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The Effect of Problem-Based Learning Models on Students' Science Process Skills and Critical Thinking Skills SDN 10 Sidomulio Sei Balai Regency Batu Bara

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Abstract

The study aims to analyze the differences in the influence of problem-based learning models with conventional learning on students' science process skills, analyze the differences in the influence of problem-based learning models with conventional learning on students' critical thinking skills, analyze the interaction between learning and students' initial abilities on students' science process skills, and analyze the interaction between learning and students' initial abilities on students' critical thinking skills at SD Negeri 10 Sidomulio Sei Balai, Batu Bara Regency. The research method is an experiment with a 2x3 ANOVA design. The study population was fourth-grade students at SD Negeri 10 Sidomulio Sei Balai, Batu Bara Regency. The research sample was determined using a cluster random sampling technique so that a sample of 56 students was obtained. Data collection techniques were tests and non-tests. The instruments used were tests of students' science process skills and critical thinking skills in science. The data analysis technique was ANOVA (Analysis of Variance) by comparing the learning outcomes of students in each class. The results of the study concluded that there were differences in students' science process skills using the PBL learning model with students' science process skills using conventional learning. There were differences in students' critical thinking skills using the PBL learning model with students' critical thinking skills using conventional learning. There is an interaction between learning and prior abilities on students' science process skills. There is an interaction between learning and prior abilities on students' critical thinking skills.

***Keywords**: PBL Model, Science Process Skills and Critical Thinking Ability*

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Latar Belakang Penelitian

Natural Science (IPA) learning in schools aims to introduce students to basic concepts about the universe, life, and the processes that occur around them. Through IPA, students are encouraged to think critically, analytically, and systematically in solving problems, and to develop a strong curiosity about natural phenomena. Science material in schools covers a variety of topics, such as physics, chemistry, biology, and geoscience, all designed to build students' understanding of how nature works (Kusuma, 2022).

IPA learning plays a crucial role in fostering curiosity (Falah, 2019). Through exploration of various natural phenomena, experiments, and scientific discoveries, students are encouraged to dig deeper and ask questions about how and why things happen. This process not only encourages them to seek answers but also develops critical and creative thinking skills. When students directly witness the results of experiments or understand natural principles, their curiosity is further piqued, encouraging them to continue learning and discovering new things (Cantona & Sudarma, 2020).

IPA learning is closely related to systematic inquiry about nature, which involves not only the collection of facts, concepts, or principles, but also a process of discovery. In science learning, students are encouraged to understand the scientific way of exploring the world around them, from formulating questions, proposing hypotheses, conducting experiments, to analyzing the results (Arwinda & Sufraini, 2025). This process fosters critical thinking and objectivity, and teaches the importance of evidence in drawing conclusions.

Science instruction emphasizes discovery as the core of the learning process. This approach encourages students to actively explore and explore various natural phenomena through experiments, observations, and problem-solving. Rather than simply memorizing information, students are encouraged to discover scientific concepts and principles themselves in a systematic, evidence-based manner (Boling et al., 2024). Through experiments and research, students learn to ask questions, formulate hypotheses, collect data, and draw conclusions based on their results. Thus, science learning focuses not only on transferring knowledge but also on developing scientific skills and new discoveries, as well as a deeper understanding of the world around them (Winarko, 2017:121).

Students' scientific process skills will significantly support their understanding and mastery of science material. These skills include the ability to observe, formulate questions, design experiments, analyze data, and draw conclusions based on the evidence found (Judiani, 2010). By developing these skills, students not only gain theoretical knowledge but also understand scientific methods for solving problems and explaining natural phenomena (Varadela et al., 2018:84).

Science process skills offer an expansion in the world of education because they can combine learning with more interactive and fun approaches, such as through games. By integrating game elements into science learning, students are not only actively engaged in learning activities but also experience a more engaging and motivating learning experience. For example, through educational games involving simple experiments, problem-solving, or simulations, students can hone their observation, analysis, and decision-making skills while remaining entertained. (Erina et al., 2018:203)

Science learning also requires advanced thinking skills, both critical and analytical. In the science learning process, students are not only required to memorize facts and concepts, but also to understand how natural phenomena occur, why they occur, and what the consequences are. Critical thinking skills are essential for analyzing data, identifying patterns, and evaluating experimental results.

Furthermore, analytical thinking skills enable students to systematically break down problems, seek cause-and-effect relationships, and draw logical conclusions. With strong thinking skills, students can more easily understand scientific principles, apply them to various situations, and develop creative and effective problem-solving skills (Halim, 2022). Therefore, science learning aims not only to teach scientific material but also to train thinking skills that will be highly useful in their daily lives and future.

Thinking skills are essential skills for analyzing ideas specifically, distinguishing them sharply, identifying problems, examining various perspectives, and developing them toward greater perfection. This ability enables a person to not only accept information raw but also to think deeply and critically about existing ideas or concepts (Wijaya, 2018:72).

Critical thinking skills support conceptual mastery, problem-solving, and the association of various science concepts with phenomena occurring in the natural world (Kharisma & Arvianto, 2019). Through critical thinking, students can analyze and evaluate information more deeply, enabling them to understand scientific principles in a more holistic manner. This ability helps students not only memorize theory but also connect the science concepts they learn to everyday events, such as weather changes, natural processes, or ecosystem interactions. Critical thinking enables students to identify existing problems (Rohmah et al., 2017:222).

Science learning plays a crucial role in improving students' science process skills and critical thinking abilities. Through science learning, students are trained to observe, formulate questions, design experiments, and analyze data systematically. These science process skills not only help them understand scientific concepts but also encourage them to think critically when dealing with various natural phenomena (Syafi'ah et al., 2022).

Learning requires an effective learning model to achieve the desired educational goals. The learning model serves as a guideline or strategy that teachers can use to deliver material in a structured, engaging, and easily understood manner for students (Sundari, 2017). The right learning model can create an active, interactive, and enjoyable learning environment, thereby increasing students' motivation and interest in participating in the learning process.

The classroom atmosphere needs to be planned and constructed in such a way, using appropriate learning models, so that the teaching and learning process can be effective and enjoyable. By designing a conducive classroom atmosphere, students will feel comfortable and motivated to actively participate in learning (Sari & Rosidah, 2023). The applied learning model can create dynamic interactions between teachers and students, as well as among students. By planning a supportive classroom atmosphere and selecting an appropriate learning model, teachers can maximize students' potential for active learning (Heatami et al., 2017:110).

Based on a preliminary study of learning implementation at SDN 10 Sidomulio Sei Balai, Batu Bara Regency, it was found that during the implementation of learning, teachers often paid little attention to the learning model used, which can impact the effectiveness of the teaching and learning process. Without selecting the right model, students may feel bored, disinterested, or have difficulty understanding the material being presented. Teachers who do not adapt learning models that are appropriate to the characteristics of the material and students' needs risk hindering the development of critical thinking skills, creativity, and collaboration (Sundari, 2017). For example, if the learning model used is too monotonous or does not actively engage students, this can reduce student participation and lower their motivation to learn.

Teachers who solely use the lecture method in learning tend to limit student interaction and active participation. While this method can be effective for conveying information concisely and directly, if used continuously, students may feel passive and less engaged in the learning process (Putra, 2017). The lecture method often does not provide opportunities for students to explore deeper understanding, ask questions, or discuss. This can impact the development of critical thinking skills and their ability to connect the material being studied to real-world phenomena. It is important for teachers to combine the lecture method with other approaches, such as group discussions, experiments, or project-based learning.

The lecture method is a form of presenting teaching material through explanation and oral narration by the teacher to students. In this method, the teacher acts as the primary source of information, delivering the material directly, often using verbal explanations to introduce specific concepts or theories. While effective for imparting knowledge quickly and to a large number of students, the lecture method tends to be one-way, with limited interaction between the teacher and students (Roestiyah, 2018:27).

Using the lecture method certainly tends to make students less creative, because learning dominated by verbal explanations from the teacher often leaves students passive. In this method, students primarily receive information directly without the opportunity to explore their own ideas or actively participate in the learning process (Helmi, 2016). This can reduce students' opportunities for critical thinking, developing their imagination, or innovating in understanding the material. Furthermore, reliance on lectures can also make the classroom atmosphere feel monotonous and unengaging, ultimately inhibiting students' interest in learning more deeply.

The lecture method tends to be verbal and less stimulating for students' creativity and critical thinking. In this approach, information is delivered orally by the teacher, often in the form of lengthy explanations that focus more on conveying facts or theories, without allowing students to explore deeper understanding. This can lead students to listen more without truly engaging.

As a result, the lecture method is often ineffective in stimulating students' curiosity, critical thinking skills, or imagination, which are crucial for their creative development. Therefore, although the lecture method has the advantage of directly conveying information, it is important for teachers to combine it with other, more interactive methods that enable students to think actively and creatively.

This lecture method has also been shown to impact students' abilities, including their science process skills and critical thinking skills. When learning focuses more on the verbal delivery of information without actively engaging students, opportunities for them to develop skills such as observation, analysis, experimentation, and problem-solving are limited. Students tend to passively receive material, without directly engaging in the process of discovery or testing scientific concepts. This reduces students' critical thinking skills because they are not encouraged to analyze, question, or formulate solutions to the problems they face.

It's time for teachers to use appropriate learning models during classroom instruction to make the teaching and learning process more effective and engaging. The right learning model can be tailored to student characteristics, the material being taught, and the desired learning objectives. By choosing interactive models, such as project-based learning, group discussions, or cooperative learning, teachers can encourage students to actively participate, think critically, and develop social skills. A variety of learning models helps students understand the material more deeply and apply it, enabling them to connect their knowledge.

Method

This study used a quasi-experimental method with an ANOVA design and was conducted in the 2022/2023 academic year. The purpose of this study was to compare the effect of implementing a problem-based learning model on students' science process skills and critical thinking abilities. In this study, each group was given a different treatment. The experimental class consisted of students taught using the problem-based learning model, while the control class consisted of students taught using conventional learning methods. The research design used a pretest-posttest with two control classes.

The population in this study were fourth-grade students at SD Negeri 10 Sidomulio, Sei Balai, Batu Bara Regency. The total number of students at the elementary school was 82, divided into three classes. The sample in this study was selected purposively, namely by selecting classes deemed representative of the population relevant to the research objectives. In this study, the sample consisted of two classes: the experimental class and the control class. The experimental class was treated with the problem-based learning model, while the control class was treated with conventional learning methods. Sample selection was based on certain criteria, such as students' initial abilities, which included high, medium, and low categories. This is done to ensure that the sample taken can provide representative data and support the success of the analysis in this study.

In data analysis, there are two types of statistical techniques frequently used: descriptive statistics and inferential statistics. Descriptive statistics are used to describe or summarize existing data in a simpler, more easily understood form. This technique includes calculating measures of central tendency such as the mean, median, and mode, as well as measures of dispersion such as the range, variance, and standard deviation. Descriptive statistics provide a general overview of the data obtained but cannot be used to draw broader conclusions.

Inferential statistics are used to make conclusions or predictions about a population based on a sample drawn from that population. This technique involves the use of hypothesis testing, regression analysis, and parameter estimation to examine relationships between variables or to estimate values that cannot be directly observed. Inferential statistics allow researchers to draw broader conclusions and generalize from the sample to the population as a whole, taking into account the level of error or uncertainty in the results obtained. These two types of statistical techniques are complementary and important in various fields of research and decision-making..

Result and Discussion

1. **Students' Science Process Skills**

The results of the 2x3 ANOVA test calculations on students' science process skills data are presented in Table 1 below.:

Table 1 Results of ANOVA Test of Science Process Skills

Tests of Between-Subjects Effects

Dependent Variable: Science Process Ability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3907.857[a]	5	781.571	11.016	.000
Intercept	219572.435	1	219572.435	3.09503	.000
Model	965.551	1	965.551	13.609	.001
KAM	1413.124	2	706.562	9.959	.000
Model * KAM	955.887	2	477.943	6.736	.003
Error	3547.500	50	70.950		
Total	309100.000	56			
Corrected Total	7455.357	55			

a. R Squared = ,524 (Adjusted R Squared = ,477)

Based on Table 1, the following explanations can be presented:

a) The Corrected Model showed a calculated sig. 0.000 <0.05, indicating that the learning model used had an effect on students' science process skills. Therefore, it can be concluded that the results of this study, related to the model, are valid.

b) The intercept is the student's score on the value variable that contributes to the score itself without being influenced by the independent variable. This means that changes in the value of the dependent variable are not affected by the independent variable. Based on the calculated sig. 0.000 <0.05, this intercept contributes significantly.

c) The PBL learning model has an effect on students' science process skills, as evidenced by the calculated sig. 0.001 <0.05.

d) There is an interaction between the learning model and prior ability on students' science process skills, as evidenced by the calculated sig. 0.003 <0.05.

2. Students' Critical Thinking Skills

The results of the 2x3 ANOVA test calculations on students' critical thinking ability data are presented in Table 2 below.

Tests of Between-Subjects Effects

Dependent Variable: Critical Thinking

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3473.263[a]	5	694.653	11.482	.000
Intercept	228570.380	1	228570.380	3.77803	.000
Model	1217.739	1	1217.739	20.128	.000
KAM	596.642	2	298.321	4.931	.011
Model * KAM	1321.902	2	660.951	10.925	.000
Error	3024.951	50	60.499		
Total	302300.000	56			
Corrected Total	6498.214	55			

a. R Squared = ,534 (Adjusted R Squared = ,488)

Based on Table 2, the following explanation can be put forward:

a) The Corrected Model showed a sig. 0.000 <0.05, indicating that the learning model used had an effect on students' critical thinking skills. Therefore, it can be concluded that the results of this study, related to the model, are valid.

b) b) The intercept is the student's score on the value variable that contributes to the score itself without being influenced by the independent variable. This means that changes in the value of the dependent variable are not affected by the independent variable. Based on the sig. 0.000 <0.05, the intercept contributes significantly.

c) c) The PBL learning model has an effect on students' critical thinking skills, as evidenced by the calculated value of 0.000 <0.05.

There is an interaction between the learning model and initial ability on students' critical thinking skills, as evidenced by the calculated value of 0.000 <0.05.

Discussion

The results of the study showed a significant difference between the science process skills of students who used the PBL learning model and those who used conventional learning. The average science process skill score of students who used the PBL learning model was 78.39, while students who used conventional learning only obtained an average score of 68.39. This difference indicates that the problem-based learning model is more effective in improving students' science process skills. This model allows students to be more involved in learning activities based on solving real problems, which in turn stimulates their critical and analytical thinking skills. In addition, this model also provides space for students to develop practical skills, such as observation, experimentation, and scientific communication, all of which are important components of science process skills. Student involvement in this contextual and collaborative learning process allows them to better understand scientific concepts in a more in-depth and applicable way.

Demikian pula, terdapat perbedaan yang There was a significant difference in critical thinking skills between students using the PBL learning model and those using conventional learning. Students using the PBL learning model achieved an average score of 81.43, while students using conventional learning achieved an average score of 65.71. These results confirm that the problem-based learning model has a greater impact on the development of students' critical thinking skills. PBL requires students to think analytically and creatively in solving given problems, which directly trains their critical thinking skills. This model also encourages students to explore various solutions to a problem, develop rational arguments, and evaluate various relevant information, which are the core of critical thinking. This process not only helps students understand the subject matter in depth but also prepares them to face more complex challenges outside the classroom.

The ANOVA test results also showed a significant interaction between the learning model and students' initial abilities on science process skills. A significance value of 0.003 ($p < 0.05$) indicates that students' initial abilities influence the extent to which the PBL learning model can improve their science process skills. Students with better prior abilities tend to be more receptive to the PBL learning model, enabling them to develop science process skills more effectively. Conversely, students with lower prior abilities may require a more in-depth and differentiated approach to implementing the PBL model to maximize its benefits. This interaction highlights the importance of tailoring the learning model to students' prior abilities to achieve better outcomes in learning science process skills. Therefore, instruction tailored to students' abilities will have a greater impact on the development of these skills.

Furthermore, this study also revealed a significant interaction between the learning model and students' prior abilities on critical thinking skills. The ANOVA test results showed a significance value of 0.000 ($p < 0.05$), indicating that students' prior abilities play a significant role in the influence of the PBL learning model on their critical thinking skills. Students with higher prior abilities tend to develop their critical thinking skills more quickly when the PBL model is implemented, which requires them to think more analytically and creatively. Conversely, students with lower prior abilities may require more time and guidance to effectively follow the dynamics of PBL learning. This interaction suggests that although the problem-based learning model is very effective in stimulating critical thinking skills, its successful implementation is highly dependent on the students' prior abilities. Therefore, it is important for teachers to consider students' prior abilities and adapt learning strategies so that all students, regardless of their ability level, can optimize the learning process and develop their critical thinking skills to the fullest.

These research results confirm the importance of the problem-based learning (PBL) model in improving students' science process skills and critical thinking abilities. In addition, the interaction between the learning model and students' initial abilities provides additional insight that the success of a learning model is highly dependent on the students' initial conditions, so that learning strategies that are more personalized and tailored to students' needs will have a significant impact on improving learning outcomes.

Conclusion

Based on the analysis and findings obtained, several conclusions can be drawn regarding the problem-based learning (PBL) model and conventional learning, as well as their impact on students' science process skills and critical thinking abilities. First, there was a significant difference in the science process skills of students using the PBL model (average 78.39) compared to conventional learning (average 68.39). Second, the PBL model also had a positive impact on students' critical thinking abilities, with an average score of 81.43, while conventional learning only had a score of 65.71. Furthermore, the analysis showed a significant interaction between the learning model and students' initial abilities in influencing science process skills, with a significance value of 0.003 ($p < 0.05$). The same was true for students' critical thinking abilities, with a significance value of 0.000 ($p < 0.05$). These findings indicate that students' initial ability level plays a significant role in the effectiveness of the learning model in improving both aspects, indicating the need for an approach tailored to students' abilities to achieve optimal results..

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