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Problem Based Learning Effect Using the TaRL Approach on Problem-Solving Skills in Global Warming Topic

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Abstract. Physics learning is often considered difficult because students are unable to relate concepts to real-world problems they encounter. This condition results in low problem-solving skills among students, especially on contextual topics such as global warming. This study aims to determine the effect of the Problem Based Learning (PBL) model with the Teaching at the Right Level (TaRL) approach on students' problem-solving skills in global warming material. The research method used was quantitative with a quasi-experimental design of the pretest-posttest control group type. The research subjects consisted of 64 tenth-grade students at SMA Negeri 87 Jakarta, divided into an experimental class using the PBL-TaRL model and a control class using scientific learning. The research instrument was an essay test of problem-solving skills based on Polya's stages. The results showed that the average posttest score of the experimental class was higher than that of the control class. Based on the Ngain results, the N-gain was 0.58 (medium category) for the experimental group compared to 0.29 (low category) for the control group. Thus, the Problem Based Learning (PBL) model with the Teaching at the Right Level (TaRL) approach had a significant effect on students' problem-solving skills in global warming material.

Keywords: problem based learning, teaching at the right level, problem solving

1. Introduction

The dynamics of the 21st century demand a paradigm shift in education, especially regarding the development of Higher Order Thinking Skills (HOTS) [1]. These skills, which are essential for overcoming obstacles in the real world, include critical thinking, problem solving, communication, and teamwork [2]. Global warming is a topic that requires deep conceptual understanding and the ability to analyze and solve complex multidisciplinary problems, which has practical consequences in the context of science education, especially physics [3]. However, findings from several studies indicate that students' problem-solving skills in the context of global warming content are still relatively weak.

Preliminary observations conducted at a public high school in Jakarta show that the majority of students still experience significant difficulties when trying to solve real-world problems related to global warming. This is reinforced by the findings [4] and [5], which state that the scientific learning approach causes students to be less actively involved, unaccustomed to thinking systematically, and unable to relate the material to real-world problems around them. When teachers are the center of learning (teacher-centered), students tend to be passive and are not given the space to build knowledge independently.

To overcome these weaknesses, various innovative learning methods have been developed and tested by previous researchers. The Problem-Based Learning (PBL) model has emerged as one of the main solutions that prioritizes the role of students in overcoming these difficulties. PBL uses contextual problems as a means to stimulate students to be active in learning, including the process of topic analysis, group discussion, and reflection [6]. Many studies show that problem-solving skills can be significantly improved through the PBL method. For example, [7] found a significant improvement in biology students' abilities after the implementation of PBL. Additionally, [8] reported that the application of PBL in a heat-resistant house design project improved students' analytical skills related to global warming issues. Similar findings were also reported by [9], which showed that the PBL model in science education provides students with the problem-solving skills necessary to face current challenges.

However, the PBL model presents challenges for students with relatively low abilities. Students often face difficulties in problem-based learning due to a lack of basic knowledge and underdeveloped cognitive strategies [10]. Thus, it is essential to implement learning techniques that are aligned with students' actual skills. One effective method is Teaching at the Right Level (TaRL), introduced by the Pratham Education Foundation. TaRL has been shown to be effective in grouping students based on their level of understanding, allowing for the adjustment of learning to individual needs[11].

The integration of the PBL model with the TaRL approach has been shown to facilitate effective and inclusive learning [12]. Several previous studies have demonstrated the impact of this combination [13] concluded that the integration of PBL and TaRL improved problem-solving skills in mathematics among elementary school students. [14] also found a positive effect on high school students' mathematics skills, particularly in matrix material. In the context of physics learning, [15] showed that the integration of PBL with TaRL in momentum and impulse material significantly improved problem-solving skills. However, research specifically focusing on the integration of PBL and TaRL in physics education related to global warming is still limited.

The TaRL approach is also in line with the principles of the National Curriculum, which prioritizes differentiated and student-centered education to improve learning [16]. Studies [17] serta [18] highlight that TaRL effectively addresses student heterogeneity in the classroom through flexible grouping and the provision of materials appropriate to students' developmental levels.

The theories underlying this research include PBL as a constructivist method that promotes active learning through real-world problem solving [19], and TaRL as a differentiation strategy that focuses on adjusting instructional levels to maximize learning achievement [10]. The integration of the two is based on adaptive learning theory, which emphasizes personalization to address variations in student abilities [11], thereby supporting the development of HOTS in the context of global issues such as global warming.

Based on this description, it is important to conduct research that focuses on the application of the Problem-Based Learning (PBL) model with the Teaching at the Right Level (TaRL) approach in teaching Global Warming material in class X at SMA Negeri 87 Jakarta. Through the integration of these two approaches, students are expected to gain challenging learning experiences that are appropriate to their ability levels, so that they can develop problem-solving skills in a gradual and focused manner. This study specifically aims to analyze the effect of applying the PBL model with the TaRL approach on students' problem-solving abilities, which are measured based on Polya's stages, namely understanding the problem, planning the solution, implementing the solution, and reviewing the results. Thus, the results of this study are expected to contribute to the development of more innovative and responsive learning strategies in improving students' critical thinking and problem-solving abilities on contextual issues such as global warming.

2. Method

This study adopted a quantitative approach to test the variables under study. The research design used was a specific quasi-experiment, namely a pretest-posttest control group design. In the initial stage, both groups took a pretest to measure their initial abilities. The treatment was given to the experimental group, while the control group did not receive the treatment. In the next stage, all groups took a final test (posttest) to measure the changes. The test was conducted in two stages, namely a pretest and a posttest. The pretest served to assess students' initial abilities before they underwent the learning process, while the posttest aimed to evaluate students' progress or changes in ability after participating in the learning process. The implementation of these two tests enabled researchers to compare students' learning outcomes quantitatively and assess the impact of the learning model applied.

The research was conducted at SMAN 87 South Jakarta in the second semester of the 2024/2025 academic year. All grade X students were included in the research population. Using the pretest results as a reference, sampling was conducted purposively. Two classes with the most comparable average scores were selected, namely class 10.G as the experimental group and class 10.A as the control group, each with 32 students. Data were collected using an essay test instrument designed according to Polya's problem-solving stages, with four indicators showing problem-solving abilities: (1) understanding the problem, (2) planning the solution, (3) implementing the plan, and (4) reviewing. Assessment was conducted using a four-point rubric, with a score of 0–3 points for each indicator, resulting in a maximum score of 12 points per question. The use of a rubric is very important in evaluating student learning outcomes objectively and accurately [20].

The instrument used for the research consisted of eight questions that had undergone a series of feasibility tests, including empirical validity, reliability, and content validity. The empirical validity test results showed that all questions had a very high Pearson Correlation value, ranging from 0.934 to 0.991 with a significance of <0.001, so all questions were considered valid. Furthermore, the reliability test produced a coefficient of 0.99, which is classified as very high, indicating that the instrument has strong consistency and stability for use in repeated measurements. Of the total 50 students who participated in the trial, all questions were declared valid according to the indicators measured. The instrument was also tested for content validity involving 8 experts, namely 5 lecturers and 3 high school physics teachers. The assessment from expert lecturers showed that all aspects (material, construct, and language) received a perfect CVI score of 1.00 in the "highly appropriate" category. Meanwhile, the high school teachers' assessment placed the material aspect with a CVI score of 0.94 (category "suitable") and the construct and language aspects with a score of 1.00 (category "very suitable"). Overall, the results of this test prove that the instrument is relevant to the competencies being measured, is structured in a coherent and systematic manner, and uses language that is easy for students to understand, making it suitable for use in research.

Table 1. Problem based learning activities.

PBL Syntax	PBL-Based Learning Activities
Problem Orientation	The teacher begins the lesson by showing a video of a contextual phenomenon related to global warming to attract students' attention and relate the material to real events. Next, a diagnostic assessment is conducted to identify students' level of understanding, which is then used as the basis for grouping according to ability level (TaRL) so that learning takes place according to students' learning abilities.
Organizing Students for Learning	Teachers form learning groups based on the results of the diagnostic assessment using the TaRL approach. Next, teachers distribute Student Worksheets (LKPD) tailored to the ability level of each group. Students at the basic level focus on understanding the basic concepts of global warming, while the advanced level group is directed to analyze the issue in depth and develop innovative and applicable solutions.
Guiding Independent Inquiry and Groups	Teachers guide students according to their ability levels. Basic level groups receive step-by-step guidance using cause-and-effect diagrams, while advanced level groups explore data and analyze independently. During the investigation, teachers ask trigger questions to stimulate problem solving and deepen conceptual understanding.
Developing and Presenting Work	After the investigation, each group compiles their findings in the form of a report or poster. Basic level groups demonstrate their understanding through concept maps, while advanced level groups present more complex results such as graphs or simulations. Presentations. are conducted in turns to facilitate cross-group learning through discussion and mutual feedback.
Analyzing and evaluates process Problem-solving problems	At the final stage, the teacher provides reflection to review strategies problem-solving strategies and learning experiences. This activity helps students recognize the development of their thinking skills and areas that need improvement. Teachers then provide feedback differentiated according to TaRL level: concept reinforcement for basic level and enrichment and new challenges for advanced level.

The application of the Problem-Based Learning (PBL) model integrated with the Teaching at the Right Level (TaRL) approach in this study was designed so that the learning process not only focused on contextual problem solving but also adjusted to the students' ability levels. Each stage of PBL is implemented through activities that guide students to understand, plan, implement, and reflect on the problem-solving process in accordance with Polya's theory. The TaRL approach is applied to each syntax to ensure that all students, whether high, medium, or low ability, obtain meaningful and equal learning experiences through differentiation of scaffolding levels, worksheet forms, and types of tasks given. Details of the implementation of learning activities in each PBL syntax combined with the TaRL approach are presented in the following Table 1.

3. Results and Discussion

This study shows that combining the Problem-Based Learning (PBL) model and the Teaching at the Right Level (TaRL) approach in physics learning on the subject of global warming results in higher problem-solving skills in the experimental class, compared to the control class that applied the scientific approach.

3.1. *Descriptive Data*

Descriptive data analysis was conducted to provide an initial overview of the problem-solving abilities of students in both research groups, namely the experimental class and the control class. The data presented includes the average pretest and posttest scores as a basis for comparison, as shown in Figure 1.

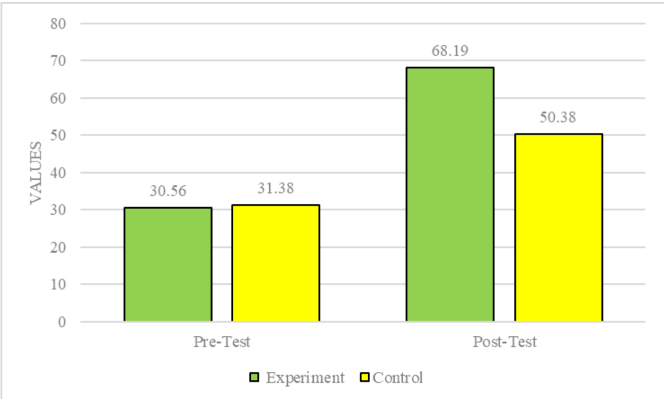

Figure 1. Descriptive analysis data.

In the pretest results, the initial abilities of students in both the experimental and control classes were still relatively low, with an average score of 30.56 for the experimental class and 31.38 for the control class. The very small difference of only 0.82 points indicates that the initial abilities of the two groups were almost the same. This is important because it ensures that the increase in ability after learning was due to the learning method applied, rather than differences in the initial abilities of the students [25]. The low average scores also indicate that most students were not yet familiar with contextual questions that required critical thinking skills, but instead relied on procedural methods of solving problems. After the treatment, the two groups showed significant differences in their posttest results. The experimental group obtained an average score of 66.19, while the control group only achieved 50.38, with a difference of 15.81 points. This difference shows that although both groups experienced improvement, the application of the PBL-TaRL model had a much greater effect.

Descriptive analysis is shown in Table 2. Based on the analysis of pretest and posttest scores on problem-solving skills indicators, it can be seen that the average score of students in the experimental class on the indicator of understanding problems increased from 8.28 to 18.78, with an increase of 13.53 points. Meanwhile, the control class only experienced an increase from 9.00 to 13.25, or an increase of 11.12 points. This greater increase in the experimental class shows that the PBL-TaRL learning model helps students to be more focused and directed in recognizing important information from a problem, while scientific learning tends to make students only understand problems superficially. The greatest increase did occur in the indicator of understanding problems, which is in line with research [26] stating that PBL-TaRL helps students to focus more on core information. However, on the indicator of planning solutions, student achievement was still relatively low compared to other indicators. This is in line with the findings [22] which state that students often have difficulty in the planning stage because this stage requires the ability to connect various concepts. On the indicator of implementing solutions, the results of the experimental class were better than the control class, which reinforces the research [15] that PBL-TaRL improves students' skills in applying problem-solving strategies. Meanwhile, although there was an improvement in the rechecking indicator, the score was still not optimal. This phenomenon is similar to the report [23]] which states that students rarely reflect because they are more accustomed to focusing on finding the final answer rather than reevaluating the process.

Table 2. *Descriptive analysis.*

Problem-Solving Ability Indicator	Experimental Class			Control Class		
	Pretest	*Postest*	Average	*Pretest*	*Postest*	Average
Understanding the problem	8.28	18.78	13.53	9.00	13.25	11.12
Planning the solution	4.03	11.38	7.70	5.16	9.16	7.16
Implementing the plan	13.03	19.66	16.36	11.38	15.72	13.55
Reviewing	5.22	16.09	10.66	5.84	12.25	9.05
Average	7.64	16.48	12.06	7.85	12.60	10.22

3.2. *Normality Test Data*

Improvements in the ability to address global warming issues can be evaluated using the N-gain formula. The N-gain results for each group are shown in Table 3.

Table 3. Normality test results.

Class	**Shapiro-Wilk**			
	df	α	Sig.	Decision
PreTest Experiment	32	0.05	0.375	Normal
PostTest Experiment	32	0.05	0.179	Normal
PreTest Control	32	0.05	0.931	Normal
PostTest Control	32	0.05	0.269	Normal

Based on the results of the Shapiro-Wilk test, it can be seen that the significance value exceeds 0.05 at all Sig. levels. For the first and second tests in the experimental group, the significance values are 0.375 and 0.179, respectively. On the other hand, the control group shows a significance value of 0.931 before the test and 0.269 after the test. Each significance value of the four groups is greater than 0.05, so we can conclude that their data follows a normal distribution. After ensuring that the data is normally distributed, we can proceed with parametric statistical tests.

3.3. *Bartlett's Homogeneity Test*

When testing homogeneity, the Bartlett test is used because it is suitable for data that is assumed to be normal. Table 4 shows the results of the SPSS homogeneity test.

Table 4. Bartlett's homogeneity test.

Class	***Box's M***			
	α	*Box's M*	Sig.	Decision
Pre-Test	0,05	0,560	0.458	Homogen
Post-Test	0,05	0.504	0.481	Homogen

Homogeneity of variance between groups was assessed using a homogeneity test. Based on the results of *Box's M* test, the significance value is 0.458 and *Box's M* value is 0.560. Because the significance value is greater than 0.05, we accept the null hypothesis that the covariance of the experimental and control groups is not significantly different. Thus, we can continue the investigation using parametric statistical tests because the data is homogeneous.

3.4. *N-Gain Test*

The N-gain formula can be used to calculate the ability to solve problems related to global warming material. Figure 2 below shows the N-gain scores for each class.

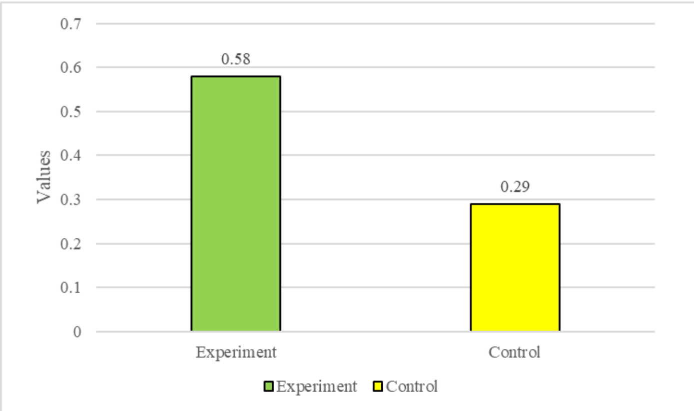

Figure 2. N-gain test.

The N-gain analysis results show that the experimental group obtained a score of 0.58, which is in the moderate category, while the control group only achieved a score of 0.29, which is in the low category. These findings indicate a significant difference in problem-solving ability between the two groups. The experimental class that applied the PBL-TaRL model achieved an increase of almost double that of the control class that used the scientific learning method. This confirms that the application of the PBL-TaRL model is more effective in improving students' problem-solving skills than scientific learning.

3.5. *N- Gain Test per Indicator*

The details of the N-Gain improvement in problem-solving skills at each Polya stage for each class can be seen in Figure 3.

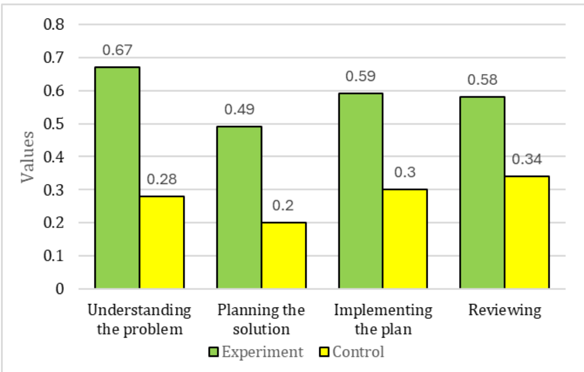

Figure 3. N- Gain test per indicator.

When viewed in more detail for each aspect of problem-solving skills, it can be seen that the experimental group showed consistent improvement. On the indicator of understanding the problem, the experimental group achieved an N-gain value of 0.67, much higher than the control group, which only achieved 0.28. This shows that the PBL- TaRL method successfully helped students recognize the core of the problem, select relevant information, and relate the problem to the knowledge they already had. Furthermore, on the indicator of planning solutions, the experimental group obtained an N- gain of 0.49, while the control group only achieved 0.20. This difference indicates that students who learn with PBL-TaRL are better trained in designing solution strategies and choosing the right way to solve problems.

Improvements were also seen in the indicator of implementing solutions, where the experimental group achieved an N-gain of 0.59, almost double that of the control group, which only achieved 0.30. This shows that students who participated in PBL-TaRL learning were more confident and proficient in applying the strategies they had created themselves. On the last indicator, namely rechecking, the experimental group recorded an N-gain of 0.58, while the control group only scored 0.34. Although the difference was not as significant as the other indicators, these results still show that PBL-TaRL-based learning encourages students' reflective abilities, even though this aspect still needs to be further strengthened.

3.6. *Discussion*

The integration of PBL and TaRL in this study PBL encourages students to tackle authentic problems, improving their critical thinking and application skills in real-world scenarios while TaRL tailors the learning experience to students' ability levels, enabling differentiated instruction that meets diverse needs [24]. In this case, the PBL learning model provides a deeper understanding of issues such as global warming, while TaRL serves to reduce students' difficulties in learning through grouping tailored to their abilities. This is a combination that is underutilized in conventional scientific approaches, which are often mechanistic and unresponsive. However, it should be noted that although this model encourages active knowledge formation, its success is highly dependent on the abilities of the teacher. Without adequate training, PBL-TaRL has the potential to become only a superficial collaborative simulation, in which students rely more on instructions from the teacher than on their own initiative [25].

The improvement in problem-understanding indicators shows how PBL-TaRL utilizes real-world problems to build student knowledge, enabling students to understand the conditions of problems in the environment. However, the difficulty in planning solutions shows that interdisciplinary concepts must be integrated, which is more complex than procedural material as mentioned by [15]. This emphasizes that the influence of the learning model depends on the characteristics of the problem. In global warming, PBL- TaRL is better at building systematic thinking, but reflection on re-examination is lacking due to the lack of routine evaluation exercises, as shown by [26] on the limitations of the scientific method in encouraging introspection. Critically, this pattern challenges the assumption of the universality of Polya's model, which is designed for structured mathematical problems. In the ambiguous context of global warming, indicators such as planning may require modification, such as the addition of elements not present in this study.

When compared to previous research, these results are in line with studies [14] dan [15] which report a significant increase in problem-solving abilities through PBL- TaRL in mathematics and physics. According to [15] on momentum and impulse material, there is a difference in achievement patterns. In that study, the indicator of implementing plans showed the highest increase because mathematical material is easier to measure and apply procedurally. However, the indicator of checking back remained a weakness, both in this study and in study[15] which showed that reflection was still a skill that was rarely practiced in physics learning. This difference in achievement shows that the characteristics of the material also influence the development of problem-solving skills. In contextual material such as global warming, students were more assisted in understand the problem, but face challenges in developing and implementing strategies. Conversely, in mathematical material, students are more skilled at executing a solution plan, but less skilled at relating concepts to real-world contexts. The shortcoming of this study lies in the achievement of indicators that are still limited to the moderate category, especially at the reflection stage.

However, this study adds a new dimension because it focuses on the topic of global warming, which is closely related to environmental issues. Thus, the novelty of this study lies in the application of PBL-TaRL in global warming material that is relevant to everyday life, while integrating cognitive skills and environmental awareness. The implications of these findings are quite important in the context of implementing the Merdeka Curriculum. First, PBL-TaRL is proven to be in line with the principles of differentiation and student- centered learning, so it can be used as an inclusive learning strategy that responds to differences in student ability levels. Second, the focus on global warming issues makes learning more meaningful because it fosters students' concern for environmental issues. However, the application of PBL-TaRL requires teachers to be prepared in designing appropriate problems, providing scaffolding at the solution planning stage, and managing discussions so that they do not stop at the initial activities. Without careful planning, this model has the potential to lose its effectiveness in training problem-solving skills.

Thus, this study contributes new insights into the application of PBL-TaRL in the topic of global warming, while also confirming that the success of this model is greatly influenced by the characteristics of the issues raised and the quality of teacher facilitation in the learning process. These findings open up opportunities for further research using a mixed-methods approach to examine in greater depth the mechanisms for improving students' problem-solving skills, thereby providing a more comprehensive picture of the influence of PBL-TaRL in various learning contexts.

4. Conclusion

Based on the results described above, which show that the application of the Problem- Based Learning (PBL) model together with the Teaching at the Right Level (TaRL) approach has a significant influence on the ability to solve problems related to climate change issues. The results of the experimental class and the control class were very different; the experimental class had a higher N-gain score and average. All Polya indicators experienced this improvement, especially in terms of problem understanding, strategy planning, solution implementation, and solution evaluation. These results indicate that the integration of PBL with TaRL can help address the issue of student ability diversity in the classroom. This is because, while TaRL offers a differentiated approach that makes learning more adaptive, PBL encourages students to actively engage in the learning process and helps build problem-solving skills.

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