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Examining the influence of the Problem Based Learning science, environment, technology, society model on 7th grade students' science literacy competencies

Salsabila Atika Sari, Sukarmin*, Meida Wulan Sari

Faculty of Teacher Training and Education, Universitas Sebelas Maret, Indonesia
*Corresponding author, email: sukarmin67@staff.uns.ac.id

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Abstract
This study aims to analyze the effect of the PBL model integrated with SETS on the science literacy skills of 7th-grade junior high school students in understanding ecology and biodiversity. This pre-experimental research used a one-group pretest-Post-test design. The sample was selected using convenience sampling. Data were collected through multiple-choice tests with science literacy indicators. Descriptive and inferential data analysis techniques were employed. The results showed that students who learned using the PBL model integrated with SETS experienced a significantly higher improvement in science literacy. A significance value (sig) of 0.000 was obtained, indicating that the application of this model is effective in improving science literacy. Learning with the PBL-SETS model enhanced students' competence in explaining scientific phenomena, evaluating and designing scientific research, and interpreting scientific data. The science knowledge aspect, including content, procedural, and epistemic knowledge, improved, although the context aspect remained low. Factors influencing students' science literacy include textbook selection, teaching models, and reading habits.

1. Introduction

Developing science literacy and education is crucial for preparing a generation capable of addressing critical issues like environmental degradation. According to the OECD (2024), science literacy refers to the ability to engage with science-related issues and concepts, allowing individuals to participate in discussions and make informed decisions regarding science and technology. However, PISA results (2022) show a significant decline in Indonesian students' science performance since 2018, with only 34% meeting literacy benchmarks compared to 76% in OECD countries. Several factors contribute to this decline. Suparya et al. (2022) found that inadequate textbooks often lack real-world applications, leading to difficulties in conceptual understanding. Additionally, widespread misconceptions, particularly in topics like energy conservation and biological systems, hinder students from grasping fundamental principles. The lack of contextual learning further exacerbates the problem, as students struggle to connect scientific concepts with everyday life. These challenges emphasize the urgent need for curriculum improvements, teacher training, and the integration of context-based learning strategies to enhance science literacy in Indonesia.

The study aims to evaluate its impact on students' science literacy. Low science literacy negatively impacts students' ability to apply knowledge in real-world contexts, reducing their problem-solving skills and responsiveness to environmental issues (Yusmar & Fadilah, 2023). Science literacy is crucial for understanding environmental, technological, and societal issues (Pratiwi et al., 2019). Addressing these challenges requires improved curricula, better textbooks, and increased teacher training (Fuadi et al., 2020).

Environmental issues in developing countries like Indonesia differ from those in developed nations. The root causes of these problems often stem from delayed development (Adharani, 2017). Various environmental issues in Indonesia have led to a decline in environmental quality, both directly and indirectly (Rochmani, 2015). Understanding these critical environmental issues can help change students' behavior, fostering a sense of environmental responsibility and contributing to future improvements. Knowledge, skills, and awareness of environmental values can encourage

students to actively participate in preservation and protection efforts (Zulfa et al., 2015). One of the most significant environmental concerns is air pollution. According to the latest report from IQAir, in 2023, Indonesia ranked 14th out of 134 countries, with an average Air Quality Index (AQI) of 105, categorized as "Unhealthy for Sensitive Groups". This data indicates that air quality in Indonesia remains a major concern in environmental improvement efforts.

Science education in junior high schools should focus on the impact of human activities on ecosystems. Conventional teaching methods, such as lectures, are often ineffective. Problem-Based Learning (PBL) with the SETS (Science, Environment, Technology, Society) method offers a promising alternative. This approach enhances critical thinking and problem-solving skills by integrating science with real-world issues (Alvionita et al., 2020). Further research is needed to evaluate the impact of PBL integrated with SETS on students' science literacy in ecology and biodiversity, particularly regarding environmental damage.

2. Method

This study employs a quantitative method with a one-group pretest-Post-test design, involving a single group of students measured before and after receiving the treatment. The treatment involves teaching science using the Problem-Based Learning (PBL) model integrated with Science, Environment, Technology, and Society (SETS). The research was conducted at SMP Negeri 1 Selogiri, Wonogiri, starting in May 2024. The population of the study consists of 281 seventh-grade students, from which 32 students were selected as a sample using convenience sampling.

The research procedure follows a structured process starting from problem identification, proposal preparation, and instrument validation. The instrument validation consists of content validity, construct validity, reliability testing, difficulty level analysis, and discrimination index assessment. The test instrument consists of 20 multiple-choice questions covering three aspects of science literacy: knowledge, competency, and context. The knowledge aspect assesses content, procedural, and epistemic knowledge. The competency aspect evaluates students' ability to explain scientific phenomena and interpret data. The context aspect measures the application of scientific knowledge in real-world settings.

Data were collected using pretests and Post-tests to measure science literacy levels before and after the intervention. Descriptive statistics were used to summarize the data, while inferential statistics determined significant changes. Normality testing (Shapiro-Wilk) and homogeneity testing (Levene's Test) were conducted as prerequisites. The paired sample t-test was used to evaluate differences, with significance set at $p < 0.05$

3. Results and Discussion

3.1. Prerequisite Testing

Prerequisite testing is conducted before performing tests for differences. The purpose of this testing is to determine the appropriate method for conducting the difference tests. This prerequisite testing involves assessing science literacy skills both overall and by each aspect. In this study, prerequisite testing includes two types: normality testing and homogeneity testing.

Results of Prerequisite Testing for Science Literacy Analysis of Students

Normality testing is performed to determine whether the data is normally distributed. Table 1displays the results of normality testing for students' science literacy skills.

Table 1. Results of Normality Testing for Science Literacy

	Sig	Result	Description	Conclusion
Pre-test	0,821	0,821 >0,05	Data is normally distributed	Proceed with homogeneity test
Post-test	0,091	0,091 > 0,05	Data is normally distributed	

According to Table 1, normality testing using the Shapiro-Wilk test indicates that the data is normally distributed, with pretest and Post-test significance values of 0.821 and 0.091, respectively,

both greater than 0.05. Therefore, the data is concluded to be normally distributed. The next step is to conduct the homogeneity test.

Table 2. Results of Homogeneity Testing for Science Literacy

	Sig	Result	Description	Conclusion
Pre-test Post-test	0.485	0.485 > 0.05	Data is homogeneous	Use parametric tests with Paired Sample t-Test

The homogeneity test results show a significance value of 0.485, meeting the assumption of equal variances necessary for parametric statistical analysis. The next step is to perform the difference test using hypothesis testing or t-tests, which are classified as parametric tests.

Results of Difference Testing

The purpose of difference testing is to identify whether there is a significant difference in science literacy scores before and after the treatment. This test was conducted using a t-test with IBM SPSS 25 software.

Table 3. Results of Difference Testing for Science Literacy

	Result	**Conclusion**
Pre-test Post-test	0.000 > 0.05	H_1Accepted

According to the t-test output, the significance value (sig) is 0.000, which is less than α 0.05. Therefore, the null hypothesis (Ho) is rejected and the alternative hypothesis (H1) is accepted, indicating a significant difference in science literacy scores of students before and after the treatment

3.2. The Impact of the Problem-Based Learning Model Integrated with Science, Environment, Technology, and Society on Students' Science Literacy

3.2.1. Knowledge Aspect

The knowledge aspect refers to students' ability to develop skills and knowledge for decision-making and problem-solving in science, technology, and society, including content, procedural, and epistemic knowledge. Out of 20 questions, 10 assess this knowledge aspect.

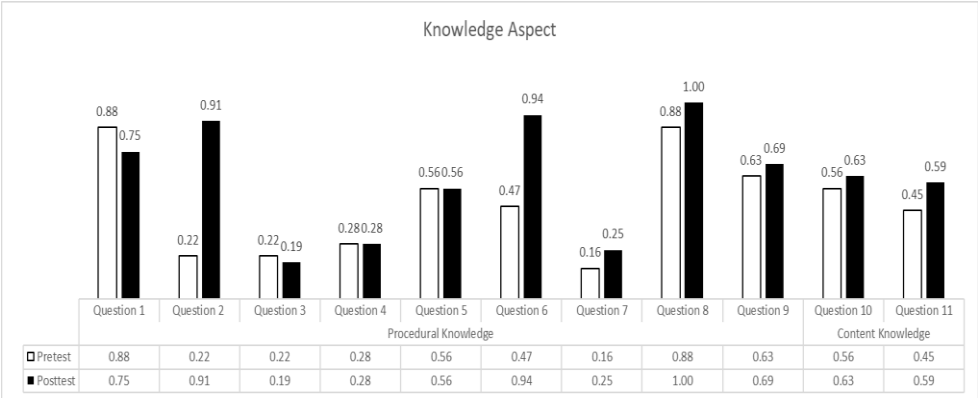

Figure 1. Comparison of Pretest and Post-test Knowledge Aspect

Analysis of the knowledge aspect, (Figure 1) assessed through 10 questions, revealed significant improvement in students' scores from pretest to Post-test, indicating that the PBL-SEST model effectively enhanced students' understanding of scientific concepts, procedures, and epistemic knowledge. This is evidenced by the increase in scores across most questions, with notable gains observed on questions 2 and 6. However, the low performance on question 4, which assessed students' understanding of the environmental impact of population growth, highlights a key limitation. Only 28% of students answered this question correctly in both tests, suggesting a gap in their ability to apply scientific concepts to real-world environmental issues. This finding underscores

the need for greater emphasis on contextual learning, as research by Fuadi et al. (2020) has shown that methods relying solely on textbooks often fail to effectively engage students and foster deep comprehension of real-world applications.

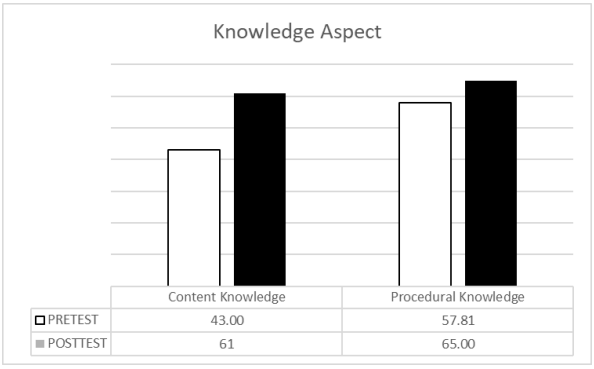

Figure 2. Pretest and Post-test Results for Students' Science Literacy in the Knowledge Aspect

Before the intervention, students' average scores on content knowledge were 43 (categorized as "poor"), increasing to 61 (categorized as "good") after the intervention. For procedural knowledge, the initial average score was 57.81 (categorized as "fair"), rising to 65 (categorized as "good"). This improvement indicates significant progress in content and procedural knowledge due to the application of the Problem-Based Learning (PBL) model. These findings align with Rusman (2010), who states that integrated PBL and SETS is effective in enhancing conceptual understanding through communication, discussion, and collaboration (Indrawan et al., 2022).

3.2.2. Competency Aspect

The competency aspect refers to students' mental abilities in problem-solving, including identifying scientific issues, explaining phenomena scientifically, and using scientific evidence. Six out of 20 questions measure this competency aspect.

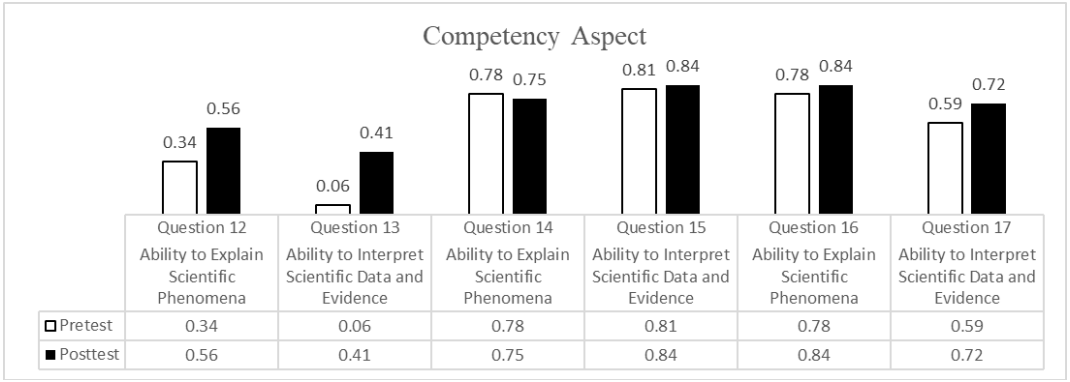

Figure 3. Comparison of Pretest and Post-test Competency Aspect

The competency aspect, assessed through 6 questions, demonstrated significant improvement in students' ability to explain scientific phenomena and interpret data after the learning intervention. This is evident in the increased scores observed across most questions, with a notable improvement on Question 13, suggesting that the PBL-SEST model effectively fostered the development of critical thinking and problem-solving skills.

However, the low performance on some questions, such as Question 14, and the overall low baseline scores in the pretest (e.g., only 6% of students correctly answered Question 13 on the impact of detergents on aquatic ecosystems) highlight the presence of significant misconceptions and a lack of in-depth understanding among students. This suggests that while the PBL-SEST model showed promise in improving competency, further interventions are needed to address these underlying issues.

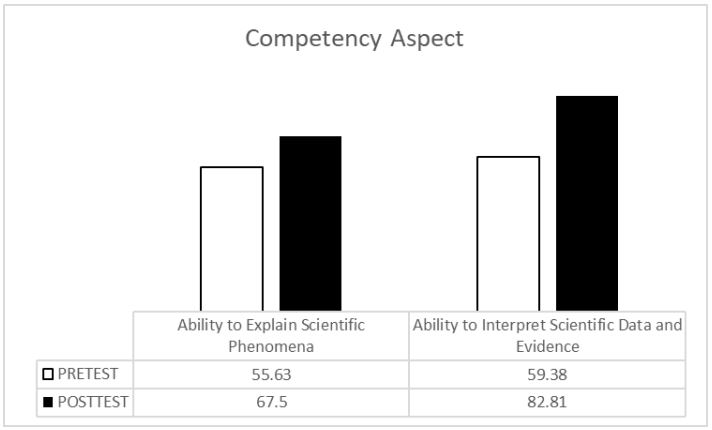

Figure 4. Pretest and Post-test Results for Students' Science Literacy in the Competency Aspect

The study shows that the application of the PBL model integrated with SETS enhances students' science literacy competency. The ability to explain scientific phenomena increased from an average of 55.62 before the intervention to 67.5 after the intervention, and the ability to interpret data and scientific evidence rose from 59.37 to 82.81. This improvement indicates that the integrated PBL-SETS model is effective in reinforcing science literacy through real-world problems and contextualization that encourage independent learning and collaboration. These findings are consistent with Mursalin & Setiaji (2021), who found that PBL and SETS promote critical thinking and the connection of knowledge with the surrounding environment.

3.2.3. Context Aspect

The context aspect refers to applying science concepts to everyday situations, including personal, local or national, and global issues. Three out of 20 questions assess this context aspect.

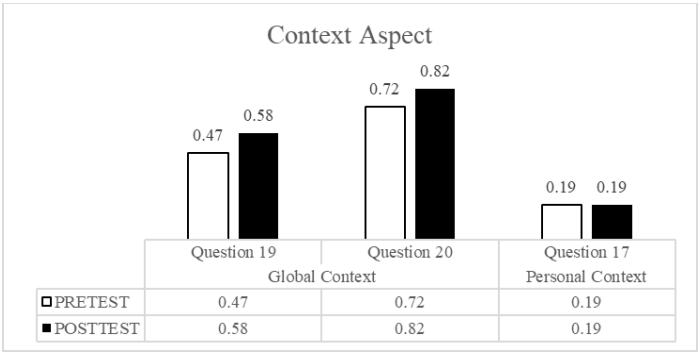

Figure 5. Comparison of Pretest and Post-test Context Aspect

The context aspect, assessed through three questions, revealed mixed results. While students demonstrated improved understanding of global environmental issues, such as global warming, their ability to apply scientific concepts to personal and local contexts remained limited. For instance, only 19% of students correctly answered Question 17, which addressed the impact of individual actions like saving electricity and planting trees on mitigating global warming. This suggests a gap between understanding global environmental issues and applying this knowledge to personal and local contexts. This finding aligns with research by Permatasari & Fitriza (2019), which emphasizes the crucial role of contextual learning in developing meaningful science literacy. Connecting scientific concepts to real-world situations is essential for students to understand their relevance and apply them in their daily lives.

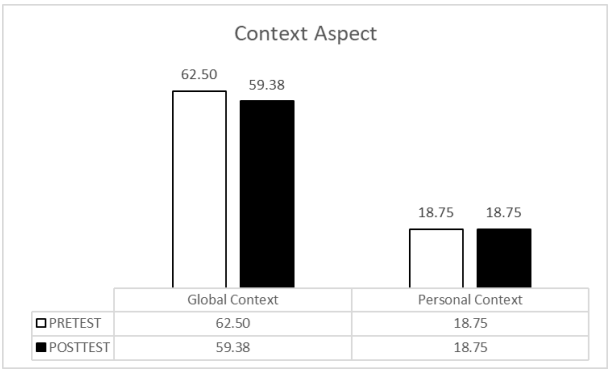

Figure 6. Pretest and Post-test Results for Students' Science Literacy in the Context Aspect

The average pretest score for global context was 62.50, while the Post-test score decreased to 59.38, and the personal context score remained at 18.75. This indicates that the learning model was not effective in improving students' understanding of the context of science literacy, as students still struggle to relate material to real-life situations (Permatasari & Fitriza, 2019). The study shows that while students may memorize material, they lack skills in applying their knowledge. Inability in one aspect of science literacy can affect other aspects (Nofiana, 2017).

4. Conclusion

Based on the testing and discussion conducted, it can be concluded that there is a significant change in students' average scores between the pretest and Post-test. The average science literacy score for students was 49.06 before the intervention, which falls into the low category. However, after the intervention, the average score increased to 64.84, placing it in the fair-to-good category. The results of the average score comparison show a significance value of $0.00 < 0.05$, indicating a significant difference in students' scores before and after the intervention. This study also demonstrates that the implementation of the Problem-Based Learning (PBL) model integrated with Science, Environment, Technology, and Society (SETS) has a positive impact on students' science literacy, with an average score increase of 15.87 following the PBL-SETS intervention. Before the intervention, the average score was 49.06, and after the intervention, it rose to 64.84. The Problem-Based Learning approach combined with SETS effectively enhanced students' abilities to explain scientific phenomena and interpret scientific data, as well as deepened their procedural and content knowledge in science.

Author Contributions

All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

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Declaration of Conflicting Interests

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