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Implementation of Problem Based Learning Integrated STEAM (PBL-STEAM) to Improve Students Science Literacy: A Case Study at SMPN 3 Blitar

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ABSTRACT

This study aims to determine the improvement of students' science literacy skills after applying the STEAM integrated problem-based learning model at SMPN 3 Blitar. This study used quantitative research with a pre-experimental design method, with a research design of one group pretest-posttest design. Data was analyzed using Wilcoxon and n-Gain tests. The results showed that the STEAM integrated problem-based learning model effectively improved students' science literacy skills. The Wilcoxon test results show a p-value of 0.000 (<0.05), which indicates a significant increase. There was an increase in the average score of 0.66, with 38% of students achieving a high n-Gain score and 62% in the medium category.

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1. Introduction

Learning in Indonesia focuses on 21st century learning which is achieved through strengthening 4C competencies which include critical thinking, collaboration, communication, and creativity (Andrian & Rusman, 2019). The relationship between the 21st century and science literacy is increasingly important along with the complexity of the problems faced by the modern world. With the rapid development of technology, it requires individuals to have a deeper understanding of science. Science literacy as an important goal in science learning and encourages students to actively participate in learning activities and increase curiosity because they have the opportunity to recognize and discover various applications of science in everyday life (Chandrikasari & Qosyim, 2019). Thus, science literacy plays an important role in the context of education, which is the main topic about preparing students to face various issues and technological

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developments in the 21st century era.

Based on PISA (Program for International Student Assessment) in 2022, the ranking of Indonesian students' science literacy test was 70 out of 81 countries consisting of 37 OECD countries and 44 partner countries (OCDE, 2024). This shows that the quality of Indonesian students' science literacy has not improved significantly with a score of 359 from the maximum score of 543 achieved by Singapore (Hafizah & Nurhaliza, 2021). The cause of low science literacy is teacher cantered learning so that students tend not to actively participate in learning. As a result, students are less able to gather information. In addition, the factors of student background, interest, learning intensity, and student attitudes towards science also influence the low achievement of students' science literacy (Lendeon & Poluakan, 2022).

Based on the results of interviews with 8th grade science teachers at SMPN 3 Blitar, it shows that the learning model used still uses a learning model that is commonly used in daily teaching and learning activities such as teacher-centered and the material presented is focused on memorization. In addition, the results of the science literacy ability test that has been conducted on students at SMP Negeri 3 Blitar City that science literacy in the school is still low as evidenced by the value of the science literacy ability test of 48%. The criteria for assessing the percentage of science literacy skills show that if the interval is ≤ 54%, then the level of science literacy is categorized as low (Wahyuni, 2019). Teaching and learning activities often use the lecture method, which causes students to be less active in the learning process.

Learning models are very important for the development of students' science literacy, so to overcome and improve students' science literacy, teachers can use various learning models. One of the learning models that is in accordance with the Student Centered pattern is Problem Based Learning (Sukirno Putri et al., 2021). The Problem Based Learning model is a learning model based on many problems that require authentic investigation, namely investigations that require relevant solutions from concrete problems. In line with this, one way to improve students' scientific literacy skills is to provide treatment that can encourage an optimal level of critical thinking. One treatment that can be applied is the STEAM learning approach, which is an integration of Science, Technology, Engineering, Arts, and Mathematics.

PBL-STEAM is learning that solves problems in everyday life by integrating STEAM science (Jihanifa et al., 2023). The PBL-STEAM connection can be seen from the PBL syntax, one of which is the syntax of organizing students. At that stage students identify what they already know, what they need to learn, and how they will solve the given problem. Students identify the skills and knowledge required from various STEAM fields to solve the problem. By combining the STEAM approach and problem-based learning models, students can not only solve problems with only concepts, but they can also see how to apply these concepts to the solutions they make (Iolanessa et al., 2020). Based on this background, the purpose of this study is to determine the effect of STEAM integrated problem-based learning model on students' science literacy skills.

2. Method

This study used a quantitative approach and pre-experimental method, using one class without a control class. By using a one group pretest-posttest design. The initial stage carried out is to give a pre-test question and then the treatment is carried out, namely the STEAM integrated problem-based learning model on additive material. Post-test questions are given after treatment with the same questions. The concept of this research can be described as follows:

Table 1. The research design used pretest and posttest.

Pretest	Treatment	*Posttest*
O_1	X	O_2

The sample used was class VIII-F SMP Negeri 3 Blitar in the 2024/2025 school year consisting of 32 students. The sampling technique in this study used purposive sampling technique. The test instrument is in the form of multiple choice totalling 10 items of multiple-choice questions. Contains 2 domains of science literacy that are measured, namely the competency domain and the knowledge domain and 5 literacy levels, namely levels 2, 3, 4, 5 and 6.

The test data were analysed using normality test analysis, t-test if normally distributed or using Wilcoxon test if the data were not normally distributed and n-gain to determine the increase. The N-gain calculation was carried out using the N-gain index analysis as follows:

$$< g > = \frac{SPost - Spre}{Smax - Spre}$$

(Sukarelawa, 2022)

Information:
$< g >$ = N-Gain
Spre= Initial score (*pretest)*
$Spost$ = Final score (*posttest)*
Smax = Maximal score

Table 2. Category of Science Literacy Improvement Using N-Gain

Nilai (g)	Kategori
(g) ≥ 0,7	High
0,7 > (g) ≥ 0,3	Medium
g < 0,3	Low

(Sukarelawa, 2022)

3. Results and Discussion

Results

The results showed that researchers obtained better science literacy skills during the pretest and posttest. With the significance value of the Wilcoxon test 0,000 <0.05, H_0 is rejected and H_1 is accepted, which means that there is a difference in pretest and posttest after the application of STEAM integrated problem-based learning on science literacy skills. This shows that applied learning is effective in improving students' science literacy skills.

Test Statistics[a]

	Posttest Literasi Sains - Pretest Literasi Sains
Z	-4.984[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Figure 1. Wilcoxon Test Results

The improvement of science literacy skills can also be seen through the N-Gain value of the pretest and posttest results presented in Table 3 below.

Table 3. N-Gain Results of Pretest and Posttest

Student Code	Value		N-Gain	Category
	Pretest	*Posttest*		
1	50	80	0,60	Medium
2	60	90	0,75	High
3	50	80	0,60	Medium
4	70	90	0,67	Medium
5	60	80	0,50	Medium
6	20	70	0,63	Medium
7	60	90	0,75	High
8	50	70	0,40	Medium
9	70	90	0,67	Medium
10	30	70	0,57	Medium
11	60	90	0,75	High
12	40	70	0,50	Medium
13	50	90	0,80	High
14	70	90	0,67	Medium
15	60	100	1,00	High
16	30	80	0,71	High
17	50	90	0,80	High
18	70	90	0,67	Medium
19	20	80	0,75	High
20	60	80	0,50	Medium
21	40	70	0,50	Medium
22	30	80	0,71	High
23	70	90	0,67	Medium
24	20	80	0,75	High
25	40	70	0,50	Medium
26	60	100	1,00	High
27	70	90	0,67	Medium

Student Code	Value		N-Gain	Category
	Pretest	*Posttest*		
28	70	90	0,67	Medium
29	60	80	0,50	Medium
30	30	90	0,86	High
31	70	90	0,67	Medium
32	50	70	0,40	Medium
Average	**51,3**	**83,4**	**0,66**	**Medium**

Based on Table 3, the pretest and posttest results show that the average N-Gain is 0,66 which is included in the moderate category. This can be interpreted that the application of the STEAM-integrated Problem Based Learning model on additive materials can improve students' science literacy skills. The following is a percentage diagram that presents the increase in pre-test and post-test students in class VIII-F.

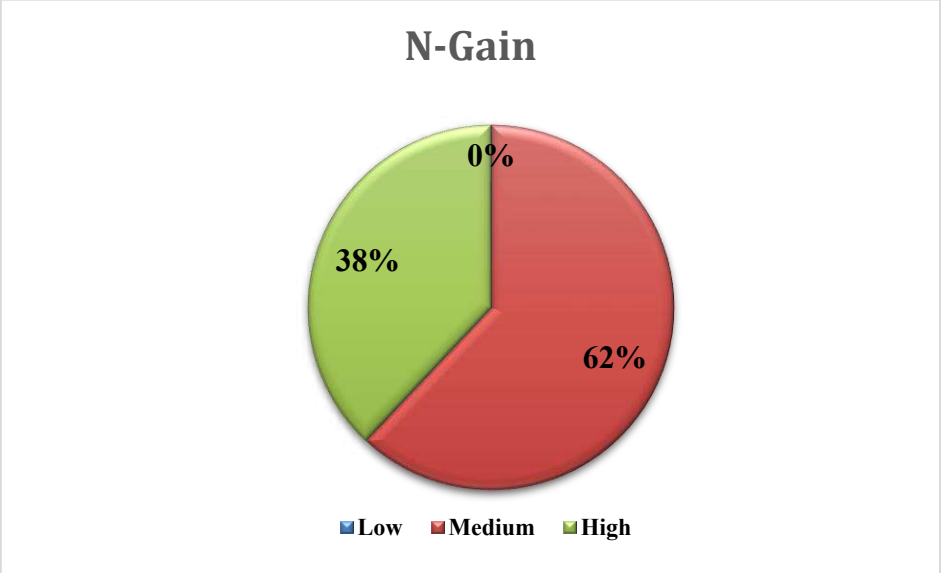

Figure 2. Diagram of Science Literacy Improvement

The improvement categories in Figure 2 are based on the categories proposed by (Sukarelawa, 2022). Based on Figure 2, 0% of students who have low improvement, 62% have moderate improvement and 38% have high category improvement.

The increase in students' science literacy skills is influenced by the increase in the achievement of science literacy levels and the average of each indicator of students' science literacy skills. The results of the percentage increase in the achievement of science literacy levels are as follows.

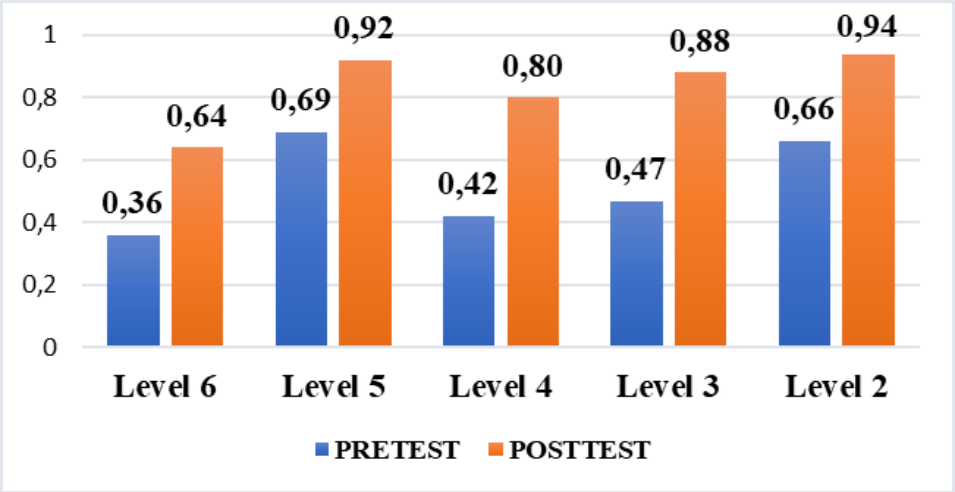

Figure 3. Average achievement of science literacy level

Based on Figure 3, the graph of the achievement of science literacy levels has increased at each level. At level 6 there was an increase of 0,28. At level 5 there was an increase of 23%. At level 4 it experienced an increase of 38%. At level 3 there was an increase of 41%. Level 2 experienced an increase of 28%. The highest increase in science literacy level achievement at level 3 and the lowest increase at level 5.

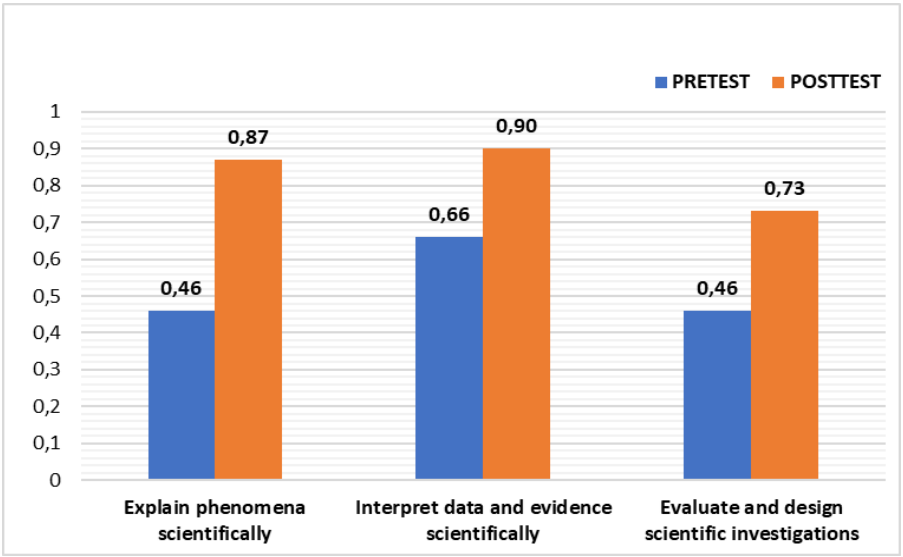

Figure 4. Average Science Literacy score by Domain Competency

Based on Figure 4, the average score of Science Literacy according to Indicators. The indicator of explaining scientific phenomena has increased by 0,41. The indicator of interpreting data and evidence scientifically has increased by 0,24. The indicator of evaluating and designing scientific investigations increased by 0,27. The highest increase occurred in the indicator of explaining phenomena scientifically.

In addition to the results of the data above, the following are the results of teacher interviews that have been conducted at SMP N 3 Blitar related to the STEAM integrated problem-based learning model:

Teacher Interview Format

School Name: SMP N 3 Blitar
Day/Date: Tuesday, December 6, 2024
Research Title: "Implementation of STEAM-integrated PBL Model to improve science literacy of junior high school students"
Respondent: Yayuk S.Pd.

No.	Question	Answer
1.	What/how is the learning model for science that is often used at school?	The model I usually use is Discovery Learning
2.	Have you ever used the PBL model? If so, is it often?	Never used the PBL model
3.	Have you ever heard of the STEAM approach? if so, has it been applied?	I have heard, but have never been applied in class
4.	What is the condition of students' science literacy in science? Is it low, medium or high? What does it prove? For example: grades etc. What activities have the school done to improve science literacy?	The condition of science literacy of students in science subjects at SMP N 3 Blitar is in the medium category. There are still some students who are reluctant to implement the literacy program held by the school every morning.
5.	How is science learning at school, is it often practicum or not?	Learning science when in class depends on the material being studied. Adjusting the material
6.	What is the cause of low science literacy?	In my opinion, many students do not see the importance of literacy in everyday life. This makes them less enthusiastic in learning. In addition, the environment around students does not support the development of science literacy - for example, there is no culture of asking questions or discussing scientific phenomena in everyday life

Student Name: Faris Maulana
Day/Date: Tuesday, December 6, 2024

No.	Question	Answer
1.	Have you ever done lab work or experiments in science lessons?	So far, science lessons have only been from books and blackboards. Never practiced directly in class or in the lab. "Sometimes I only see pictures or videos but never hold the tools directly. So sometimes I'm confused about how to imagine the process.
2.	Have you ever heard the term "STEAM" in school lessons?	I have never heard the term STEAM.
3.	If not, what do you think when you hear the word "STEAM"?	If it has something to do with art and technology, it seems interesting. But so far it has never been taught at school

Based on the results of teacher and student interviews above, they have never used the Problem Based Learning model, which is very relevant to strengthening science literacy because it encourages solving real problems. The teacher also stated that he had heard of the STEAM approach but had not applied it in learning. This is consistent with the answers of students who claimed to have never heard the term STEAM at all.

According to the teacher, students' science literacy is in the medium category. Some students seem reluctant to participate in the literacy program held every morning. his shows that students' awareness of the importance of science literacy is uneven. The teacher also mentioned that the cause of low science literacy is because students have not seen the relevance of science in everyday life, and the surrounding environment does not encourage a culture of scientific inquiry or discussion.

Discussion

From the pretest and posttest data, students' science literacy skills have increased. This can be seen from the average n-gain result of 0.66 which is included in the moderate category. The results of the Wilcoxon test which showed 0.000 <0.05 further strengthened this. Because the value of 0.000 is smaller than 0.05, it can be concluded that there is a significant difference between the pre-test and post-test after the application of the STEAM integrated problem-based learning model.

Figure 3 shows the highest increase at level 3 with an increase of 0.41. At level 3, students can use knowledge considering material that is complex enough to examine relevant phenomena, students can combine procedural knowledge to conduct simple experiments and provide supporting evidence for scientific claims. In addition to the increase in science literacy achievement, the posttest results showed the highest achievement at level 3. This is in line with the research of Saptaningrum et al., (2023) the level of science literacy at level 3 can mean that most students have a sufficient level of mastery of science literacy.

Overall levels 2, 3, 4, 5, and 6 experienced an increase in science literacy achievement. The treatment of STEAM-integrated problem-based learning model has an impact on increasing the level of science literacy. Research conducted by Nurul Firdausi Nuzula and Elok Sudibyo (2022) explained that the problem-based learning model learning obtained a positive response from students with a very good category that supported the growth of students' science literacy skills so that it could develop students' science literacy competencies. According to Arends in his book, problem-based learning is an approach in which students face real problems with the aim of building their own knowledge, developing higher-order thinking skills, and increasing independence and self-confidence (Arends, 2014). The knowledge is used to interpret data based on scientific facts and evidence. So that students are triggered to explore the case given by the teacher in the student worksheet.

The average score of science literacy according to indicators, the highest difference in the competency domain of explaining phenomena scientifically. The highest increase in pretest and posttest scores based on the competency domain is explaining phenomena scientifically with a difference of 0.41. This is because in learning, students are presented with scientific phenomena on student worksheets

and asked to ask research questions and analyze problems from the phenomena that occur. The teacher invites students to discuss phenomena that occur around the environment and the application of science in the learning process. So that students when working on the posttest students can answer competency questions to explain phenomena scientifically with a very good average. This is in line with the research of NURUL et al., (2021) students are trained to identify cases that exist around the environment and analyze thoroughly. From this activity students can answer questions well. These activities result in students being more active in exploring ideas and finding solutions to problems (Wulansari et al., 2019).

Average increase in science literacy scores according to the lowest competency in interpreting data and evidence scientifically with a difference of 0.24. The low competency of interpreting data and evidence scientifically is due to the lack of students' ability to use scientific knowledge and provide explanations for the data found. So that the increase in the competency of interpreting data and evidence scientifically is lower than the competency of explaining phenomena scientifically and evaluating and designing scientific investigations because it is supported by assistance from teachers to determine research questions. Therefore, students take longer to master the competency of interpreting data and evidence scientifically because the abilities of students required in this competency are more complex (Azrai et al., 2020). One way to improve understanding of communicating conclusions related to evidence and making reflections based on the social implications of scientific conclusions can be using STEAM integrated learning. STEAM-integrated learning involves students in problem-solving activities related to science, technology, engineering, art, and mathematics (Estriyanto, 2020).

Specifically, students with high N-Gain categories generally show stronger mastery in the aspect of explaining phenomena scientifically, because the PBL-STEAM approach encourages students to understand concepts through real contexts and analyze the phenomena raised in the student worksheet. In line with the previous results, the highest increase based on indicators occurred in the competency of explaining scientific phenomena with an average difference of 0.41, which indicates that students can connect science concepts to the real world. Meanwhile, students in the medium N-Gain category generally experienced challenges in the competency of interpreting data and evidence scientifically. This can be seen from the results of the previous analysis which showed a difference of only 0.24 in this respect. This competency requires a high ability to think analytically and interpret experimental data or graphs, which has not been fully mastered by most students. According to Azrai et al. (2020), this aspect does take longer to master because it involves higher-level thinking skills and basic statistical understanding.

Therefore, although the N-Gain results are in the medium category overall, this analysis provides insight that the aspect of interpreting data and scientific evidence is an area that requires further attention and strengthening. Future learning strategies need to be directed at improving the ability to interpret data, analyze graphs, and evidence-based scientific arguments. The application of STEAM learning that is more oriented towards data exploration, processing of experimental results, and data-based reflection can strengthen this aspect. Estriyanto (2020) stated that STEAM integration is effective in improving students' analytical thinking skills when learning is focused on data-based project exploration and in-depth scientific discussions.

Based on interviews and literature reviews, it is known that students' science literacy achievement is not only influenced by classroom learning strategies but also by various external factors. These external factors include family environment, socioeconomic background, access to learning resources, and the influence of media and technology. In the interviews, teachers and students both stated that limited learning support at home is one of the causes of students' difficulties in understanding science lessons in depth. For example, students who do not have parents who actively accompany learning or do not have adequate learning facilities at home (such as science books, the internet, or a quiet environment) tend to experience obstacles in developing their science literacy skills.

Research by Anjani and Suryadi (2020) in the Indonesian Journal of Science Education shows that the family environment greatly influences students' attitudes and interest in science. Children from families who have a habit of discussing, reading books or paying attention to scientific events around them tend to have higher science literacy. In addition, socioeconomic status also affects students' access to science learning resources. Students from lower socio-economic families often do not have access to technology, reference books or extracurricular activities that support the development of scientific thinking skills. In addition, the influence of media and technology is also part of the external factors that can have both positive and negative impacts. Extensive access to digital-based educational content can enrich students' science understanding, but a lack of digital literacy and supervision can also result in students consuming more entertainment content than scientific content. Research by Fitriani et al. (2019) mentioned that the skills of managing digital technology and the ability to sort information from the internet are an important part of modern science literacy.

4. Conclusions

Based on the results of the research and discussion that has been described, it is concluded that the application of STEAM integrated problem-based learning significantly improves students' science literacy skills with an average n-gain of 0.66 which is included in the moderate category. This increase shows that the STEAM-integrated problem-based learning model is an effective method for developing students' analytical, problem-solving, and science literacy skills.

The learning developed in this study, namely through the Problem Based Learning model integrated with the STEAM approach, aims not only to improve students' conceptual understanding in the short term, but also has significant long-term benefits in shaping 21st century life skills. The science literacy built through this approach does not simply emphasize mastery of scientific facts, but also develops critical thinking, problem solving, collaboration, and creativity. This is important to prepare students for the complex and ever-changing challenges of the real world, especially in the digital era and industrial revolution 4.0.

In the long run, students who have good science literacy will be better prepared to become citizens who are able to make evidence-based decisions, contribute to environmental and social issues, and understand the impact of science and technology on their lives. They will also have a strong foundation of scientific thinking, which will be beneficial in various professions, not only in science, but also in everyday life, such as in making health decisions, understanding the news,

or assessing information circulated in the media. Research by Laugksch (2000) confirms that science literacy is an important component of modern citizenship education as it helps individuals to understand the world rationally, make intelligent decisions and actively participate in society. Therefore, the long-term benefits of this learning are not only seen in the improvement of academic grades, but also in character building and students' readiness to become lifelong learners.

Suggestions that can be given for further research this research as input for teachers at school in learning to use the STEAM integrated Problem Based Learning model to improve students' science literacy and habits in making groups independently in other subjects, need good organization and communication in making heterogeneous groups to minimize wasted time.

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