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Effect of Project-Based Learning Integrated with the SETS Approach on High School Students' Problem-Solving Skills

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Abstract

The urgency of this study lies in the need to enhance high school students' problem-solving skills through Project-Based Learning integrated with the SETS (Science, Environment, Technology, and Society) approach. Problem-solving skills are emphasized as an important graduate competency in Regulation of the Minister of Primary and Secondary Education of the Republic of Indonesia Number 10 of 2025. However, preliminary findings showed that the *problem-solving* skills of Grade X students at SMA Negeri 12 Bandar Lampung remained low because classroom learning activities had not sufficiently supported the development of these skills. This study aimed to analyze the effect of implementing *Project-Based Learning* integrated with the SETS approach on Grade X students' *problem-solving* skills in biology learning. A quantitative approach with a quasi-experimental method and a *pretest-posttest control group design* was employed. The sample consisted of 72 students, with 36 students in the experimental class and 36 students in the control class. Data were collected through an essay-based *problem-solving* test and documentation. The results showed a significant effect of *Project-Based Learning* integrated with the SETS approach on Grade X students' *problem-solving* skills in biology learning, as indicated by the *Independent Samples t-test* ($p < .001$). In addition, the experimental group obtained a higher mean *posttest* score (73.97) than the control group (64.53), with *N-Gain* values of 0.55 and 0.41, respectively. The implementation of *Project-Based Learning* integrated with the SETS approach was effective in improving students' *problem-solving* skills. Integrating the learning model with this approach enriched students' learning experiences.

Keywords: *Problem-Solving Skills, Learning Model, Sets Approach, Project-Based Learning.*

Introduction

Problem solving is an individual's ability to address a problem by developing a strategy or plan to be implemented (Alimuddin et al., 2023). Problem-solving skills are an important aspect of education, particularly in the learning process, because they ultimately become competencies that can be applied in everyday life (Nurhalisa et al., 2021). Education does not focus only on memorization but also encompasses critical and creative reasoning and expertise in solving problems (Wahyuni et al., 2024). National education is intended to develop resilient graduate profiles; students are not only expected to analyze and solve problems using literacy and numeracy skills, but are also encouraged to innovate and formulate solution ideas for problems in their surroundings. These expectations are regulated in Indonesia's graduate competency standards through Ministerial Regulation Number 10 of 2025 (Rahmawati et al., 2025). Problem solving enables students to gain understanding, experience, and skills that can be implemented in community life (Zayyadi et al., 2019). This demonstrates that problem solving is an important competency in education for developing resilient students who are prepared to face complex challenges (Attami et al., 2020 ; Yang et al, 2025). In biology

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learning, *problem-solving* skills are essential for developing a rational and comprehensive understanding of problems (Idris et al., 2026). Biology learning requires students not only to understand concepts but also to construct their existing knowledge in relation to a problem. It engages students in connecting knowledge with an in-depth investigative process; when students have strong *problem-solving* skills, they are better able to examine information and relevant strategies related to the material being studied (Arbiana et al., 2024).

One component of problem solving is making appropriate decisions among several available options (Promma et al, 2025). The level of *problem-solving* skill is grounded in students' understanding of the problems presented to them and their ability to resolve those problems (Rahayu et al., 2021). Through biology learning, students not only understand scientific concepts but can also study phenomena by designing solutions to the problems they encounter, enabling them to examine problems and make decisions to resolve them. Problem-solving skill is therefore important for developing logical and comprehensive understanding. In biology learning, this skill needs to be emphasized because it is consistent with patterns of thinking that require analysis, reasoning, and accuracy (Marsel & Fadilah, 2025). The importance of *problem-solving* skills, particularly in biology learning, is reflected in the Phase E competencies, which require students to understand science concepts and principles, recognize their interrelationships, apply them to solve real-life problems, and use science concepts to address issues related to climate change (Azhari et al., 2020).

Preliminary research conducted at SMA Negeri 12 Bandar Lampung showed that the *problem-solving* skills of Grade X students were in the low category. Students' *problem-solving* skills may be influenced by several factors, including limited conceptual understanding during learning activities, which can make it difficult for students to answer *problem-solving* questions in detail. Students also reported difficulty understanding biological concepts or the material being taught. They perceived biology as covering highly complex content and as tending to emphasize memorization, which reduced their understanding of the material. This finding is consistent with previous research identifying memorization-oriented biology learning as one factor that contributes to students' difficulty in understanding biology lessons (Azizah & Alberida, 2021).

Project-Based Learning integrated with the SETS approach is one learning model that may address these problems. This model encourages students to become actively involved in constructing knowledge and examining solutions that can be implemented in the form of tangible projects, while also assigning students collaborative responsibility throughout the process. Previous studies have shown that *Project-Based Learning* can improve learning outcomes, critical thinking, and *problem-solving* skills (Zaharah & Silitonga, 2023). The model also requires solution planning, task allocation, resource management, and project evaluation. These processes directly encourage students to become more active and creative in innovating, expressing arguments, and collaborating to solve problems (Lion et al., 2022). Although previous studies have demonstrated the positive effects of *Project-Based Learning*, a limitation is that the model often focuses on the final product without sufficiently considering the sustainability value of the project being developed. An additional approach is therefore needed so that project-based learning encourages analytical thinking rather than merely focusing on completing the final product. Integration with the SETS (*Science, Environment, Technology, Society*) approach can provide students with a broader understanding. This approach emphasizes a comprehensive understanding of the interactions among science and technology and their impacts on the environment and society.

Through such understanding, students are encouraged to engage cognitively and develop critical awareness when solving real-world problems (Widiastuti & Purnawijaya, 2021). Through the integration of *Project-Based Learning* with the SETS approach, students do not merely learn scientific theory but can also analyze real issues related to the environment, the use of technology, and their implications for society. This process creates meaningful learning experiences that are expected to strengthen students' *problem-solving* skills. Ultimately, students can identify problems, improve their academic understanding, develop skills for addressing global challenges, and increase their social and environmental awareness.

Based on the preceding discussion, this study addresses the following question: 'Does *Project-Based Learning* integrated with the SETS (*Science, Environment, Technology, Society*) approach affect Grade X students' *problem-solving* skills in biology learning?' The scope of this study was limited to biology learning on the topic of environmental pollution and was implemented with Grade X students at SMA Negeri 12 Bandar Lampung during the second semester of the 2025/2026 academic year. The *problem-solving* skills evaluated in this study comprised four main indicators: (1) understanding the problem, (2) devising a *problem-solving* plan, (3) carrying out the *problem-solving* plan, and (4) reviewing the answer. The novelty of this study lies in integrating *Project-Based Learning* with the SETS (*Science, Environment, Technology, Society*) approach to examine the *problem-solving* skills of Grade X students in biology learning, particularly at SMA Negeri 12 Bandar Lampung.

Method

This study employed a quantitative approach using a quasi-experimental design with a *pretest-posttest control group design*, involving two groups selected through randomization. The two groups consisted of an experimental group and a control group. Both groups were administered a *pretest* and a *posttest* to identify changes in students' *problem-solving* skills before and after the treatment. The study was conducted at UPT SMA Negeri 12 Bandar Lampung, located in Bandar Lampung City, Lampung Province, during the second semester of the 2025/2026 academic year. The target population comprised all Grade X students at SMA Negeri 12 Bandar Lampung in the 2025/2026 academic year. The research sample consisted of all students in Class X.8 as the experimental group, who received *Project-Based Learning* integrated with the SETS approach, and Class X.7 as the control or comparison group, who received *Inquiry Learning*. Each class consisted of 36 students.

The sample was selected using *Cluster Random Sampling*, through which each eligible cluster in the population had an opportunity to be selected as a research group. Data collection involved both test and non-test techniques. The test technique consisted of essay questions designed to measure *problem-solving* skills. The instrument was systematically developed and had been validated before use to measure students' *problem-solving* skills. The non-test technique consisted of documentation used to collect data or records, such as student scores and photographs taken during learning activities. Before being used for research data collection, the instrument underwent expert validation and construct validation to ensure its feasibility and quality. Content validity was assessed by lecturers with relevant expertise, while construct validation was conducted outside the study population to avoid bias toward the research participants.

Construct validation included tests of item validity, reliability, discrimination power, and item difficulty using SPSS version 31. After the instrument was declared valid and met the feasibility criteria, it was administered to the experimental and control classes as the *pretest*

and *posttest*. After the *posttest*, the results were analyzed using *N-Gain* to examine improvements in students' *problem-solving* skills before and after the treatment. To determine the effect of *Project-Based Learning* integrated with the SETS approach on students' *problem-solving* skills, hypothesis testing was conducted as part of the inferential analysis using an *Independent Samples t-test*, assuming that the data were normally distributed and homogeneous.

Results

Pretest Results for Problem-Solving Skills

The pretest was administered to both classes to map students' problem-solving skills before the learning activities were implemented. The pretest results for both classes are presented in Table 1.

Table 1. *Pretest Results for Problem-Solving Skills*

Class	N	Mean	Minimum	Maximum
Experimental	36	42.77	33	56
Control	36	40.27	30	50

As shown in Table 1, the experimental class obtained a minimum score of 33, a maximum score of 56, and a mean score of 42.77. The control class obtained a minimum score of 30, a maximum score of 50, and a mean score of 40.27. These results indicate that the *pretest* scores of the experimental and control classes were relatively similar, suggesting that students in both classes had not yet fully developed *problem-solving* skills for the material to be taught.

Posttest Results for Problem-Solving Skills

After the experimental class received *Project-Based Learning* integrated with the SETS approach, a *posttest* was administered to examine improvements in students' *problem-solving* skills. The *posttest* results for both classes are presented in Table 2.

Table 2. *Posttest Results for Problem-Solving Skills*

Class	N	Mean	Minimum	Maximum
Experimental	36	73.97	60	86
Control	36	64.53	50	80

Table 2 shows that the experimental class obtained a minimum score of 60, a maximum score of 86, and a mean *posttest* score of 73.97. In comparison, the control class obtained a minimum score of 50, a maximum score of 80, and a mean *posttest* score of 64.53. These results demonstrate a difference in mean *problem-solving* scores between the experimental and control classes, with the experimental class tending to show higher *problem-solving* skills than the control class.

N-Gain Analysis

N-Gain analysis was conducted to determine the improvement in students' *problem-solving* skills after the treatment. The *N-Gain* results for both classes are presented in Table 3.

Table 3. *N-Gain Analysis of Problem-Solving Skills*

Class	Mean N-Gain	Category
Experimental	0.55	Moderate
Control	0.41	Moderate

Table 3 shows that the mean *N-Gain* score of the experimental class was 0.55, categorized as moderate, while the control class obtained a mean *N-Gain* score of 0.41, which was also categorized as moderate. Although both classes were in the same category, the experimental class had a higher *N-Gain* score, with a difference of 0.14. These results indicate that the improvement in *problem-solving* skills in the experimental class was greater than that in the control class. The difference suggests that the learning implemented in the experimental class contributed more optimally to helping students understand problems, devise solutions, carry out strategies, and review their solutions. However, the *N-Gain* results need to be supported by inferential statistical testing to determine whether the difference in improvement between the two classes was statistically significant.

Mean Scores for Problem-Solving Skill Indicators in the Experimental Class

The mean score for each *problem-solving* indicator was calculated to objectively examine the extent of students' *problem-solving* skills. The mean scores for each *problem-solving* indicator in the experimental class are presented in Figure 1.

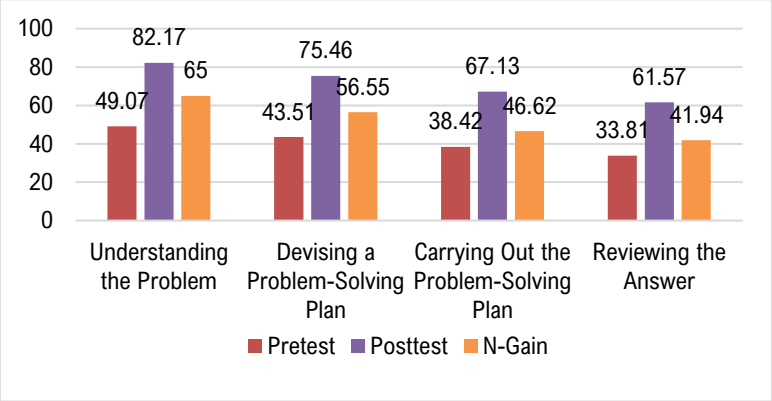


Figure 1. *Mean Scores for Problem-Solving Skill Indicators in the Experimental Class*

Figure 1 summarizes the mean scores for each *problem-solving* indicator at *pretest* and *posttest*, as well as the *N-Gain* values in the experimental class. These data were obtained by analyzing students' responses to the essay-based *problem-solving* test administered at *pretest* and *posttest*. For the first indicator, understanding the problem, the *N-Gain* in the experimental class reached 65.00%; for the second indicator, devising a *problem-solving* plan, it reached 56.55%; for the third indicator, carrying out the *problem-solving* plan, it reached 46.62%; and for the fourth indicator, reviewing the answer, it reached 41.94%. Posttest scores increased for all indicators compared with *pretest* scores.

Mean Scores for Problem-Solving Skill Indicators in the Control Class

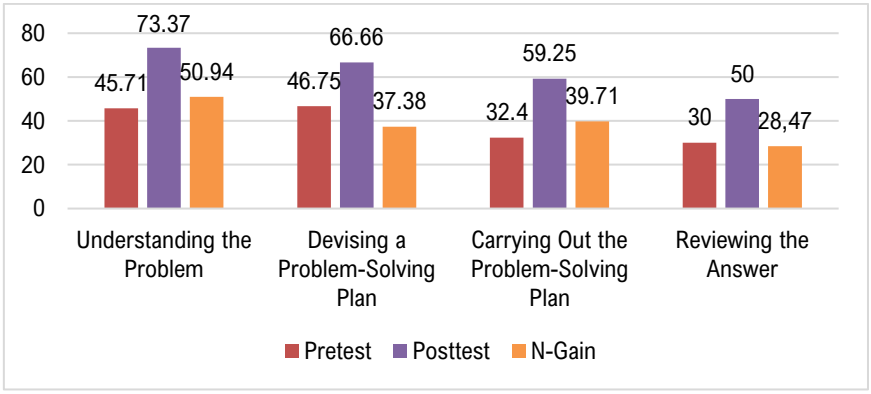


Figure 2. *Mean Scores for Problem-Solving Skill Indicators in the Control Class*

An objective assessment of students' *problem-solving* skills was conducted by calculating the mean score for each indicator. The mean scores obtained in the control class are presented in Figure 2. Figure 2 shows the mean scores for each *problem-solving* indicator at *pretest* and *posttest*, as well as the *N-Gain* values in the control class. These data were obtained by analyzing students' responses to the essay-based *problem-solving* test administered at *pretest* and *posttest*. The mean *posttest* score for each *problem-solving* indicator increased compared with the *pretest* score. The *N-Gain* for the first indicator reached 50.94%, the second indicator 37.38%, the third indicator 39.71%, and the fourth indicator 28.47%.

Normality Test Analysis

The normality test was conducted as a prerequisite test on the *pretest* and *posttest* data before hypothesis testing. The results of the *Shapiro-Wilk* normality test for the experimental and control classes are presented in Table 4.

***Table 4**. Normality Test of Problem-Solving Skills in the Experimental and Control Classes*

Class	Assessment	Significance	Category
Experimental	*Pretest*	0.057	Normal
	Posttest	0.284	Normal
Control	*Pretest*	0.052	Normal
	Posttest	0.134	Normal

Data are considered normally distributed when the significance value is greater than .05. Based on Table 4, the significance values of the *pretest* and *posttest* data in both classes were greater than .05; therefore, the data from both classes were normally distributed.

Homogeneity Analysis

A homogeneity test using *Levene's test* was conducted to determine whether the two groups had equivalent variance distributions. The results are presented in Table 5.

***Table 5.** Homogeneity Test of Problem-Solving Skills*

Problem-Solving Skills	Significance	Category
Pretest	0.738	Homogeneous
Posttest	0.141	Homogeneous

Based on the homogeneity test criteria, the samples are considered to come from populations with homogeneous variances when the significance value is greater than .05 and nonhomogeneous when it is less than .05. The results in Table 5 show that the significance values for both *pretest* and *posttest* data were greater than .05; therefore, the data from the two groups had equivalent or homogeneous variances.

Hypothesis Testing

Hypothesis testing was conducted using an *Independent Samples t-test* after the prerequisite assumptions of normality and homogeneity had been met. The *posttest* data were normally distributed and homogeneous and were therefore appropriate for t-test analysis. The t-test results are presented in Table 6.

***Table 6**. t-Test Results for Posttest Problem-Solving Skills*

Result	Sig. (2-tailed)
Posttest	< .001

According to the hypothesis-testing criterion, the null hypothesis (H0) is rejected and the alternative hypothesis (H1) is accepted when the significance value is less than .05. As shown

in Table 6, the hypothesis test yielded p < .001. Thus, there was a significant difference in *problem-solving* skills between students who received *Project-Based Learning* integrated with the SETS approach and those in the comparison class.

Discussion

Based on the data analysis, the results showed a significant difference in students' *problem-solving* skills between the experimental class that implemented *Project-Based Learning* integrated with the SETS approach and the control class. This empirical evidence indicates that integrating *Project-Based Learning* with the SETS approach contributed positively to improving Grade X students' *problem-solving* skills in biology at SMA Negeri 12 Bandar Lampung. Based on the *pretest* and *posttest* assessments, improvements were observed across the *problem-solving* indicators. This study used Polya's *problem-solving* stages as indicators for assessing students' *problem-solving* skills. The first indicator, understanding the problem, directs students to identify problems presented in their surroundings. Through *Project-Based Learning* integrated with SETS, students can respond to a problem and formulate solution ideas that are implemented in the form of a project. The first *problem-solving* indicator was higher in the experimental class than in the control class because *Project-Based Learning* includes learning stages that present contextual problems and require students to use critical reasoning to understand what is needed and plan a solution.

This finding is supported by previous research indicating that the stages of *Project-Based Learning* require students to generate ideas during project planning; therefore, students need to understand the context of the problem so that they become accustomed to solving problems and understanding the material that has been taught (Febrila et al., 2023). The second indicator, devising a *problem-solving* plan, also improved more in the experimental class than in the control class. This indicator reflects students' ability to formulate the steps of a solution that will be implemented. The difference in improvement occurred because *Project-Based Learning* is characterized by authentic projects, in which students translate their solution plans into concrete outcomes. Integration with the SETS approach also encourages students to examine problems from multiple perspectives, thereby broadening the range of possible solutions. Students are directly involved in collaborative activities to design solutions, determine the project to be developed, and prepare the necessary tools and materials. This process enables students not only to understand theory but also to apply knowledge directly to solve problems (Waruwu et al., 2023).

For the third indicator, carrying out the *problem-solving* plan, the mean score was also higher in the experimental class than in the control class. In *Project-Based Learning*, the fourth stage, supervising and monitoring project progress, is related to this indicator. This stage indirectly requires students to implement their planned solutions through project-development activities. *Project-Based Learning* provides meaningful experiences through the resolution of authentic problems. Its systematic stages are effective for improving *problem-solving* because students engage in investigating problems and producing a product rather than merely learning theory (Anggraini & Rais, 2024). *Project-Based Learning* is also aligned with the fourth *problem-solving* indicator, reviewing the answer. Through the final *Project-Based Learning* stage, which involves assessing project outcomes and evaluating the learning experience, students are expected to identify and reflect on shortcomings by reviewing the results obtained. This is supported by the higher mean indicator score in the experimental

class than in the control class. The stages of *Project-Based Learning* are therefore consistent with Polya's *problem-solving* process (Junaid et al., 2025).

The *N-Gain* analysis showed that the greatest improvement in the experimental class occurred for the first *problem-solving* indicator, understanding the problem. This finding indicates that understanding the problem is an essential initial step before students determine a solution, and it emphasizes the importance of correctly recognizing and representing a problem (Rahmazatullaili et al., 2017). The study showed improvements in *problem-solving* skills in both the experimental and control classes. However, the experimental class, which implemented *Project-Based Learning* integrated with the SETS approach, showed greater improvement. This is reflected in the mean *N-Gain* of 0.55 in the experimental class compared with 0.41 in the control class. Although both values were categorized as moderate, the experimental class achieved the higher gain. The implementation of *Project-Based Learning* had a positive contribution to *problem-solving* skills because students did not merely receive information from the teacher but actively analyzed problems and developed solutions to the problems presented.

This process develops more specific knowledge and trains analytical reasoning (Dewi et al., 2026). The improvement in *problem-solving* skills in the experimental class can be attributed to the systematic stages of *Project-Based Learning* integrated with the SETS approach. Students were presented with problems that required them to seek solutions and were given opportunities to explore and collaborate through experiences that encouraged critical reasoning and creativity. Integration of the SETS approach also contributed to the improvement in *problem-solving* skills because students did not simply design projects in response to problems; they also connected their findings with scientific theory, technological applications, and environmental and social impacts (Hasanah & Diliarosta, 2025). In line with this perspective, *Project-Based Learning* and the SETS approach are grounded in constructivist theory and contextual learning, in which students actively develop their skills through authentic learning experiences (Pratami, 2024). The findings are also supported by previous research indicating that *Project-Based Learning* integrated with the SETS approach is effective in developing student skills, including creative reasoning among senior high school students (Kalsum et al., 2019).

Conclusion

The results showed that the implementation of *Project-Based Learning* integrated with the SETS (*Science, Environment, Technology, Society*) approach had a positive effect on the *problem-solving* skills of Grade X students in Biology at SMA Negeri 12 Bandar Lampung. The experimental class obtained a mean *posttest* score of 73.97, which was higher than the control class mean of 64.53. Improvement in *problem-solving* skills was also reflected in the *N-Gain* values of 0.55 for the experimental class and 0.41 for the control class. The *Independent Samples t-test* yielded $p < .001$, indicating a significant difference in *problem-solving* skills between the two classes. These findings highlight the importance of *Project-Based Learning* integrated with the SETS approach as an alternative strategy for Biology learning. This model can help students connect concepts of science, technology, environment, and society when analyzing and solving contextual problems through project activities. This study was limited to a sample from one school and a relatively short project implementation period; therefore, the findings cannot yet be broadly generalized. Future studies are recommended to involve larger samples from several schools, provide a longer period for

project implementation, and develop project types that are appropriate to the characteristics of the subject matter and learning objectives. Further research may also examine the effects of this model on students' critical thinking, creativity, collaboration, and learning outcomes.

Acknowledgment

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