the development of problem-solving skills, especially in Natural Sciences (IPA), where students should be able to relate their learning to real-world phenomena. Initial observations in class VII at MTsN 7 Bulukumba revealed that many students merely memorized content without truly understanding it and struggled to solve problems using a constructive approach.

Science education, particularly the topics of substances and their changes, necessitates an approach that prioritizes conceptual understanding. Students need to do more than memorize information; they must engage in critical thinking to understand and apply these concepts in real-life situations. Interviews with science teachers at MTsN 7 Bulukumba indicated that only 53% of students met the Minimum Completion Criteria (KKTM) for the subject of substances and their transformations.

One effective model for fostering critical thinking is the problem-based learning (PBL) approach. This model engages students in solving real-world problems that are relevant to their lives, stimulating critical thinking, analysis, and synthesis skills. According to Warsono (2012), PBL challenges students with complex problems that require them to think critically and collaborate with peers to devise solutions. Studies by Rizky et al. (2022) and Patmawati (2022) confirm that PBL positively impacts the development of critical thinking and academic performance across various subjects. This study, therefore, seeks to explore the

impact of PBL on enhancing critical thinking and science learning outcomes for seventh-grade students at MTsN 7 Bulukumba.

LITERATURE REVIEW

Critical Thinking Skills

Critical thinking skills refer to the ability to evaluate and analyze information in a methodical and rational manner, as well as the capacity to address problems by applying a deep understanding of the content. According to Simatupang et al. (2022), critical thinking involves analyzing, assessing, and applying information to create solutions to various challenges. This skill is essential in education, enabling students to make informed decisions and effectively solve problems.

Siahaan et al. (2022) argue that critical thinking skills are most effectively nurtured when the learning model adopted is rooted in constructivist principles. In such an approach, students are encouraged to independently explore and investigate knowledge through hands-on experiences, fostering deeper learning. Problem-Based Learning Model (PBL)

The problem-based learning (PBL) model is an educational strategy that centers on presenting students with real-world issues, motivating them to actively engage in finding solutions. Warsono (2012) emphasizes that PBL is particularly effective for developing critical thinking skills since it exposes students to situations that require thorough analysis and evaluation of information.

Studies, such as those by Rizky et al. (2022), demonstrate that PBL can enhance both critical thinking skills and academic performance, particularly in topics such as environmental change at SMAN 4 Malang. Similarly, Patmawati (2022) highlighted the positive impact of PBL on improving critical thinking and academic outcomes in biology at SMAN 10 Luwu Utara.

Natural Sciences (IPA)

Natural Sciences (IPA) is a subject that examines natural phenomena through scientific methods, including observation, experimentation, and data analysis. Agustini (2020) explains that IPA encompasses three core components: concepts, principles, and theories. Effective science education must include hands-on activities that foster the development of critical thinking and independent problem-solving abilities. Khusnah (2020) further elaborates that science education emphasizes critical thinking, curiosity, and environmental responsibility, all of which can be cultivated through active learning experiences. Therefore, methods like PBL are highly suitable for enhancing students' critical thinking skills in science education.

METHODOLOGY

This research adopts a quasi-experimental design, specifically a pretest-posttest control group design (Sugiyono, 2019). The study was conducted during the odd semester of the 2024/2025 academic year at MTsN 7 Bulukumba, located on Jalan Lotong - Lotong, Benjala Village, Bontobahari District, Bulukumba Regency.

The study population consisted of all seventh-grade students of MTsN 7 Bulukumba during the 2024/2025 academic year, totaling 79 students spread across three classes: VIIA, VIIB, and VIIC. Simple random sampling was employed to select the sample. From the three classes, two groups were randomly chosen, and then further randomized to determine the experimental and control groups. Following the randomization process, class VIIA was assigned as the experimental group with 27 students, while class VIIB was selected as the control group with 28 students.

This study includes two types of variables: independent and dependent variables. The independent variable is the problem-based learning (PBL) model, which was implemented with the seventh-grade students at MTsN 7 Bulukumba. The dependent variables are the critical thinking skills and the science learning outcomes of these students.

Data collection methods for this study involved administering tests on critical thinking skills, learning outcomes, and using implementation observation sheets. The data were analyzed through both descriptive and inferential statistics, followed by decision-making based on the research findings. The formulation of the statistical hypothesis is as follows:

H0: $\mu 1 \leq \mu 2$

H1: $\mu 1 > \mu 2$.

RESEARCH RESULT

Descriptive Statistical Analysis Results

The descriptive analysis of critical thinking skills was derived from the pretest and posttest scores, which were collected before and after implementing both the problem-based learning (PBL) model and the direct learning model. This analysis provides an overview of the changes in students' critical thinking abilities as a result of the two different teaching methods. The data from these assessments are summarized in Table 1 below.

Table 1 Descriptive of Students' Critical Thinking Skills

KBK Value Statistics	Experimental Group		Control Group	
	Pretest	*Posttest*	*Pretest*	*Posttest*
N	27	27	28	28
Range	30	30	25	40
Min	5	65	0	50
Max	35	95	25	90
Mean	20.93	82.59	13.04	73.04
Std dev	6.93	7.38	5.83	10.39

Table 1 demonstrates differences in the lowest, highest, average, and standard deviation values between the experimental and control groups, both before (pretest) and after (posttest) implementing the problem-based learning (PBL) model and the direct learning model, respectively. These descriptive statistics highlight the variation in critical thinking skills between the two groups over the course of the study. Following this, the data from Table 1 is further

categorized into frequency distributions and percentage categories, as shown in Table 2. This categorization allows for a more detailed breakdown of the students' performance levels and helps to better understand the impact of the two teaching methods on critical thinking skills.

Table 2 Frequency Distribution and Percentage of Critical Thinking Skills Categories

Interval	*Experimental Group*				*Control Group*				*Category*
	Pretest		*Posttest*		*Pretest*		*Posttest*		
	F	*%*	*F*	*%*	*F*	*%*	*F*	*%*	
84-100	0	0	14	51.9	0	0	4	14.3	Very high
67-83	0	0	12	44.4	0	0	16	57.1	Tall
50-66	0	0	1	3.7	0	0	8	28.6	Currently
33-49	1	3.7	0	0	0	0	0	0	Low
≤32	26	96.3	0	0	28	100	0	0	Very low
Total	27	100	27	100	28	100	28	100	

Based on Table 2, it is evident that the experimental group, which utilized the problem-based learning (PBL) model, demonstrated a higher percentage of improvement in critical thinking skills when compared to the control group, which received direct learning instruction. This reinforces the idea that PBL has a more significant positive effect on developing students' critical thinking abilities. Additionally, Table 3 presents detailed data on the scores for each indicator of the students' critical thinking skills. By examining this data, we can pinpoint which specific aspects of critical thinking—such as analysis, evaluation, or problem-solving—were most impacted by the two different teaching approaches. This can provide further insight into which areas of critical thinking were enhanced more effectively by PBL compared to direct learning.

Table 3. Total Score for Each Critical Thinking Skills Indicator

No.	**Critical Thinking Skills Indicators**	**Total Score**	
		Experimental Group	**Control Group**
1.	Analytical Ability	94	83
2.	Ability to Synthesize	86	77
3.	Problem solving skills	89	97
4.	Ability to Summarize	89	84
5.	Ability to evaluate	88	68

Table 3 reveals that in the experimental group, the highest score was achieved in the ability to analyze, while the ability to synthesize had the lowest score among the indicators of critical thinking skills. This suggests that the

problem-based learning (PBL) model had a stronger influence on students' analytical thinking but was less effective in enhancing their synthesizing skills. On the other hand, in the control group, the ability to solve problems received the highest score, indicating that the direct learning model may have been more effective in fostering problem-solving skills. However, the ability to evaluate scored the lowest, suggesting that direct learning was less effective in developing students' evaluative thinking. urthermore, when examining the science learning outcomes of students in both the experimental and control groups, Table 4 provides an overview of how students performed on the topic of substances and their changes at MTsN 7 Bulukumba. This data allows for a deeper understanding of how the two teaching methods PBL and direct learning affected the students' academic achievement in science.

Table 4. Descriptive Test of Student Learning Outcomes

Statistics	Experimental Group		Control Group	
	Pre	Posttest	Pretest	Posttest
Sample Size	27	27	28	28
Range	30	30	40	50
Minimum Score	5	70	0	45
Maximum Score	35	100	40	95
Mean	15.37	86.67	17.32	75.89
Standard Deviation	8.31	7.97	9.95	11.39

Table 4 highlights the differences between the lowest, highest, average, and standard deviation values for the experimental group and the control group, both before (pretest) and after (posttest) the implementation of the problem-based learning (PBL) model and the direct learning model, respectively. These values reflect how the students' science learning outcomes changed over the course of the study, offering a comparison between the two groups' performance. Following this, Table 5 presents the results of the learning outcome test, broken down by sub-material. This table will provide more specific insight into how well the students grasped particular aspects of the material on substances and their changes, further differentiating the effectiveness of the two teaching approaches.

Table 5 Average Score of Learning Outcome Test by Sub-Material

No.	Sub-Material	Experimental Group	Control Group
1.	Matter and Particle Model	24.5	23.8
2.	Changes in Matter	23	20.3

No.	Sub-Material	Experimental Group	Control Group
3.	Physical and Chemical Changes	17	17

Table 5 reveals that, for both the experimental and control groups, the sub-material on the state of matter and particle models yielded the highest average learning outcome test scores. This can be attributed to the fact that this material primarily focused on remembering (Level C1), which requires students to recall basic facts and concepts. Since the content was more straightforward and did not involve higher-order thinking skills, both the experimental group (which used the problem-based learning model) and the control group (which used direct learning) were able to achieve higher scores in this area. This result suggests that while the problem-based learning (PBL) model is effective in fostering critical thinking skills, the students were still able to perform well in material that emphasized basic memorization. However, it is important to note that this sub-material did not fully challenge the students' critical thinking abilities, as it focused more on recall than on analysis or synthesis.

Inferential Statistical Analysis Results

The purpose of inferential statistics in this study is to test the research hypotheses, which requires performing parametric statistical prerequisite tests before conducting the hypothesis tests. The prerequisite tests include normality tests and homogeneity tests. To assess the normality of the data, the Shapiro-Wilk test was employed using SPSS 26 for Windows. This test helps determine whether the data follows a normal distribution. The decision rule for this test is based on the significance value: if the significance value is greater than the alpha level of 5% (0.05), the data is considered to be normally distributed. The results of the normality test for students' critical thinking skills are presented in Table 6, which provides a clear indication of whether the data meets the assumption of normality required for further statistical analysis.

Table 6. Normality Test Results

Data	Experimental Group		Control Group	
	Sig.	Conclusion	Sig.	Conclusion
Critical Thinking Skills	0.199	Normal	0.165	Normal
Learning outcomes	0.069 years	Normal	0.252	Normal

Based on the data presented in Table 6, it can be concluded that both the experimental group and the control group have normally distributed data. This conclusion is drawn from the fact that the significance values for the Shapiro-Wilk normality test for both groups are greater than the alpha level of 5% (sig. $\alpha = 0.05$). Since the p-values (significance values) exceed 0.05, we accept the null hypothesis, which states that the data is normally distributed.

The homogeneity test is conducted to determine whether the two groups, the experimental group and the control group, come from populations with the same variance (homogeneous). This test is a prerequisite before performing an independent sample t-test. The decision rule for this test is that if the significance value is greater than 0.05, the data distribution is considered homogeneous, meaning that the variances of the two groups are similar. If the significance value is less than 0.05, the data distribution is not homogeneous, indicating a significant difference in variance between the two groups. This homogeneity test is carried out using the Levene test, which examines the equality of variances between the experimental and control groups. Once the assumption of homogeneity is met, an independent sample t-test can be conducted to compare the means of the two groups.

Table 7 Homogeneity Test Results

Data	Important Values	Explanation
Critical Thinking Skills	0.065 years	Homogeneous
Learning outcomes	0.097 years	Homogeneous

Based on the data in Table 7, it can be concluded that the significance value is greater than 0.05, indicating that the data comes from a homogeneous population. Since the prerequisite tests for normality and homogeneity have been met, the next step is data analysis for hypothesis testing. Hypothesis testing is conducted to statistically test the validity of a statement and to draw conclusions on whether to accept or reject the hypothesis. In this study, the data analysis technique used is parametric inferential statistics, specifically the independent sample t-test, performed using the SPSS 26 for Windows program. The t-test is used to determine whether there are significant differences in critical thinking skills and learning outcomes between the experimental and control groups. The decision rule for hypothesis testing is as follows: if the significance value (sig) is less than alpha (0.05), then H1 (the alternative hypothesis) is accepted, indicating a significant difference. If the significance value is greater than or equal to 0.05, then H0 (the null hypothesis) is accepted, suggesting no significant difference. The results of this test can be seen in Table 8.

Table 8 Results of the t-Independent Sample Test

Variables	Sig. (2-tails)
Critical Thinking Skills	0.000
Learning outcomes	0.000

Table 8 shows that the significance value (2-tailed) for critical thinking skills and learning outcomes is 0.000. Since the 2-tailed significance value is 0.000, the 1-tailed value would also be 0.000 (half of the 2-tailed value). Given that the significance value is less than 0.05, the null hypothesis (H0) is rejected and the alternative hypothesis (H1) is accepted. This indicates that there is a statistically

significant difference between the groups. The results suggest that the average scores of the experimental group, which implemented the problem-based learning (PBL) model, are higher than those of the control group, which applied the direct learning model. Therefore, it can be concluded that the application of the problem-based learning model has a positive influence on enhancing critical thinking skills and learning outcomes in the Natural Sciences (IPA) subject at MTsN 7 Bulukumba

DISCUSSION

Critical thinking skills are essential in the learning process, particularly for enhancing students' analytical, synthesis, problem-solving, conclusion-drawing, and evaluative skills regarding concepts or phenomena. The problem-based learning (PBL) model has proven to be an effective approach for developing these critical thinking abilities.

In a study conducted at MTsN 7 Bulukumba with seventh-grade students, the application of the PBL model resulted in a significant improvement in students' critical thinking skills. The posttest scores indicated that students were better able to analyze, synthesize, solve problems, draw conclusions, and evaluate information. The average N-Gain Score for the experimental group was classified as very high, confirming the effectiveness of the PBL model. Among the five indicators of critical thinking skills, the ability to analyze was the most prominent for the experimental group. PBL encourages students to think critically by guiding them through learning stages focused on solving real-world problems.

The direct learning model, on the other hand, is a teacher-centered approach where information is delivered through explanations, demonstrations, and guided exercises. Based on the average N-Gain Score, critical thinking skills in the direct learning model were categorized as high. Among the five critical thinking indicators, problem-solving skills were most prominent in the control group.

In terms of learning outcomes, the experimental group showed the following results: the highest score was 100, the lowest was 70, with most students scoring between 80-95. The average N-Gain Score for the experimental group’s learning outcomes was 0.8, categorizing them as very high. In terms of the sub-material questions, the "state of matter and particle models" sub-material had the highest scores. This sub-material was based on level C1 (remembering), where students were primarily required to recall and recognize the concepts. These results indicate that problem-based learning significantly improves students' learning outcomes. Through problem exploration, discussions, and independent investigations, students not only gain theoretical knowledge but also apply it in problem-solving situations.

The control group, which used the direct learning model, had the following learning outcomes: the highest score was 95, the lowest was 45, and the average N-Gain Score was 0.7, classifying the outcomes as high. Most students answered questions at level C1, which focuses on remembering and understanding the concepts taught.

When comparing the average N-Gain scores of both groups, the experimental group outperformed the control group. This suggests that the problem-based learning model is more effective in improving students' learning outcomes. Therefore, it can be concluded that the PBL model positively impacts students' learning outcomes in the Natural Sciences subject at MTsN 7 Bulukumba.

The research findings, supported by the significance value (Sig. 1-tailed) of 0.000 for the critical thinking skills variable, indicate a significant relationship between the application of the PBL model and the improvement of students' critical thinking skills. This small significance value suggests a strong connection between the independent variable (PBL) and the dependent variable (critical thinking skills).

Inferential test results also showed that the significance value (1-tailed) for the learning outcome variable was less than 0.05, confirming the hypothesis and indicating a positive effect of the PBL model on students' learning outcomes. Additionally, there was a significant difference in learning outcomes between the experimental group (PBL) and the control group (direct learning).

From the descriptive statistical analysis, it is evident that the PBL model produced better results compared to direct learning. This is because direct learning remains teacher-centered, which may lead to lower student engagement and understanding of the material. In conclusion, the application of the problem-based learning model positively influenced students' learning outcomes in the material of substances and their changes at MTsN 7 Bulukumba.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Based on the data analysis and discussion of the research conducted at MTsN 7 Bulukumba, the following conclusions can be drawn:

1. Critical Thinking Skills with Problem-Based Learning (PBL): The critical thinking skills of class VII students at MTsN 7 Bulukumba, when taught using the problem-based learning model, are classified in the very high category.
2. Critical Thinking Skills with Direct Learning: The critical thinking skills of class VII students at MTsN 7 Bulukumba, when taught using the direct learning model, are categorized as high.
3. Learning Outcomes with Problem-Based Learning: The learning outcomes of class VII students at MTsN 7 Bulukumba, using the problem-based learning model, are classified in the very high category.
4. Learning Outcomes with Direct Learning: The learning outcomes of class VII students at MTsN 7 Bulukumba, when taught using the direct learning model, are classified as high.
5. Influence of PBL on Critical Thinking Skills: There is a significant influence of the application of the problem-based learning model on students' critical thinking skills in the natural science subject (specifically the material on matter and its changes) for class VII students at MTsN 7 Bulukumba.
6. Influence of PBL on Learning Outcomes: The application of the problem-based learning model also significantly influences student learning outcomes in natural science subjects for class VII students at MTsN 7 Bulukumba.

These findings suggest that the problem-based learning model is more effective in enhancing both critical thinking skills and learning outcomes compared to the direct learning model in the context of natural science education at MTsN 7 Bulukumba.

Recommendation

1. Problem-Based Learning as an Alternative Model: The problem-based learning (PBL) model can be an effective alternative teaching strategy for teachers aiming to enhance students' critical thinking skills and improve their learning outcomes. By focusing on real-world problems and encouraging active student participation, PBL fosters deeper understanding, analytical thinking, and problem-solving abilities, which are essential for students' academic and personal growth.
2. Effective Time Management in PBL Implementation: When implementing the problem-based learning model, it is crucial for teachers to organize and manage time effectively. Proper time management ensures that the teaching and learning process is conducted smoothly, allowing adequate time for problem exploration, student discussions, and reflection. Efficient time management will also ensure that students can fully engage with the learning material and complete their tasks effectively, ultimately leading to better learning outcomes and a more meaningful educational experience.

ADVANCED RESEARCH

Every study has its limitations, and this research is no exception. The primary limitation of this study lies in the sample size, which was restricted to grade VII students at MTsN 7 Bulukumba. As a result, the findings cannot be generalized to the entire population of students from other schools or educational levels. Additionally, the study's duration of one semester limited the ability to observe the long-term effects of the problem-based learning (PBL) model on critical thinking skills and learning outcomes.

External factors, such as the students' psychological conditions and the level of social support they received, were not fully controlled or accounted for, which could have influenced the outcomes. Given these limitations, it is recommended that future research involve larger and more diverse samples to enhance the generalizability of the findings. Furthermore, extending the study duration would allow for a more comprehensive understanding of the long-term effects of PBL. Future studies should also consider other external factors and variables, such as learning motivation, which may have an impact on the results. Lastly, employing a qualitative approach in future research could provide a deeper understanding of students' experiences and perceptions during the problem-based learning process, offering valuable insights into how this model can be further optimized.

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