



THE EFFECT OF THE PROBLEM BASED LEARNING MODEL ON SCIENCE PROBLEM SOLVING ABILITY AND SELF REGULATED LEARNING

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Abstract. The demands of 21st century education emphasize the importance of higher-order thinking skills (HOTS). One approach considered effective in supporting the achievement of these goals is the implementation of the Problem Based Learning (PBL) model. This study aims to evaluate the effectiveness of the PBL model in enhancing problem solving skills in science subjects and self regulated learning among elementary school students. The research employed a quasi-experimental method with a Nonequivalent Control Group Design. The sample consisted of two classes, each serving as either the experimental or the control group. Data were collected using instruments in the form of a test to assess science problem solving ability and a questionnaire to measure self-regulation learning. The analysis using MANOVA revealed a significant effect of PBL implementation on the simultaneous improvement of both variables, with a significance level of 0.001, which is less than 0.05. These results indicate that PBL is capable of creating an active, reflective, and collaborative learning environment. The conclusion of this study affirms that PBL is an effective alternative instructional strategy for supporting students' holistic competency development. Therefore, it is recommended that this model be implemented more broadly in thematic learning at the elementary school level and further explored for development across different educational levels and contexts.

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INTRODUCTION

21st Century education no longer focuses solely on content mastery but also emphasizes the development of Higher Order Thinking Skills (HOTS), which enable students to face complex and unstructured real-world situations (Frananda et al., 2023; Rahayu et al., 2022; Fanani, 2018). Two crucial competencies that students must possess to navigate the challenges of the 21st century are problem-solving skills and self-regulated learning (Abror, 2022). Two crucial competencies that students must possess to navigate the challenges of the 21st century are problem-solving skills and self-regulated learning (Ahdiat, 2024; OECD, 2022). Meanwhile, self-regulated learning is a major determinant of long-term academic success, as it involves initiative, self-control, and the ability to reflect on and evaluate the learning process (A'yun, 2022; Zimmerer, 1996).

These skills are essential for addressing the complex and dynamic challenges of the global era. However, the results of the 2022 Programme for International Student Assessment (PISA) indicate that Indonesia continues to face significant challenges in this regard. Reading literacy scores declined from 371 in 2018 to 359 in 2022, mathematics literacy from 379 to 366, and science literacy from 396 to 383 (Nizam, 2016; OECD, 2019). Although Indonesia's ranking improved by 5–6 positions, the decline in scores reflects a significant learning loss caused by the COVID-19 pandemic. Educational disparities between urban and rural areas are

also a growing concern. An analysis of PISA 2022 data shows that students in rural areas have limited access to adequate educational infrastructure, including physical facilities and digital devices (Ma & Qin, 2021). This situation negatively impacts the quality of learning and the development of students' critical thinking skills in these areas.

To address these challenges, various innovative pedagogical approaches have been proposed. One of the most prominent and empirically proven methods is the Problem Based Learning (PBL) model (Lestari et al., 2021; Rihayati et al., 2023). PBL emphasizes presenting real-world problems as triggers for learning, encouraging students to actively seek information, engage in discussion, and formulate solutions. Through this approach, students are expected not only to acquire conceptual understanding but also to develop critical thinking skills, collaborative abilities, and the capacity to regulate their own learning process (Dharma & Lestari, 2022; Guntur et al., 2025; Hmelo-Silver, 2004). In the context of PBL, students are encouraged to set learning goals, monitor their progress, and evaluate outcomes—key indicators of self-regulated learning (Zimmerman, 1990).

This explanation aligns with the objectives of science learning in elementary schools as outlined by the National Education Standards Agency (BSNP) (BSNP, 2016; Kemendikbudristek, 2022; Ramadhani et al., 2021), one of which is to equip students with the ability to develop process skills for investigating the natural environment, making decisions, and solving problems (Airlanda, 2020; Nabil et al., 2021; Ramdani et al., 2020). Science learning should also encourage students to become critical thinkers. Students with critical thinking skills will be better equipped to solve problems, which they can later apply in real-life situations (Purnamasari et al., 2021; Roudlo, 2020; Lestari et al., 2022). Therefore, the success of science learning is closely related to students' problem solving abilities and self regulated learning.

Several studies have demonstrated the effectiveness of the PBL model in improving student learning outcomes and critical thinking skills (Merici, 2023; Hmelo-Silver, 2004). Previous research has found that students engaged in PBL-based instruction tend to achieve higher academic performance and exhibit greater learning motivation compared to those taught through conventional methods (Zulaeliah, 2021; Susana et al., 2023). Other studies highlight the importance of integrating metacognitive strategies into problem-based learning to enhance students' self-regulation skills (Guntur et al., 2025). Nonetheless, comprehensive studies that examine the simultaneous impact of PBL on both problem-solving skills and self-regulated learning within the Indonesian school context remain limited. This limitation opens a critical space for further in-depth research, particularly to empirically investigate how the implementation of the PBL model contributes to the improvement of both learning skills. Moreover, it is also important to understand the extent to which the PBL model can be adapted within the Indonesian educational context, which is characterized by heterogeneity in terms of resources, learning culture, as well as teacher and student readiness.

Based on the aforementioned background, this study aims to analyze the effect of the problem based learning model on science problem solving skills and self regulated learning of fifth grade elementary school students. The focus of the study is not only on the effectiveness of PBL as an innovative instructional strategy but also on its contribution to shaping independent and adaptive learners, in alignment with the Profil Pelajar Pancasila and the goals of the Merdeka Curriculum. Thus, the results of this study are expected to provide both theoretical and practical contributions. Theoretically, this research will strengthen the scientific foundation regarding the relationship between problem-based learning approaches and cognitive and metacognitive skills development. The findings may serve as a reference for educators, curriculum developers, and policymakers in designing holistic and responsive instruction that meets the demands of 21st-century education.

RESEARCH METHODS

This study employs a quantitative approach using a quasi-experimental design, specifically the Nonequivalent Control Group Design. This design involves two groups: an



experimental group and a control group, both of which were given a pre-test and a post-test. The Problem Based Learning (PBL) model was applied to the experimental group, while the control group received conventional instruction (Dantes, 2017; Sugiyono, 2022). The research instruments used in this study included a science problem-solving skills test and a self-regulated learning questionnaire. The science problem-solving skills test was developed in the form of essay questions, while the self-regulated learning questionnaire was designed to measure three main aspects: planning, monitoring, and reflection. All instruments were validated by experts in the field of education and learning evaluation, and were declared valid in terms of content.

Empirical validity was tested using the Pearson Product Moment correlation, which showed that all items had validity coefficients higher than the critical r value (r calculated $> r$ table) at the 5% significance level, indicating that the items were valid. Reliability testing was conducted using Cronbach's Alpha coefficient. The results of the analysis indicated that both the test and the questionnaire had reliability coefficients above 0.80, categorizing them as highly reliable. Therefore, the instruments used in this study are considered to be valid and consistent, and are suitable for accurately measuring students' science problem-solving skills and self-regulated learning. The Nonequivalent Control Group Design used in this study is illustrated in Figure 1.

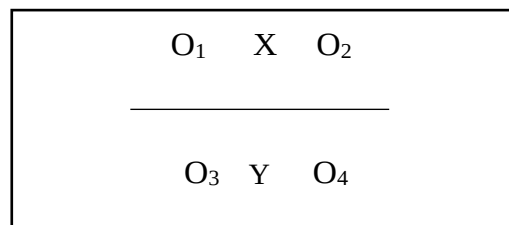


Figure 1. Nonequivalent Control Group Design

Description: O1: *pretest* of the experimental group; O2: *posttest* of the experimental group; O3: *pretest* of the control group; O4: *posttest* of the control group; X: Instruction using the Problem Based Learning (PBL) model; Y: Instruction using conventional teaching methods

The population in this study consisted of all fifth-grade students from four classes in public elementary schools located in Negara Subdistrict, Jembrana Regency, totaling 127 students. The sampling technique used was cluster random sampling, as all public schools in the subdistrict have relatively homogeneous quality in terms of graduate competency standards, learning processes, teacher quality, and school management. The school randomly selected as the experimental class was SDN 2 Tegal Badeng Barat, consisting of 30 students, while SDN 1 Tegal Badeng Barat was selected as the control class, consisting of 35 students. Further details can be seen in Table 1.

Table 1. Research Sample

Nama Sekolah	Kelas	Jumlah Siswa
SDN 1 Tegal Badeng Barat	V	35
SDN 1 Tegal Badeng Barat	V	30
Total		65

Data were collected through the administration of pre-tests and post-tests, as well as the distribution of questionnaires before and after the treatment. Data analysis was conducted using Multivariate Analysis of Variance (MANOVA) to test the effect of the PBL model on two dependent variables: problem-solving ability and self-regulated learning. Before the main analysis, the data were first tested for normality, homogeneity, and linearity assumptions.

RESULT AND DISCUSSION

Before conducting the main analysis, prerequisite tests were performed, including normality testing and variance homogeneity testing, to ensure the suitability of the data for parametric tests. The normality test in the context of MANOVA aims to ensure that each dependent variable, both individually and collectively, follows a normal distribution in each group being analyzed. Meanwhile, the homogeneity test is conducted to examine whether the



covariance matrices across groups are homogeneous or uniform. The results of the normality and homogeneity tests can be seen in [Table 2](#) and [Table 3](#).

Table 2. Shapiro-Wilk Normality Test Results

Problem Solving Ability			Self Regulation Learnig			
	Statistic	df	Sig.	Statistic	df	Sig.
NGain_Persen	0,967	65	0,073	0,975	65	0,197

Based on the results of the Shapiro-Wilk normality test ([Table 2](#)), the significance values obtained were 0.073 and 0.197. Since the significance values are greater than 0.05, it can be concluded that the data for problem-solving ability and self-regulated learning follow a normal distribution.

Table 3. Homogeneity Test Results

Kemampuan Memecahkan Masalah				Self Regulation Learnig			
Levene Statistic	df1	df2	Sig.	Levene Statistic	df1	df2	Sig.
1,815	1	63	0,197	1,766	1	63	0,179

Based on the results of the homogeneity test calculation presented in the output [Table 3](#), the significance values for critical thinking ability were 0.197 and 0.179. Given that the significance level or probability value is greater than 0.05, it can be stated that the population has equal or homogeneous variances. Therefore, based on these significance values, it can be concluded that the populations in the experimental class and the control class have equal or homogeneous variances.

After meeting the normality and homogeneity requirements, hypothesis testing was then conducted to test the proposed hypotheses based on the problem solving ability and self regulated learning scores of students in the experimental and control classes. The hypothesis test used was MANOVA (Multivariate Analysis of Variance). The results can be seen in [Table 4](#).

Table 4. MANOVA Test Results

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	0,962	943,217 ^a	2,000	62,000	0,001
	Wilks' Lambda	0,038	943,217 ^a	2,000	62,000	0,001
	Hotelling's Trace	28,574	943,217 ^a	2,000	62,000	0,001
	Roy's Largest Root	28,574	943,217 ^a	2,000	62,000	0,001
Group	Pillai's Trace	0,547	37,612 ^a	2,000	62,000	0,001
	Wilks' Lambda	0,453	37,612 ^a	2,000	62,000	0,001
	Hotelling's Trace	1,205	37,612 ^a	2,000	62,000	0,001
	Roy's Largest Root	1,205	37,612 ^a	2,000	62,000	0,001

Based on the output above, it is known that the test result has a significance value of $0.001 < 0.05$. This means that there is a significant effect on problem-solving ability and self-regulated learning between students taught using the problem-based learning model and those taught using conventional methods in the 5th grade of elementary school. Furthermore, this also means that the variables of problem-solving ability and self-regulated learning have a simultaneous effect on the problem-based learning model.

Substantively, these findings indicate that the implementation of the Problem Based Learning (PBL) model significantly improves students' problem-solving ability and self-regulated learning compared to conventional learning ([Ma'wa et al., 2021](#); [Merici, 2023](#)). The PBL model is designed to place students at the center of the learning activity by involving them directly in solving real-world problems that are contextual to their daily lives ([Elmanidar et al., 2023](#)). In the process, students engage in exploration, group discussions, question formulation, and reflection on the solutions they generate. Such activities not only stimulate critical and analytical thinking skills but also require students to take responsibility for their own learning process, which in turn strengthens aspects of self-regulated learning ([Lestari et al., 2023](#); [Suciono, 2021](#); [Wardana et al., 2022](#)).

PBL also facilitates a collaborative and constructive learning experience, where students learn not only from learning resources or teachers but also from social interactions with peers



(Guntur et al., 2025; Susana et al., 2023). This collaboration strengthens communication skills, teamwork, and tolerance for differing viewpoints (Berliandaldo et al., 2021). Thus, learning becomes more meaningful and transformative by integrating cognitive, affective, and social dimensions into a unified process. This learning process creates a reflective space that allows students to gradually and independently develop their own learning strategies.

These findings are also relevant to the social constructivist theory proposed by Vygotsky, where knowledge is constructed through social interaction and an environment that supports scaffolding in the learning process (Vygotsky's, 2003). In this context, the teacher acts as a facilitator, providing assistance as needed and gradually withdrawing that support as students begin to complete tasks independently. The PBL model provides a space for this mechanism to occur naturally. Additionally, Zimmerman's theory of self-regulated learning explains that the ability to manage goals, strategies, and self-monitoring during learning is strongly influenced by active learning experiences, such as those provided in the PBL model (Zimmerman, 1990).

Furthermore, the success of this model in simultaneously enhancing two dimensions of competence indicates that PBL has great potential in preparing students to face the challenges of the 21st century (Lestari, et al., 2023). The current world demands graduates who are not only academically proficient but also adaptive, reflective, and independent in addressing complex and dynamic problems. Therefore, the implementation of the PBL model can serve as an effective pedagogical solution for developing character and lifelong learning skills, in line with the direction of national education policies, including the Merdeka Curriculum (Frananda et al., 2023; Haryati et al., 2022; Khoirurrijal, 2022).

Thus, it can be concluded that the Problem-Based Learning model is not only effective in enhancing cognitive outcomes such as science problem-solving ability but also has a direct impact on strengthening the affective and metacognitive aspects, namely self-regulated learning. These findings have important implications for teachers in designing learning strategies that focus on the comprehensive development of students' potential, as well as for education policymakers to encourage the implementation of innovative learning models that are relevant to the needs of the times.

CONCLUSIONS AND SUGGESTIONS

This study shows that the use of the Problem-Based Learning (PBL) model is significantly effective in improving elementary school students' science problem-solving ability and self-regulated learning. Based on the MANOVA analysis results, a significance value of $0.001 < 0.05$ was obtained, confirming a significant effect on both variables after the implementation of the PBL model. The class receiving the PBL treatment showed greater development compared to the conventional class, both in terms of critical thinking and learning independence.

Overall, the PBL model is capable of creating an active, reflective, and collaborative learning environment, which not only improves cognitive learning outcomes but also encourages students to become independent learners ready to face the challenges of 21st-century education. Therefore, it is recommended that teachers implement the PBL approach in the learning process, particularly in the context of thematic learning at the elementary school level. Additionally, it is also important to integrate media and contextual learning resources that are relevant to students' lives to make the learning experience more meaningful. Future research is recommended to explore the application of this model at various grade levels and across other subjects to expand its positive impact.

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