



The Influence of the STEM-Based Problem-Based Learning Model on Students' Science Literacy Skills in Science Learning

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Abstract: This research is motivated by the low level of science literacy among students in Indonesia, including at SMP Negeri 17 Kota Jambi. The study aims to determine the effect of the STEM-based PBL model on the science literacy of seventh-grade students at SMP Negeri 17 Kota Jambi. This type of research is a quasi-experiment with a pre-test post-test control group design. The research sample consisted of two classes: the experimental class (VII C) with 32 students who received the STEM-based PBL model treatment, and the control class (VII E) with 31 students who used the direct instruction model. The research results science literacy skills improved, with an average pre-test score of 58.5 and a post-test score of 79.75, while the control class increased from 38.32 to 60.38. The N-Gain value for science literacy in the experimental class was 50.83 (moderate category), which was higher than the control class's 38.32. The t-test results show a significance value of $0.037 < 0.05$, which means there is a significant difference between the two groups. It can be concluded that the implementation of the STEM-based PBL model is effective in improving students' science literacy skills in science learning.

Keywords: 21st-century skills; PBL; Science learning; Science literacy; STEM

Introduction

The implementation of PBL and STEM in Indonesia still faces challenges (Akhdinirwanto et al., 2020). Many teachers still don't fully understand how to integrate STEM into problem-based learning. Teachers also face other obstacles such as a lack of facilities and resources to support STEM-based learning in schools. Although the PBL model is effective in improving students' conceptual understanding, its implementation is still limited because teachers tend to use conventional methods that are easier to manage in the classroom (Paramitha et al., 2023; Kusuma et al., 2025). The STEM-based PBL model encourages students to work collaboratively on STEM-based problems, enhancing scientific literacy thru information exploration from various sources, data analysis, and evidence-based problem-solving. Science literacy is not only a tool for developing academic competence, but also shapes students' characters to be responsive to scientific and technological developments, and to be able to actively

participate in a science-based society (Suryanti et al., 2025; Vrtič, 2022). Students with science literacy skills are those who can solve problems using scientific concepts acquired thru education (Wen et al., 2020; Husna et al., 2022). Science literacy helps students understand how natural phenomena and technology contribute to the work being done, as well as how to use technology effectively (Pratama et al., 2025; Doyle, 2025).

Science literacy can assist students in solving problems using scientific concepts learned in education (Diantari et al., 2025; Auralia & Juliani, 2024). Scientific literacy skills in Indonesia have not yet reached ideal standards. In reality, the level of scientific literacy in Indonesia is still considered low (Ermiyawati et al., 2025; Putri et al., 2025). A survey conducted by the Program for International Student Assessment (PISA) in 2019, released by the Organization for Economic Co-operation and Development (OECD), ranked Indonesia 69th out of 80 countries, placing it among the bottom 12 countries with low science literacy levels (Krichen et al., 2024; Valeeva et al., 2023). PISA data serves as an important

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foundation in the world of education because it provides an objective overview of students' scientific literacy abilities (Trisanti et al., 2025; Valio et al., 2025). This result can be used as a reference and inform policy-making to design more effective learning strategies, methods, and models for improving scientific literacy skills. The data from the report of SMP Negeri 17 Kota Jambi shows that for the indicator of students' scientific literacy skills, the minimum competency has been achieved with a good category, reaching 77.27%. However, this score is not sufficient to indicate that students' scientific literacy skills are at a high level. This data is also consistent with the results of the science literacy test conducted at SMP Negeri 17 Kota Jambi.

The results of the science literacy test for 57 students at SMP Negeri 17 Kota Jambi show that the students' literacy skills are still considered low. The test results provide a consistent picture, indicating that students face a number of challenges in science learning. Teachers stated that to complete the given tasks and train cooperation among students, science literacy skills can be honed. The problems faced by teachers and students in class VII phase D at SMP Negeri 17 Kota Jambi require a solution by implementing STEM-based problem-based learning to improve students' scientific literacy in science lessons at SMP Negeri 17 Kota Jambi.

Method

The type of research uses a quasi-experimental design involving two groups: an experimental group and a control group. The control group was not given treatment using the STEM-based PBL model, while the experimental group was given treatment using the STEM-based PBL model. The research design used is the pre-test post-test only control group design. The research was conducted at SMP Negeri 17 in Jambi City. This research will be conducted in the fall semester of the 2025/2026 academic year. The sampling technique used in this study is random sampling. The sample for this study was class VII E, consisting of 31 students as the control group, and class VII C, consisting of 32 students as the experimental group. The type of research data is primary data. The data was obtained directly from the student data source.

The data collected were pre-test and post-test scores. The research instrument consisted of an objective test, the validity of which was then tested using the product-moment correlation > 0.05. Reliability was tested using the Cronbach Alpha (α) test, and item discrimination and difficulty were tested using three index categories: difficult, moderate, and easy, with a distribution of 50% (moderate), 30% (easy), and 20% (difficult). Wahab et al. (2023) states that the proportion

of difficulty levels can be arranged in a 3-5-2 ratio, meaning that 30% of the test items are easy, 50% are moderate, and 20% are difficult. Data collection techniques using observation, tests, and documentation. Data collection techniques with normality testing using the Kolmogorov-Smirnov test, homogeneity testing using the Levene test, hypothesis testing using the t-test, and N-Gain test.

Result and Discussion

The results of the statistical test on the effect of the STEM-based PBL model on science literacy of seventh-grade students at SMP Negeri 17 Kota Jambi can be seen in Table 1. This data is the result of a comparison between the control group and the experimental group to test the research hypothesis regarding the effect of this learning model on improving collaboration skills.

Table 1. Statistical test results of implementing the STEM-based PBL model on science literacy skills of 7th grade students at SMP Negeri 17 Jambi City

Parameter	Class		Information
	Control	Experiment	
N-Gain	35.32%	50.83%	Effectiveness 15%
Test Kolmogorov-Smirnov	0.06	0.06	Normally distributed 1
Test Levene		0.62	0.62 > 0.05 Homogeneous variance
Test-t		0.030.03	<0.05 H _a accepted

The N-Gain test aims to determine the effectiveness of using the STEM-based PBL model on students' science literacy skills by calculating the difference between pre-test and post-test scores. Based on the N-Gain Score test results, the score for control class students was 0.3532, indicating a moderate category. Experimental class students obtained an N-Gain Score of 0.5083, also indicating a moderate category. Based on the results obtained, the data shows that science literacy skills in the experimental class increased by 0.15 or 15% compared to the control class. Normality testing of collaboration ability was conducted using the Kolmogorov-Smirnov test. The normality test aims to determine whether the data obtained in the experimental and control classes come from a population with a normal distribution or not. Based on the data above, the control class obtained a value of 0.064 > 0.05, indicating a normal distribution, while the experimental group obtained a result of 0.060 > 0.05, also indicating a normal distribution for both groups. The data from the normality test results of pre-test science literacy can be seen in Appendix 16.

The homogeneity test aims to determine whether the two sample groups are homogeneous or not. The homogeneity test used is the Levene's test. The results of

the homogeneity test were $0.62 > 0.05$, indicating that the variance data were homogeneously distributed. The data from the pre-test homogeneity test results can be seen in Appendix 16. The t-test is a paired samples test used to test the hypothesis. The results of the paired samples test were $0.037 < 0.05$, indicating that H_a is accepted.

Increased science literacy because the STEM approach in PBL integrates science, technology, engineering, and mathematics in a real-life context (Nur & Ikhsan, 2024; Bahriah & Irwandi, 2018). Students can understand science concepts more meaningfully and connect them to everyday life (Drymiotou et al., 2021; Aidoo, 2024; Rusmansyah et al., 2023). The analysis results show a significant difference between the science literacy scores of the experimental group and the control group, with a significance value (p) of $0.000 (< 0.05)$. The average post-test score of the experimental group was higher than that of the control group. The conclusion of this study indicates that STEM-based learning is effective in improving students' scientific literacy on the topic of temperature and heat (Ratnasari et al., 2023; Utami et al., 2025). The results of the study show that the paired t-test indicates a significant improvement in students' scientific literacy skills in both groups, and the N-Gain test results for scientific literacy show an increase in scientific literacy in both groups with high criteria, so it can be concluded that the STEM-based PBL model is effective in improving students' scientific literacy (Sholihah et al., 2023; Purnomo et al., 2023).

The results prove that the STEM-based PBL model can improve students' critical thinking, science process skills, scientific literacy, achievement, problem-solving skills, learning interest, learning motivation, and conceptual understanding in science learning (Sarwi et al., 2021). Students who have science learning problems related to these variables can be addressed using STEM-integrated PBL (Simanjuntak & Purwaningsih, 2024; Pozuelo-Muñoz et al., 2025). STEM-based PBL learning is a learning approach that integrates science, technology, engineering, and mathematics elements in solving real-world problems (Lee & Lee, 2025; Le et al., 2023). Students not only understand scientific concepts but are also trained to use technology as a presentation medium, design or modify solutions, and mathematically process experimental data. However, not all STEM aspects are implemented with equal weight in every activity. Learning that integrates two or more disciplines can still be categorized as STEM-based. The research results confirm an imbalance in representation between disciplines in STEM research and educational practice, where science (45%) tends to be more dominant than technology (12%), engineering (9%), and mathematics (15%). Nevertheless, it can be

said to be STEM-integrated even if not all aspects are implemented equally, as it allows for the connection between two or more disciplines in supporting problem-solving and achieving learning goals (English, 2016; Xu et al., 2024). The research results indicate that the simultaneous application of STEM-based PBL has a positive effect on students' scientific literacy (Suciana et al., 2023).

STEM-based learning uses science, technology, engineering, and mathematics in a real-world context that connects schools, the world of work, and the global world to develop literacy, enabling students to compete in the 21st century (Fathoni, 2020; Herlinawati et al., 2024). STEM-based PBL can develop 21st-century skills such as scientific literacy, communication, creativity, and collaboration, which are crucial for students in facing global challenges (Megawati, 2024). The research explains that STEM-based learning can be applied to science learning, supported by research results showing that STEM learning can improve science literacy, creativity, mastery of scientific concepts, collaboration, and student learning outcomes during the learning process. STEM, which is related to four fields of science (science, technology, engineering, and mathematics), can work well if applied to science learning (Akbariah et al., 2023; Tairas et al., 2025).

Conclusion

Based on the research that has been conducted, it can be concluded that the STEM-based PBL model has a significant effect on students' science literacy in 7th-grade science subjects at SMPN 17 Kota Jambi. The STEM-based PBL model is an innovative solution that is highly recommended for science learning, especially on temperature and heat topics, because it has been empirically proven to optimize learning outcomes and prepare students to face the global challenges of the 21st century.

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Author Contributions

Conceptualization, methodology, validation, A.Z.; formal analysis, investigation, M.F.; resources, data curation, writing—original draft preparation, S.; writing—review and editing, visualization, M.C. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The researchers funded this research independently.

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