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# The Effect of Problem-Based Learning within Socioscientific Contexts on Students' Scientific Literacy and Argumentation Skills

Ade Putri Purnamasari[1*], Ketut Suma[1], Ni Ketut Rapi[2]

[1] Science Education, Postgraduate Program, Universitas Pendidikan Ganseha, Singaraja, Indonesia.
[2] Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Pendidikan Ganseha, Singaraja, Indonesia.

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Corresponding Author:
Ade Putri Purnamasari
ade.putri@student.undiksha.ac.id

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**Abstract:** Scientific argumentation is a critical cognitive and social skill that enables students to evaluate claims, assess evidence, and communicate reasoning logically—skills central to scientific literacy. The main objective of this study is to compare the effectiveness of the PBL-SSI vs. PBL model on improving students' Scientific Literacy and Scientific Argumentation Skills. This type of research is a quasi-research with a pre-test post-test non-equivalent control group design. The study population was all 233 students of grade VII of SMP Negeri 1 Sidemen in the 2024/2025 academic year. Based on the analysis, the results found: there are differences in scientific literacy and scientific argumentation skills of students who learn using problem-based learning models in the context of socio-scientific issues with problem-based learning models ($F = 2.44$; $p < 0.05$), there are differences in scientific literacy who learn using problem-based learning models in the context of socio-scientific issues with problem-based learning models. ($F = 56.96$; $p < 0.05$), there is a difference in the scientific argumentation ability of students who learn using a problem-based learning model in the context of socio-scientific issues with a problem-based learning model ($F = 39.86$; $p < 0.05$). There is a positive influence of 97% on the problem-based learning model in the context of socio-scientific issues on improving students' scientific literacy and scientific argumentation abilities.

**Keywords:** PBL (Problem-Based Learning Model); PBL-SSI (Problem-Based Learning Model in the Context of Social and Scientific Issues); Scientific argumentation; Scientific literacy

## Introduction

Scientific Literacy is a crucial skill for students to apply science appropriately, making them scientifically literate (Husna et al., 2022). Scientific literacy encompasses not only an understanding of science but also the ability to apply scientific knowledge and processes in real-world situations to solve personal, social, and global problems (Vo & Simmie, 2025). The meaning of scientific literacy continues to evolve from a focus on memorizing concepts, to assessing risks and their impact on society (Valladares, 2021), to emphasizing social, cultural, political, and environmental issues (Geerts et al., 2023). Its three main visions are: Vision I (conceptual understanding), Vision II (scientific practice/inquiry), and Vision III (application of science and technology in everyday life) (Sjöström, 2025). The Socio-Scientific Issues (SSI) approach is highly compatible with Scientific Literacy because it focuses on the humanistic aspects of science and the character development of global citizens (Zeidler et al., 2019). SSI involves socio-scientific issues

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relevant to people's lives (Dusturi et al., 2024). SSI is important because it makes science learning relevant, enhances student argumentation, and is a key component of Scientific Literacy (Sadler, 2020). Improving the quality of human resources requires argumentation skills that involve scientific concepts, principles, and practices with social, political, ethical, and economic considerations (Istiana & Herawatia, 2019). Argumentation is an effort to prove the truth of a statement with facts (Rahayu et al., 2020). Providing opportunities for students to argue is an effort to improve scientific literacy (Fadlika et al., 2022). The quality of science learning needs to be improved to be applicable and develop thinking skills (Bahri et al., 2021). Government efforts (PPG, Merdeka Curriculum, etc.) aim to improve teacher and learning quality.

Based on the results of the 2022 PISA, Indonesia's average scientific literacy score (383 points) is still low (ranked 68th out of 81 countries), lower than the OECD average (485 points) and even lower than the 2018 PISA score (396 points). The low scientific literacy is confirmed by various other studies (Hidayah et al., 2019; Sujudi et al., 2020; Maulina et al., 2022), influenced by factors such as reading interest, evaluations that are not yet literacy-oriented, and lack of teacher knowledge. Students' Scientific Argumentation Ability is also relatively low (Wulandari et al., 2023), caused by a lack of argumentation habits, weak conceptual understanding, and inappropriate learning models. The dominant lecture method does not provide opportunities for students to understand everyday phenomena and is not optimal in developing scientific literacy (Lendeon & Poluakan, 2022). The Problem-Based Learning (PBL) model is based on authentic investigations to solve real problems and build students' conceptual understanding through everyday life problems (Akcay & Benek, 2024). PBL Support for Scientific Literacy: PBL has been proven to be effective and has a significant influence in improving students' Scientific Literacy in the aspects of competence, knowledge, context, and attitude; PBL-SSI Support for Scientific Literacy & Argumentation: SSI is suitable for use as a context because it is open-ended and involves social, political, economic, and ethical aspects (Azizah et al., 2021).

PBL with SSI contexts (PBL-SSI) is recommended because it trains literacy skills through and has a positive impact on aspects of scientific literacy competencies (Rubini et al., 2019); Empirical Evidence of PBL-SSI: Research shows that PBL-SSI can improve Scientific Literacy higher than pure scientific learning/PBL. PBL-SSI is also better at improving students' argumentation skills than pure PBL (Fang et al., 2019; Anwar et al., 2021). Although numerous studies support the effectiveness of PBL-SSI on Scientific Literacy or on Scientific Argumentation previous research has not simultaneously examined the effect of PBL-SSI on two dependent variables (Scientific Literacy and Scientific Argumentation), nor has it explicitly compared PBL-SSI with pure PBL in this context. Therefore, this study aims to examine the effect of PBL-SSI on these two dependent variables in seventh-grade junior high school students.

## Method

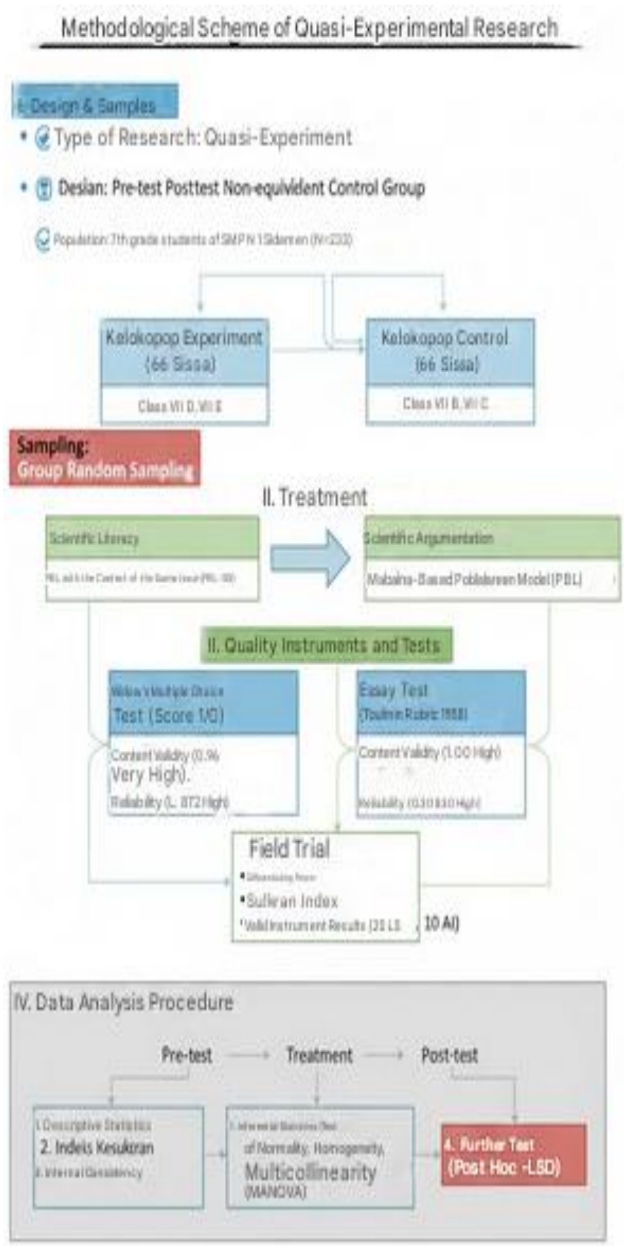


**Figure 1.** Scheme (visual flowchart) representing the research method

This study used a quasi-experimental approach with a pre-test post-test non-equivalent control group design. The study population was all seventh-grade students of SMP Negeri 1 Sidemen (N = 233), from which samples were taken through group random sampling technique, resulting in two experimental groups and two control groups, each totaling 66 students. The independent variable was the learning model: the Problem-Based Learning Model with a Social Science Issue Context (PBL-SSI) applied to the experimental group, and the Problem-Based Learning Model (PBL) applied to the control group. The dependent variables measured were Scientific Literacy and Scientific Argumentation Ability.

The instruments used were a multiple-choice test for Scientific Literacy and an essay test (with Toulmin, 1958 rubric) for Scientific Argumentation, which were given as pre-test and post-test. Both instruments have undergone content validity testing (expert judgment) with very high validity coefficients (Scientific Literacy 0.96 and Scientific Argumentation 1.00), as well as field trials that resulted in 25 Scientific Literacy items and all Scientific Argumentation items being declared valid. The reliability of both tests was also declared very high (K-R 20 Scientific Literacy 0.872; Alpha Cronbach Scientific Argumentation 0.830). Data analysis used descriptive and inferential statistics. The main inferential test was Multivariate Analysis of Variance (MANOVA) after fulfilling the assumption tests (normality, homogeneity, and multicollinearity), and continued with the Least Significant Difference (LSD) test to determine the average differences between specific groups.

## Result and Discussion

The results of the study indicate that a problem-based learning model with a social science issue context is effective in improving students' scientific literacy and scientific argumentation skills at the junior high school level. Based on the descriptive statistics results shown in Figure 2, it shows that the average scientific literacy scores of students in both the experimental and control classes increased.

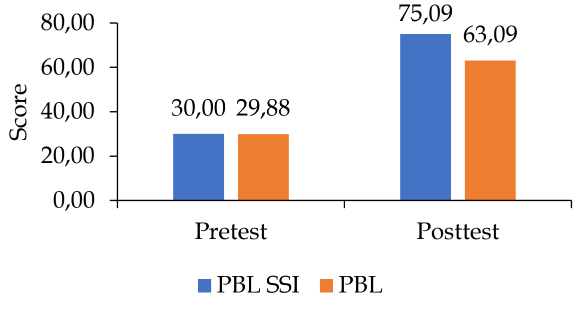


**Figure 2.** Pre-test and post-test average score for scientific literacy

The average normalized score gain (g) in the experimental class was 0.64, while in the control class it was 0.47 (Figure 3). Higher gains were seen in students who used a problem-based learning model with a social science context. This is because the problem-based learning model with a social science context provides a better contribution to improving scientific literacy.

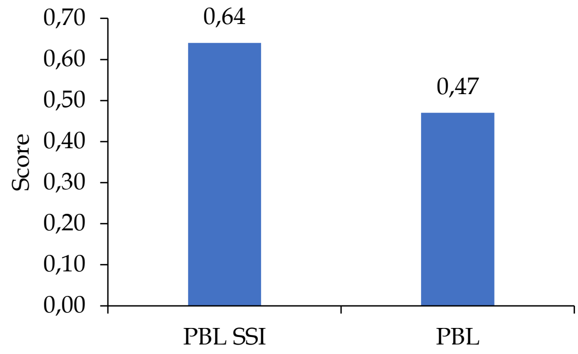


**Figure 3.** Average normalized gain score scientific literacy

Next, the results of the scientific literacy test were analyzed based on context, knowledge, and scientific competency. The results of the scientific literacy test for the scientific context aspect for each indicator are presented in Figure 4.

In the experimental class, the highest score for the context aspect of scientific literacy was in the global context. This is because during problem-based learning within the context of socio-scientific issues, students interact extensively with social and scientific issues that have broad reach and impact. Students now have easy access to a variety of global information through the internet, electronic media, and print media. Students frequently read or watch news, articles, and documentaries that often relate to global scientific issues, so when confronted with these contexts in a test, they feel more familiar or relevant. The results for students' scientific knowledge aspects for each indicator are presented in Figure 5.

In the experimental class, the highest scientific knowledge aspect was epistemic knowledge. Epistemic knowledge is knowledge of ideas and explanations of characteristics essential to the process of knowledge formation in science and its role in proving the truth of knowledge produced by science (Zetterqvist & Bach, 2023). Examples include making observations, forming hypotheses, and providing evidence to support scientific statements. This indicates that students already have an understanding of content and procedural knowledge in the context presented, thus enabling them to master epistemic knowledge. The results for each indicator of students' scientific competency aspects are presented in Figure 6.

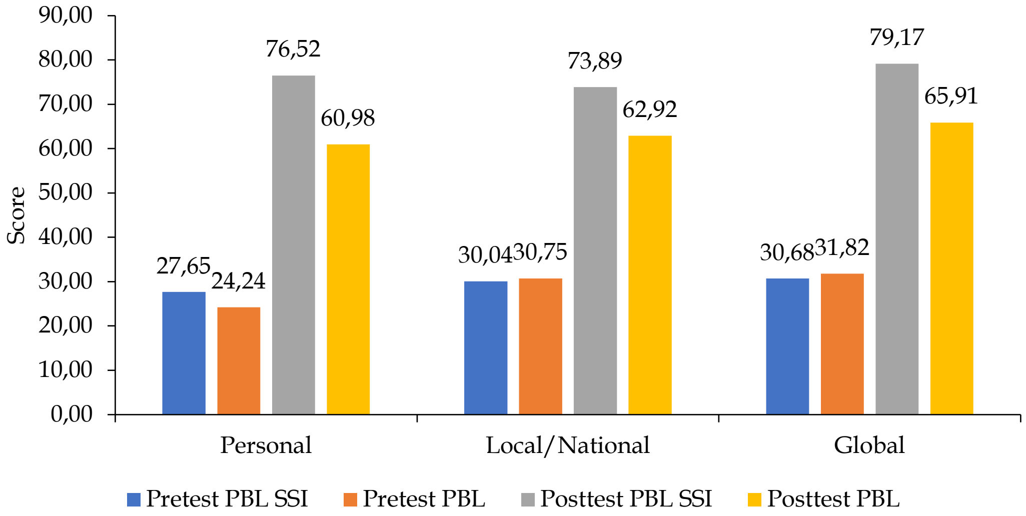


**Figure 4.** Scores for each indicator in the science context aspect

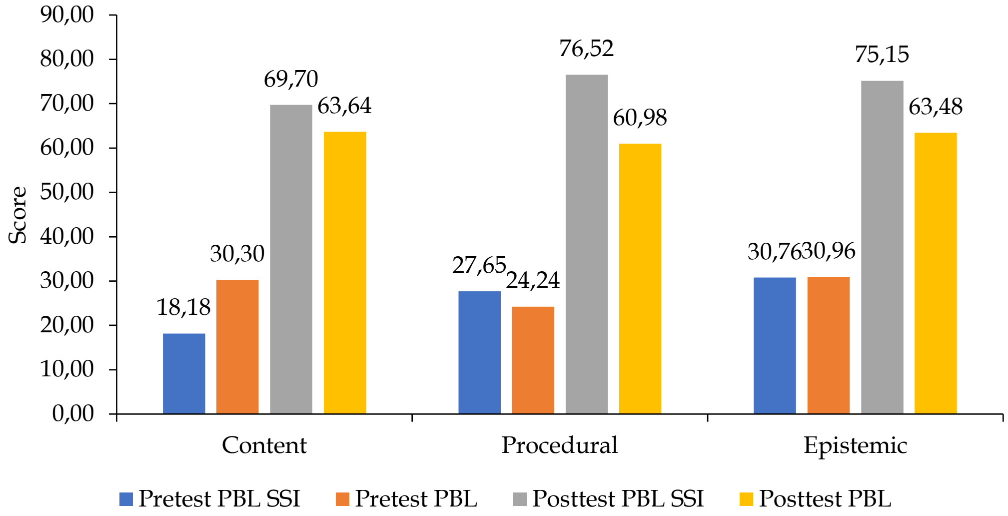


**Figure 5.** Score for each indicator on the science knowledge aspect

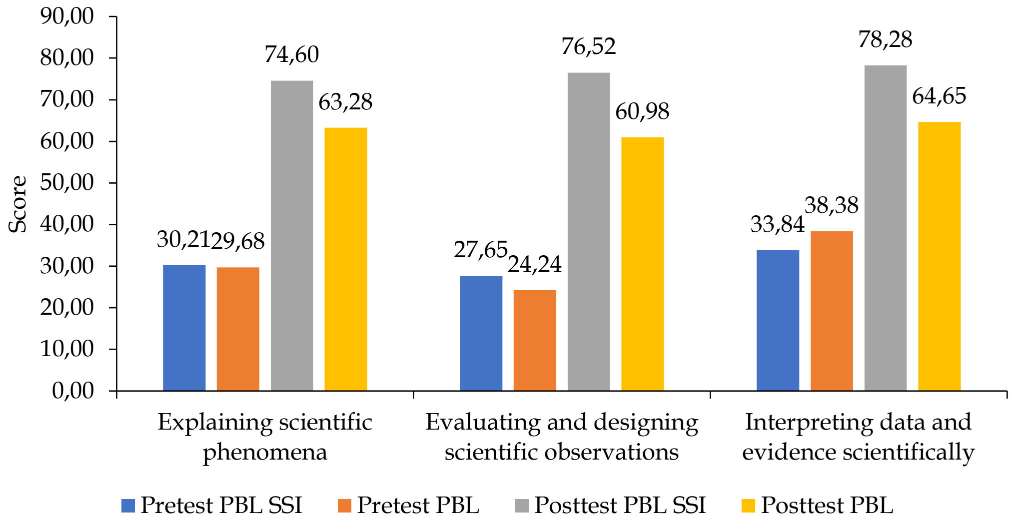


**Figure 6.** Scores for each indicator in the science competency aspect

In the experimental class, the highest science competency is interpreting data and evidence scientifically. Students learn using student worksheets (LKPD) that align with the stages of the problem-based learning model within the context of socio-scientific issues, namely the stages of developing and presenting work, as well as analyzing and evaluating the problem-solving process (Utami et al., 2019). During the development and presentation stages, students engage directly with evidence obtained through discussions. Students also prepare group reports on the results of their discussions, incorporating evidence in the form of data processed into other forms and drawing conclusions based on the data before presenting them. Thus, students are required to have the ability to interpret scientific evidence or data obtained through observation or based on existing theory, which is used to draw conclusions and provide appropriate reasons for accepting or rejecting those reasons.

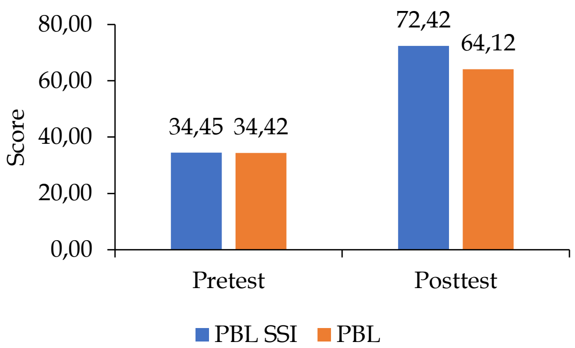


**Figure 7.** Average pre-test and post-test score range for students' scientific argumentation skills

This competency requires knowledge of the key features and practices of experimental investigations and other forms of scientific inquiry (content and procedural knowledge), as well as the function of procedures in justifying any claims made by science (epistemic knowledge). This competency may also require the use of basic mathematical tools to analyze or summarize data. The results of this study align with research conducted by Küçükaydın & Ayaz (2025), which revealed that the highest competency aspect is found in the indicator of interpreting data and evidence scientifically. Achievement of literacy skills in this indicator demonstrates that students have good abilities in identifying assumptions, evidence, and the reasoning behind conclusions drawn in solving problems. In line with the scientific literacy results, scientific argumentation skills also increased, as seen in Figure 6. Based on the descriptive statistics, it can be seen that the average score of scientific argumentation skills of students in the experimental class taught using a problem-based learning model with a social science issue context increased significantly compared to the average score of scientific argumentation skills of students in the control class taught using a problem-based learning model.

The average normalized score gain (g) in the experimental class was 0.58, while the control class was 0.45 (Figure 8). Higher gains were observed among students taught using a problem-based learning model with a social science context.

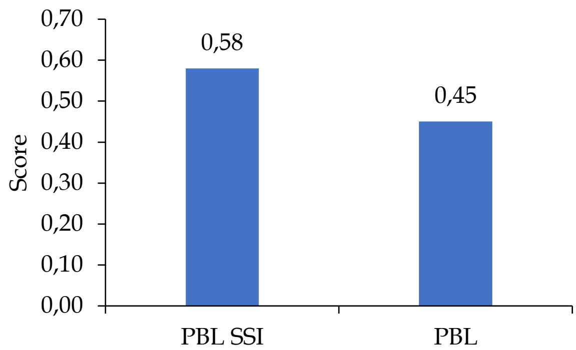


**Figure 8.** Average normalized gain score

The results for students' scientific argumentation abilities for each indicator are presented in Figure 9.

Based on this, there was a difference between the pre-test and post-test scores in the problem-based learning model class with a social science issue context and the problem-based learning model class. In the experimental class, the highest scientific argumentation ability indicator was found in the backing indicator, followed by the warrant, rebuttal, data, and claim indicators. The backing indicator had the highest average because students were able to provide a reasoning linking statements to the evidence provided. Students were able to provide explanations for their own thinking. Students were able to develop existing concepts by providing explanations connecting claims and data. This indicates that students already possess higher-order thinking skills, making the problem-based learning model with a social science issue context effective in developing students' ability to construct logical and strong arguments (Wardani & Fiorintina, 2023).

After descriptive analysis, statistical tests were conducted using MANOVA. The results of the normality test with the Kolmogorov-Smirnov test and Shapiro-Wilk test statistics show that all variables are normally distributed because all $p > 0.05$. The homogeneity of variance test conducted with Levene's Test of Equality of Error Variance shows that the results of the scientific literacy score data show a significance figure of 0.65 and the scientific argumentation ability shows a significance figure of 0.95. This means that the data variance is homogeneous because p > 0.05. Based on the results of the product moment correlation obtained Tolerance > 0.10 and VIF < 10.00, it can be concluded that the variables of scientific literacy and students' scientific argumentation ability do not experience multicollinearity. Thus, multivariate analysis can be continued to test the hypothesis. The summary of the Multivariate Test Results for the first hypothesis can be seen in Table 1.

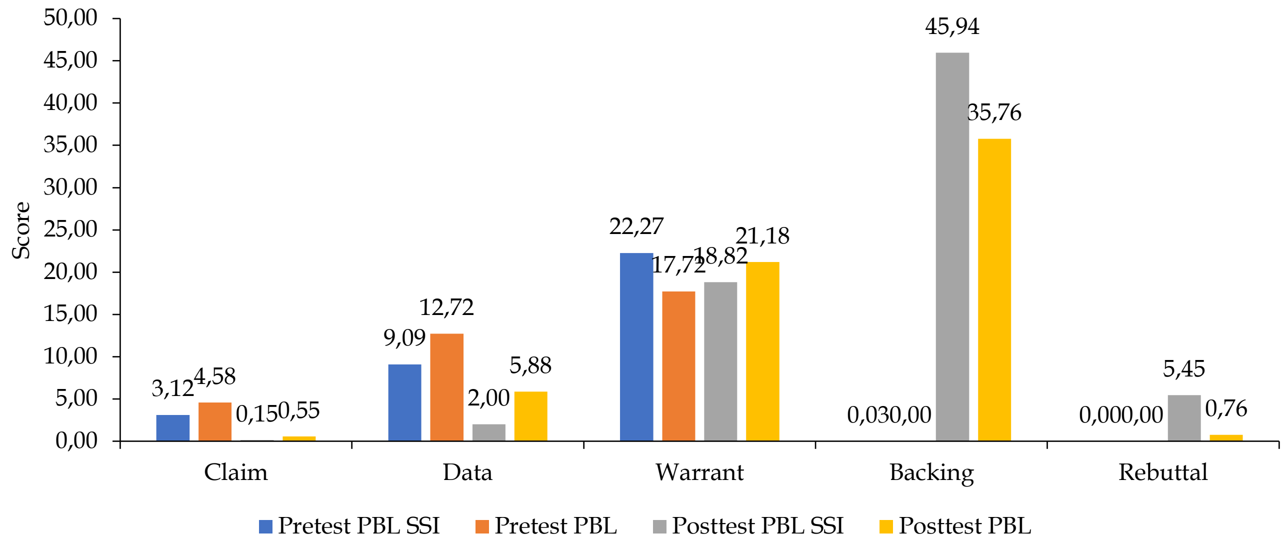


**Figure 9.** Scores for each indicator scientific argumentation skills

**Table 1.** Multivariate test results

| Effect | F | p | Partial Eta Squared |
|---|---|---|---|
| Pillai's Trace | 2.441E3[a] | 0.00 | 0.97 |
| Wilks' Lambda | 2.441E3[a] | 0.00 | 0.97 |
| Hotelling's Trace | 2.441E3[a] | 0.00 | 0.97 |
| Roy's Largest Root | 2.441E3[a] | 0.00 | 0.97 |

Based on Table 1, it can be interpreted that Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root all obtained a significance level < 0.05, thus rejecting the null hypothesis. This indicates a difference in scientific literacy and scientific argumentation skills between students taught using the problem-based learning model with a social science issue context and the problem-based learning model. Next, to see the effect of the independent variable on the dependent variable, the Intercept table can be viewed by examining the Partial Eta Squared column, which shows a value of 0.974. This means that the analysis results indicate that the problem-based learning model with a social science issue context significantly influenced scientific literacy test scores and scientific argumentation skills scores, with an effect on both of them of 97%. The results of the hypothesis test indicate a difference in scientific literacy and scientific argumentation skills between the problem-based learning model with a social science issue context and the problem-based learning model. This is because the problem-based learning model in the context of socio-scientific issues essentially provides students with the broadest possible opportunity to actively and openly reflect on and understand various perspectives on scientific problems (Mhlongo et al., 2023).

Socio-scientific issues are open-ended issues, both procedurally and conceptually, related to science and allow for rational solutions that can be influenced by social aspects such as cultural identity, politics, economics, and ethics (Sadler, 2020). In addition, learning with socio-scientific issues uses various problems covering current scientific topics, so that these problems are relevant to students' interests and needs, met with examples from everyday life, both personal, local, and global aspects (Akyol and Kanadlı, 2022). In line with the results of research by Yew & Goh (2016), learning with a problem-based learning model in the context of socio-scientific issues provides opportunities for students to investigate and investigate a problem on various scientific and socioscientific issues in group discussions that illustrate scientific knowledge, ethics, and values. This will also stimulate various student arguments in discussing socioscientific issues, thereby training students' scientific argumentation skills.

Problem-based learning models in the context of socioscientific issues can improve argumentation skills because students are given a problem or issue that occurs in everyday life in personal, local, and global aspects that are real examples of the material being studied. Students find it easier to understand the material presented because they have previously known or heard about the issue. A summary of the Test of Between-Subjects Effects on Scientific Literacy can be seen in Table 2.

**Table 2.** Test of between-subjects effects on scientific literacy

| Source | F | p |
|---|---|---|
| Corrected Model | 56.96 | 0.00 |
| Intercept | 2.333E3 | 0.00 |
| Learning Model | 56.968 | 0.00 |

Table 2 shows that the calculation results, the F value is 56.96 with a $p < 0.05$, namely 0.000 so the null hypothesis is rejected. Based on this, it means there is a difference in the scientific literacy of students who are taught using a problem-based learning model with a social science issue context and a problem-based learning model. Thus, the dependent variable of scientific literacy is significantly influenced by the learning model used in the learning process. Consistent results were also presented by Widyasari & Hermanto (2023) and Auliya & Muchlis (2024) who stated that there was a greater increase in students' scientific literacy abilities by applying a problem-based learning model with a social science issue context. Problem-based learning is actually learning that uses authentic problems to solve. Authentic problems that are more effective for improving scientific literacy are social problems related to science (socio-scientific issues), as in this study. Socio-scientific issues are important in science education because they can be used as a core tool for developing scientific literacy.

Contextual issues in science learning can be called one solution to improve students' scientific literacy, for example, one of which is socio-scientific issues (Viehmann et al., 2024; Högström et al., 2025). The socio-scientific context is presented in the form of problems where scientific knowledge and social awareness emerge in mental conflict that requires scientific literacy to make responsible decisions. This is in line with research by Khairrunisa et al. (2025) and Wisdayana et al. (2025) who found that problem-based learning with socio-scientific issues can improve students' scientific literacy because it can facilitate students to create explanations of scientific phenomena. The results of research by Chomsun et al. (2025) and Damayanti & Kuswandi (2024) show that the average percentage of students' scientific literacy overall is in the good category because during the learning process, students communicate with each other and collaborate with their groups to complete the socio-scientific topics being studied. Recapitulation of the Test of Between-Subjects Effects of Scientific Literacy can be seen in Table 3.

Table 3 shows that the F-value is 39.86, with a significance level of 0.00, which is less than 0.05. Therefore, the null hypothesis is rejected. This indicates a difference in the scientific argumentation skills of students taught using a problem-based learning model with a socio-scientific issue context compared to a problem-based learning model. Based on research by Auliah et al. (2024) learning with a socio-scientific issue approach can improve students' scientific argumentation because, in the socio-scientific issue learning process, students are presented with issues from a scientific background perspective. Furthermore, students are required to evaluate the presented socio-scientific issues (evaluation of information), assess their local, national, and global impacts, and make decisions related to these socio-scientific issues. This aligns with research conducted by Ningrum et al. (2021), which found that improved argumentation skills occurred because the problem-based learning model, contextualized in socio-scientific issues, presented unstructured problems involving multiple disciplines and required more argumentation because it was used to generate and support alternative solutions, reflecting the interdisciplinary thinking skills indicator. Further testing was conducted using the LSD test, with the criterion being that if the significance value was less than 0.05, there was a significant difference. The results of the LSD test are shown in Table 4.

**Table 3.** Test of between-subjects effects on scientific argumentation ability

| Source | F | p |
|---|---|---|
| Corrected Model | 39.86 | 0.000 |
| Intercept | 3.307E3 | 0.000 |
| Learning Model | 39.86 | 0.000 |

**Table 4.** LSD test results

| Dependent Variable | Learning model | (J) Learning Model | Average | Sig.[a] |
|---|---|---|---|---|
| Scientific | PBL SSI | PBL | 17.87* | 0.00 |
| Literacy | PBL | PBL SSI | -17.87* | 0.00 |
| Scientific | PBL SSI | PBL | 11.50* | 0.00 |
| Argumentation | PBL | PBL SSI | -11.50* | 0.00 |

Based on Table 4, it is known that the results of the LSD test for scientific literacy are all significant because $p < 0.05$ with the largest average difference value of 17.87 in the PBL SSI vs PBL model. These results support the second hypothesis test that there are differences in the scientific literacy of students who are taught using a problem-based learning model in the context of socio-scientific issues with a problem-based learning model. The results of further tests with LSD for scientific argumentation skills obtained all significant results because $p < 0.05$ with the largest average difference value of 11.50 in the PBL SSI vs PBL model. These results support the third hypothesis test that there are differences in the argumentation skills of students who are taught using a problem-based learning model in the context of socio-scientific issues with a problem-based learning model. These findings suggest that embedding socioscientific issues within PBL not only contextualizes science learning but also fosters deeper reasoning and evidence-based argumentation.

## Conclusion

Based on the presentation of research results and discussion, it can be concluded that there are differences in scientific literacy and scientific argumentation abilities of students who are taught using problem-based learning models in the context of socio-scientific issues with problem-based learning models. This is indicated by an F value of 2.41 with a significance level of 0.000. There are differences in scientific literacy of students who are taught using problem-based learning models in the context of socio-scientific issues with problem-based learning models. This is indicated by an F value of 56.968 with a significance level of 0.000. There are differences in scientific argumentation abilities of students who are taught using problem-based learning models in the context of socio-scientific issues with problem-based learning models. This is indicated by an F value of 39.86 with a significance level of 0.000. There is a positive influence of 97% on the problem-based learning model in the context of socio-scientific issues on increasing scientific literacy and scientific argumentation abilities of junior high school students.

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**Author Contributions**
Conceptualization, methodology, validation, A.P.P., K.S., and N.K.R.; data analysis using SPSS and Microsoft Excel, formal analysis, resources, data curation, writing—original draft preparation, writing—review and editing, A.P.P.; investigation, supervision, K.S. and N.K.R.; All authors have read and approved the published version of the manuscript.

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**Conflicts of Interest**
The author declares no conflict of interest.

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