



Effectiveness of the Problem Based Learning Model to Enhance Students' Science Literacy Skills on Redox Reactions Topic

Muzamil Falaq^{1*}, Sugiarti¹, Alimin¹

¹Universitas Negeri Makassar, Makassar 90222 Indonesia

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*Corresponding author:

muzamilfalaq2003@gmail.com

Abstract

One of the reasons students are not good at science literacy is the domination of conventional teacher-centered learning models. Science literacy can be enhanced only by embracing other models that are centered on the scientific process, for example, the Problem-Based Learning (PBL) model. This study examines analytically the effect of the PBL model on science literacy skills of grade XII students in SMAN 6 Bulukumba in the 2024/2025 academic year, specifically redox reactions. The sample selection in this study used a random sampling technique. Applying the quasi-experimental design with the posttest control group, the study utilized a comprehensive measurement of science literacy according to the context, knowledge, and competence aspects. Test data were contrasted employing both descriptive and inferential statistical analysis. Results of homogeneity and normality testing supported that the two groups were randomly drawn from homogeneous populations, although the data were not normally distributed. Thus, hypothesis testing was carried out employing the Mann-Whitney U test, with a Z_{count} value greater than Z_{table} ($1.77 > 1.64$). These results indicate that the Problem-Based Learning model improves grade XII students of SMAN 6 Bulukumba adequately in terms of their chemistry literacy skills, i.e., in the field of redox reactions.

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1. INTRODUCTION

The learning process within the classroom between teachers and students has also improved following the demands of the times. Twenty-first century learning emphasizes learner-centric approaches that foster engagement, enabling learners to be proficient and capable to tackle contemporary issues. Learners in this era need to gain collaboration, communication, critical thinking, and creativity skills (Arianti & Pramudita, 2022; Handayani et al., 2023). Apart from these four skills, science literacy is also an important skill for students in addressing issues of global problems today and in the future (Noor, 2021; Yuliati, 2017).

Science literacy is now being defined as the ability to employ scientific knowledge in identifying phenomena or issues, making conclusions based on scientific evidence, and engaging in the scientific investigation process (OECD, 2019). It is a final goal of

science teaching and serves as a principle of guidance in the 21st century (Hafizah & Nurhaliza, 2021; Yuliati, 2017). Science literacy embraces a wide range of dimensions, such as understanding concepts, analytical skills, inference-making, and articulation of knowledge gained through reasoning (OECD, 2019). Students with highly developed research skills express a high degree of science literacy. With well-developed research skills, students should be capable of addressing challenges in real life with their scientific knowledge (Lendeon & Poluakan, 2021).

Science literacy, as outlined in the PISA framework, is set within four dimensions: context, knowledge, competence, and attitude. Context as a dimension reflects learners' ability to identify scientific issues in personal, local, and global contexts (Hafizah & Nurhaliza, 2021; OECD, 2019). The knowledge dimension deals with fundamental scientific concepts that

enable students to recognize and define problems, which consists of content, procedural, and epistemic knowledge (Rini et al., 2021; Wasis et al., 2020). The competence dimension is the core of science literacy and involves being able to describe phenomena, design or evaluate investigations, and interpret or apply scientific evidence. The fourth dimension, attitude, enables learners' interest in science matters and includes aspects such as interest and motivation in science (Alatas & Fauziah, 2020).

Science literacy is highly correlated with other learning factors, including academic performance and critical thinking. Such students with higher science literacy levels tend to be more test-ready because they have higher conceptual understanding and higher critical thinking capacity, particularly in data analysis, information evaluation, and logical conclusion drawing (Karira & Sunarti, 2022; Nugraha, 2022). Moreover, science literacy serves to form students that are competent in the mastery of scientific concepts. This is accomplished through continuous engagement with reading, questioning, and exploration of scientific phenomena that enhance their understanding of science content (Ashari et al., 2023; Juhji & Mansur, 2020).

Overall, the science literacy levels among Indonesian students are low, as shown by Indonesia's performance in global assessments such as PISA. The country has always had low performance, at one time ranking in the bottom ten globally, and recent results in 2022 indicated a decline in science literacy scores from 2018 (OECD, 2023). The students in South Sulawesi Province also have comparatively low science literacy (Adnan et al., 2021; Randan et al., 2022). This situation is believed to be caused by classroom practices that have not been effective in building science literacy competency (Novita et al., 2021; Yuliati, 2017). Particularly, in relation to the competence dimension, the majority of South Sulawesi students are still at a low level in terms of explaining phenomena scientifically and confirming data with evidence. They are attributable to the absence of learning autonomy and the small number of assessment tasks for building science literacy competencies (Adnan et al., 2021; Zuhri et al., 2023).

Through SMAN 6 Bulukumba chemistry students' interviews, it was discovered that there had never been a test of science literacy, and among the topics considered most challenging to understand was redox reactions. Although there has not been a direct test

of literacy, science literacy skills among students appear relatively low. During learning, the majority of students cannot solve problems related to identifying and using scientific evidence. For instance, when confronted with phenomenon-based questions, students in general find it difficult to recognize the phenomena and to apply scientific knowledge in addressing the problems. Observations also demonstrated that instructional methods in the classroom are primarily founded on traditional models, whereby students are primarily passively listening to teacher narratives.

Redox reactions were selected as the focus of this study because they represent a fundamental yet context-rich chemistry concept closely associated with everyday phenomena such as corrosion, combustion, respiration, and battery operation. This strong real-world relevance makes redox content highly suitable for fostering scientific literacy, particularly in the ability to explain and apply scientific principles. Moreover, redox is widely recognized as a challenging topic for students, requiring higher-order reasoning in understanding oxidation–reduction processes, which further supports its appropriateness as a context for assessing scientific literacy.

Several factors contribute to low science literacy among learners, one being the use of instruction models that do not improve learners' motivation (Fuadi et al., 2020; Suparya et al., 2022). Another approach that has the potential to improve science literacy includes the Problem-Based Learning (PBL) model. The model requires students to construct problems from real cases, design problem-solving strategies, and draw conclusions from scientific facts and principles. In doing so, learners' science literacy skills are implicitly developed. Moreover, the PBL model encourages active discussion, group work, and presentation of outcomes, all of which support the improvement of science literacy (Aiman & Ahmad, 2020; Widiana et al., 2020; Yusuf et al., 2023).

This study is centered on the context, knowledge, and competency dimensions of science literacy in the 2018 PISA framework definition. The three dimensions were selected due to their interdependence. The competency dimension is the center of science literacy and entails the ability to give scientific explanations, plan and test investigations, and interpret or use scientific information. Every element of the competency dimension requires the support of the

knowledge dimension, including content, procedural, and epistemic knowledge, in order to tackle scientific problems at personal, national, and international levels. The selection of the dimensions was also made with the aim of enabling a further breakdown examination of how the Problem-Based Learning model impacts every level of science literacy.

This study offers a distinct contribution by applying a contextual learning approach to strengthen science illiteracy in the topic of redox reactions. Although Problem Based Learning has been widely examined, few studies have explored its impact on scientific literacy within conceptually demanding topic such as redox reactions. By employing PISA-aligned dimensions and expert-validated essay assessments, this study provides a more authentic measure of students' reasoning and explanatory skills than the multiple-choice instruments commonly used in previous research. Conducting the research in SMAN 6 Bulukumba also adds insight from a learning context that has received limited empirical attention. Collectively, these elements underscore the study's novelty and highlight its relevance for improving chemistry learning in real classroom settings.

2. METHOD

This study employs a quasi-experimental design of a posttest control group. The sampling was done through simple random sampling. For the experimental group (class XII A1) with 34 students, the instruction was conducted through the Problem-Based Learning model, and for the control group (class XII A3) with 32 students, the instruction was done through a conventional learning model (direct instruction). Data collection was administered through seven essay questions on redox reactions that were designed to assess science literacy. These testing instruments were validated by experts and were found to be highly reliable (0,88) and valid (0,81).

This study focuses on the context, knowledge, and competence dimensions because these domains correspond directly to the indicators and essay-based assessment developed in the instrument used. The tasks were designed to measure students' conceptual understanding, contextual application, and scientific reasoning core cognitive components emphasized in these three PISA dimensions. Since the instrument does not assess affective elements, incorporating the attitude dimension would be inconsistent with the study's

measurement framework. Limiting the scope to these three dimensions therefore ensures methodological alignment and supports a valid evaluation of the impact of PBL on students' science literacy.

The use of the problem-based learning model in the experimental group involved five stages. The first stage was "orienting to the problem." In this stage, students were presented with everyday phenomena related to redox reactions, presented in narrative form. This stage was designed to stimulate curiosity and activate students' prior knowledge. The second stage was "organizing students." In this stage, students were divided into small groups and tasked with formulating problems based on the presented phenomena, tailored to the learning objectives.

The third stage is known as conducting group investigations. In this stage, each group gathers information to answer the problem statement. Students can use various learning resources to obtain answers, including teaching materials provided by the researcher and textbooks.

The fourth stage is called developing and presenting solutions. Each group synthesizes their findings into coherent explanations supported by conceptual evidence. Students present their solutions through oral and written formats, enabling peer critique and inter-group discussion aimed at evaluating the quality of reasoning and conceptual accuracy. The fifth stage is evaluating the outcomes of the problem-solving process. In this stage, the teacher reflects on the results of the students' problem-solving process, provides conceptual reinforcement, and guides students in drawing conclusions from the material they have learned.

Data analysis employed in this research integrates both descriptive and inferential statistics. Descriptive statistics are employed to summarize the data and provide a general overview of its characteristics. Inferential statistics are utilized to test the research hypotheses in order to draw conclusions from the findings. Prior to hypothesis testing, the prerequisite tests, i.e., normality and homogeneity tests, were conducted. These tests ensured that statistical assumptions were met, i.e., that data were normally distributed and were from homogeneous populations. Where these conditions were achieved, a t-test was utilized for hypothesis testing. Where data were not normally distributed, the Mann-Whitney test was applied

as an appropriate non-parametric alternative. The posttest mean scores of science literacy were classified into several classes, as shown in Table 1.

Table 1. Categorization of science literacy test score

Value Range	Criterion
86-100	Very high
76-85	High
60-75	Quite high
55-59	Low
<55	Very low

3. RESULT AND DISCUSSION

3.1. Result

Descriptive statistical analysis provides a clear summary of the research findings, making it easy for readers to comprehend the results. The descriptive findings for both groups are shown in Table 2.

Table 2. Results descriptive statistical analysis

Group	Criterion	Frequency	Percentage
XII A1	Very high	7	20.59
	High	19	55.88
	Quite high	8	23.53
	Low	0	0.00
	Very low	0	0.00
XII A3	Very high	5	14.71
	High	15	44.12
	Quite high	10	29.41
	Low	2	5.88
	Very low	0	0.00

The study analyzes dimensions of science literacy according to the 2018 PISA framework, i.e., context, knowledge, and competence. Figure 1 presents the average values of the context dimension for the personal, national, and global levels in both groups.

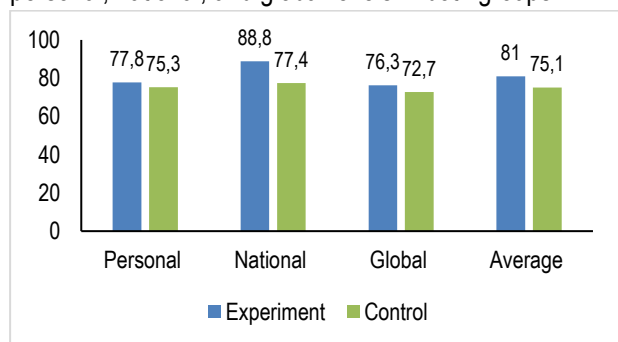


Figure 1. Average score of science literacy context dimension

Based on the scores in Figure 1, the overall mean score of the context dimension of the experimental

group is in the high category, while the control group is in fairly high. This indicates that in the context dimension, the experimental group is better than the control group.

The superiority of the experimental group in the context dimension was evident in both the knowledge and competence dimensions. The two groups' mean scores of the knowledge dimension are in Figure 2, and the two groups' mean scores of the competence dimension in explaining phenomena scientifically (indicator 1), evaluating and designing scientific investigations (indicator 2), and interpreting or using scientific evidence (indicator 3), are in Figure 3.

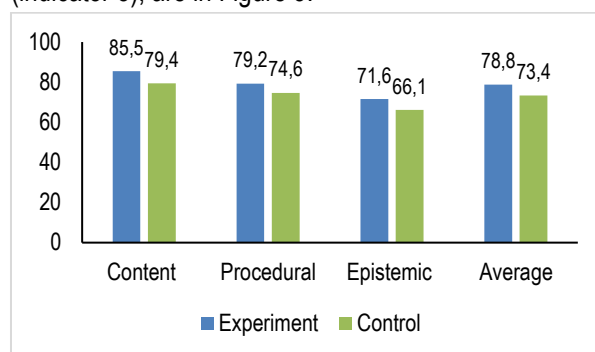


Figure 2. Average score of science literacy knowledge dimension

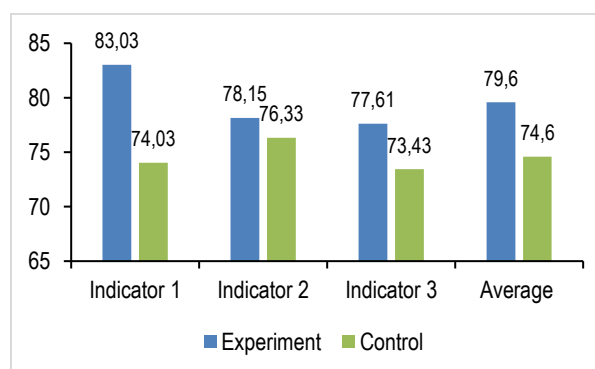


Figure 3. Average score of science literacy competency dimension

Inferential statistical analysis was conducted in order to examine the effect of the Problem-Based Learning model on students' scientific literacy. Prior to conducting the analysis, prerequisite tests were conducted, including tests for normality and homogeneity tests. The chi-square test with a 0.05 significance level was used as the normality test in this study. From the results, it could be seen that the data for both groups were not normally distributed, as shown in Table 3.

Table 3. Results normality test

Group	χ^2_{count}	$\chi^2_{\text{table}}(\alpha) = 0,05$	Conclusion
XII A1	12,78	7,815	Abnormal
XII A3	18,10	7,815	Abnormal

F-test at the 0.05 level of significance was employed in testing for homogeneity. With a numerator degree of freedom 31 and a denominator degree of freedom 33, the results confirmed that the two groups were drawn from homogeneous populations, as indicated in Table 4.

Table 4. Results homogeneity test

Group	F_{count}	$F_{\text{table}}(\alpha) = 0,05$	Conclusion
XII A1	1,33	1,79	Homogeneous
XII A3			

Based on the results of the prerequisite tests, the data were non-normal but homogeneous. Hence, the hypothesis testing was carried out using a non-parametric test, i.e., the Mann-Whitney test. The results of this hypothesis test are presented in Table 5.

Table 5. Results Hypotesis Test

Z_{count}	$Z_{\text{table}}(\alpha) = 0,05$	Conclusion
1,77	1,64	H_0 rejected H_1 accepted

The results in Table 5 show that science literacy of grade XII students in SMAN 6 Bulukumba is significantly influenced by the Problem-Based Learning model.

3.2. Discussion

Problem-Based Learning model applied in the experimental group followed the syntax proposed by Arends and termed as orientation to the problem, organizing students, conducting group investigations, developing and presenting solutions, and evaluating the outcomes of the problem-solving process (Arends, 2012). Findings of the descriptive analysis presented in Figures 1 to 3 also support the reality that the Problem-Based Learning model has a clear positive effect on the scientific literacy of the students in the three dimensions examined in this research.

The attitude dimension was not measured because the assessment instrument used in this study was designed exclusively to evaluate cognitive aspects of scientific literacy—namely context, knowledge, and

competence. These dimensions align directly with the structure of the expert-validated essay tasks, whereas the attitude dimension requires a different type of affective instrument that was beyond the methodological focus of the research. Limiting the scope to the three cognitive dimensions ensures coherence between the framework and the measurement tools and strengthens the validity of interpreting PBL's impact on students' scientific literacy.

As can be seen in Figure 1, the overall mean score of the experimental group on the context dimension (81.0) falls within the high category, while that of the control group (75.1) is in the fairly high category. This indicates that the experimental group scored higher than the control group in the context dimension. The superiority of the experimental group in this aspect is attributed to the problem-orientation stage of the model, during which the teacher presents redox-based problems of everyday life. Through this, the students are practiced in applying scientific knowledge in problem-solving. For the control group taught through direct instruction, no problem-based learning was conducted, thus the poor performance in the context dimension compared to the experimental group.

The learning process of the Problem-Based Learning model is initiated through the presentation of problems that can be used in real situations. By solving these kinds of problems, students acquire the habit of applying scientific principles to solve real-life problems, thus developing problem-solving skills. The process not only develops problem-oriented personality but also builds conceptual understanding and scientific literacy, particularly in the context dimension (Aripin et al., 2025; Asmiyunda & Hardeli, 2023).

Previous research has also shown that the use of the *Problem Based Learning* model can have a positive impact on students' science literacy skills in the context dimension (Alatas & Fauziah, 2020; Mallika & Suresh, 2020; Patne et al., 2020). In fact, a study revealed that the *Problem Based Learning* model is superior to PjBl in training science literacy. A research by Aini (2022) found that the Problem-Based Learning model has a larger impact on the dimension of science context compared to Project-Based Learning since it is more focused on student inquiry into associated ideas to solve problems, hence allowing learners to establish new learning against existing knowledge.

Based on the scores in Figure 2, the experimental group's mean total score of the knowledge dimension (78.8) is categorized as high, and that of the control group (73.4) is in the fairly high category. Thus, the experimental group is better in the knowledge dimension when compared to the control group.

Problem-Based Learning model is the most influential factor in the experimental group's higher scores in the knowledge dimension. This model welcomes students to be directly involved from the start of the learning process. Students are first introduced to a problem and are guided to identify the problem on their own (Alatas & Fauziah, 2020). The activeness of students is not only to formulate problems, but also directed to design problem solving and make conclusions based on facts and scientific concepts (Fauziah et al., 2019; Widiana et al., 2020). These structured learning experiences, through analytical and critical thinking, therefore have positive influences on students' scientific literacy in the knowledge dimension (Fareza et al., 2024; Wahdaniyah et al., 2023).

Problem-based teaching puts the problem at the center of learning and problem-solving at the terminal end. When problems are related to day-to-day life, they not only catch the interest of learners but also motivate them to seek relevant information on their own for solutions (Aiman & Ahmad, 2020). By passing through organized learning stages, learners not only strengthen their conceptual understanding but also learn to interpret and analyze problems, along with developing their reasoning skills. These processes are important in promoting students' scientific literacy in the knowledge domain (Alatas & Fauziah, 2020; Oktafiana et al., 2024).

Competence dimension of science literacy is the fourth of the dimensions. This dimension should be supported by a solid basis of general scientific concepts and theories. That is, the achievement of competence entails mastery of the science literacy knowledge dimension (Musa et al., 2023; Noor, 2021). In Figure 3, the experimental group's mean score of the overall competence dimension was high (79.6), while that of the control group was relatively high (74.6).

The learning process that was employed by both groups assisted the experimental group in attaining a higher mean score for the competence dimension. The Problem-Based Learning strategy puts students at the center of learning by making them autonomous and

participative learners in the learning of scientific information through inquiry and investigation. Ultimately, this process equips students with the authority to apply their knowledge to practical situations (Nasor et al., 2023; Parno et al., 2020). This is evidenced by Kurniawati & Hidayah (2021), who note that the Problem-Based Learning model can engage students as active participants in a directed and structured process, thereby influencing the development of their science literacy. Similarly, Lendeon & Poluakan (2021) note that the Problem-Based Learning model encourages science literacy in all three indicators of the competence dimension.

The results of the hypothesis test presented in Table 5 confirm that science literacy among SMAN 6 Bulukumba grade XII students is strongly influenced by the Problem-Based Learning model. This model is designed particularly to improve students' critical thinking ability, collaborate together in groups, and come up with solutions independently. Through this active participation of students in the learning process, the model supports both scientific literacy and critical thinking. Students are not passive recipients of information but are provoked to learn and problem-solve from everyday contexts so they can construct a richer and deeper understanding of scientific concepts (Aiman & Ahmad, 2020; Yuliati, 2017).

Every syntax of the Problem-Based Learning model serves a particular purpose in augmenting students' science literacy in all three dimensions of context, knowledge, and competence. Presenting problems in the problem-oriented syntax acclimatizes students to the context dimension of science literacy indirectly. The second syntax extends the knowledge and competence dimensions by requiring students to define and identify problems according to issues that have been introduced beforehand, with problem defining configured within the topic of study. The third, fourth, and fifth syntax contributes to the extension of the competence dimension because students investigate, process data through inquiry, apply scientific information, and evaluate problem-solving outcomes (Hafizah & Nurhaliza, 2021; Kurniawati., & Hidayah, 2021).

Problem-Based Learning model has been, over and again, shown to be of great influence on the science literacy capacity of students. Zulfa et al (2022) suggest that the outstanding science literacy achievement of students taught using the model is a result of its ability to

stimulate active and critical engagement in problem-solving. Furthermore, Fauziah et al (2019) emphasize that the problem-solving steps of the model—investigation, identification, and communication of knowledge—are effective in developing science literacy. This is corroborated by Alatas & Fauziah (2020), who highlight the fact that Problem-Based Learning model has a positive impact on all areas of science literacy according to PISA 2018.

The findings offer practical implications for chemistry teaching and curriculum design. Teachers can integrate PBL by using real-world redox phenomena as problem triggers and by incorporating essay-based assessments to capture students' reasoning more authentically. At the curriculum level, the results support embedding PBL-oriented learning sequences and performance-based assessments into chemistry units, particularly for conceptually demanding topics such as redox reactions.

4. CONCLUSION

Inferential statistical analysis based on the Mann-Whitney test at a level of significance of 0.05 indicates that the results of $Z_{\text{count}} (1.77) > Z_{\text{table}} (1.64)$ indicate that H_0 was rejected and H_1 was accepted. These findings indicate a significant effect of the Problem-Based Learning model towards the science literacy abilities of grade XII students at SMAN 6 Bulukumba in the subject of redox reactions. The study emphasizes the major impact of the Problem-Based Learning model in cultivating science literacy in all aspects of context, knowledge, and proficiency.

This study demonstrates that PBL effectively improves students' scientific literacy in the context, knowledge, and competence dimensions of redox reactions. Incorporating PBL into routine chemistry lessons, supported by authentic problem scenarios, can help students connect redox concepts to real-life applications. Future research is encouraged to include the attitude dimension to offer a more comprehensive account of students' scientific literacy growth.

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6. REFERENCES

- Adnan, A., Mulbar, U., Sugiarti, S., & Bahri, A. (2021). Scientific Literacy Skills of Students: Problem of Biology Teaching in Junior High School in South Sulawesi, Indonesia. *International Journal of Instruction*, 14(3), 847–860. <https://doi.org/10.29333/iji.2021.14349a>
- Aiman, U., & Ahmad, R. A. R. (2020). Model Pembelajaran Berbasis Masalah (PBL) Terhadap Literasi Sains Siswa Kelas V Sekolah Dasar. *Jurnal Pendidikan Dasar Flobamorata.*, 1(1), 1–5. <https://doi.org/https://doi.org/10.51494/jpdf.v1i1.195>
- Aini, M. Q. (2022). Perbedaan Literasi Sains Siswa Dalam Implementasi Model Pembelajaran Problem Based Learning Dan Project Based Learning. *EDUCATOR : Jurnal Inovasi Tenaga Pendidik Dan Kependidikan*, 2(2), 221–235. <https://doi.org/https://doi.org/10.51878/educator.v2i2.1354>
- Alatas, F., & Fauziah, L. (2020). Model Problem Based Learning (PBL) Untuk Meningkatkan Kemampuan Literasi Sains pada Konsep Pemansasn Global. *JIPVA (Jurnal Pendidikan IPA Veteran)*, 4(2), 102–114. <https://doi.org/https://doi.org/10.31331/jipva.v4i2.862>
- Arends, R. (2012). *Learning To Teach, Ninth Edition*. New York: McGraw-Hill.
- Arianti, N., & Pramudita, D. A. (2022). Implementasi Pembelajaran Abad 21 Melalui Kerangka Community of Inquiry Dengan Model Think Pair Share. *Jurnal Visi Ilmu Pendidikan*, 14(1), 65. <https://doi.org/10.26418/jvip.v14i1.50290>
- Aripin, N., Mufit, F., Lufri, Andromeda, & Festiyed. (2025). The Role of Problem-Based Learning in Developing Science Literacy and 21st-Century Skills in High School Students: A Meta-Analysis. *Jurnal Ilmiah Pendidikan MIPA*, 15(1), 269–284. <http://dx.doi.org/10.30998/formatif.v15i1.27799>
- Ashari, S. E., Rachmadiarti, F., & Herdyastuti, N. (2023). Analysis of the Science Literacy Profile of Students at State Junior High School. *IJORER : International Journal of Recent Educational Research*, 4(6), 889–898. <https://doi.org/10.46245/ijorer.v4i6.340>

- Asmiyunda, & Hardeli. (2023). The Effect of Problem-Based Learning (PBL) on Learning Outcomes: Meta-Analysis *Pedagogia Jurnal Ilmu Pendidikan. Pedagogia Jurnal Ilmu Pendidikan*, 21(2), 161–172. <https://doi.org/10.17509/pedagogia.v12i2>
- Fareza, F. S., Van Hayus, E. S., Ari, S. S., Sri, Y., Mohammad, M., Maria, U., Agung, N. C. S., & Bakti, M. (2024). Problem-Based Learning Model on Students' Chemical Literacy and Critical Thinking on Reaction Rate Material. *JPI (Jurnal Pendidikan Indonesia)*, 13(3), 426–435. <https://doi.org/10.23887/jpiundiksha.v13i3.79331>
- Fauziah, N., Andayani, Y., & Hakim, A. (2019). Meningkatkan Literasi Sains Peserta Didik Melalui Pembelajaran Berbasis Masalah Berorientasi Green Chemistry Pada Materi Laju Reaksi. *J. Pijar MIPA*, 14(2), 31–35. <https://doi.org/https://dx.doi.org/10.29303/jpm.v14i2.1203>
- Fuadi, H., Robbia, A. Z., Jamaluddin, & Jufri, A. W. (2020). Analisis Faktor Penyebab Rendahnya Kemampuan Literasi Sains Peserta Didik. *Jurnal Ilmiah Profesi Pendidikan*, 5(2), 108–116. <https://doi.org/https://dx.doi.org/10.29303/jipp.v5i2.122>
- Hafizah, E., & Nurhaliza, S. (2021). Implementasi Problem Based Learning (PBL) Terhadap Kemampuan Literasi Sains Siswa. *Quantum: Jurnal Inovasi Pendidikan Sains*, 12(1), 1–11. <https://doi.org/https://dx.doi.org/10.20527/quantum.v12i1.9497>
- Handayani, P. H., Marbun, S., & Novitri, D. M. (2023). 21st Century Learning: 4C Skills In Case Method And Team Based Project Learning. *Elementary School Journal Pgsd Fip Unimed*, 13(2), 181–193. <https://doi.org/10.24114/esjpgsd.v13i2.44522>
- Juhji, & Mansur. (2020). Pengaruh Literasi Sains Dan Keterampilan Berpikir Kritis Terhadap Penguasaan Konsep Dasar Biologi. *Edusains*, 12(1), 113–120. <https://doi.org/https://dx.doi.org/10.15408/es.v12i1.13048>
- Karira, N. ., & Sunarti, T. (2022). Analisis Keterkaitan Kemampuan Literasi Sains dan Keterampilan Berpikir Kritis. *SEMINAR NASIONAL FISIKA (SNF) 2022*, 26–31.
- Kurniawati., & Hidayah, N. (2021). Pengaruh Pembelajaran Problem Based Learning Berbasis Blended Learning terhadap Kemampuan Literasi Sains. *Bioedusiana*, 6(2), 175–191. <https://doi.org/https://dx.doi.org/10.37058/bioed.v6i2.3090>
- Lendeon, G. R., & Poluakan, C. (2021). Pengaruh Model Problem Based Learning (PBL) Terhadap Kemampuan Literasi Sains Siswa. *Sciencing: Science Learning Journal*, 3(1), 14–21. <https://doi.org/https://dx.doi.org/10.62388/jpdp.v3i2.336>
- Mallika, A., & Suresh, K. (2020). Cultivating Scientific Literacy in Students with Problem-Based Learning Techniques. *International Journal of Early Childhood Special Education (INT-JECSE)*, 12(2). <https://doi.org/DOI:10.48047/intjecse/v12i2.201199>
- Musa, W. J. A., Zainudin, F., Isa, I., & Kilo, J. La. (2023). Analisis Kemampuan Literasi Sains Ditinjau dari Aspek Kompetensi Sains Siswa pada Materi Global Warming. *Jambura Journal of Educational Chemistry*, 5(2), 142–149. <https://doi.org/10.34312/jjec.v5i2.12705>
- Nasor, A., Lutfi, A., & Prahani, B. K. (2023). Science Literacy Profile of Junior High School Students on Context, Competencies, and Knowledge. *IJORER : International Journal of Recent Educational Research*, 4(6), 847–861. <https://doi.org/https://doi.org/10.46245/ijorer.v4i6.436>
- Noor, M. S. A. M. (2021). Assessing Secondary Students' Scientific Literacy: A Comparative Study of Suburban Schools in England and Malaysia. *Science Education International*, 32(4), 343–352. <https://doi.org/https://doi.org/10.33828/sei.v32.i4.9>
- Novita, M., Rusilowati, A., Susilo, S., & Marwoto, P. (2021). Meta-Analysis Literasi Sains Siswa di Indonesia. *Unnes Physics Education Journal*, 10(3), 209–215. <https://doi.org/https://doi.org/10.15294/upej.v10i3.55667>
- Nugraha, D. M. D. P. (2022). Hubungan Kemampuan Literasi Sains Dengan Hasil Belajar IPA Siswa Sekolah Dasar. *Jurnal Elementary Kajian Teori Dan Hasil Penelitian Pendidikan Sekolah Dasar*, 5(2), 153–158. <https://doi.org/https://doi.org/10.31764/elementary.v5i2.8874>
- OECD. (2019). *PISA 2018 Assessment and Analytical Framework: Science, Reading, Mathematic, Financial Literacy and Collaborative Problem Solving*. Paris: OECD Publishing.

- OECD. (2023). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*. Paris: OECD Publishing.
<https://doi.org/https://doi.org/10.1787/53f23881-en>.
- Oktafiana, I., Khumairoh, S., Sadida, M. N., & Hakim, F. (2024). Literature Review: Pengaruh Problem Based Learning (PBL) Terhadap Kemampuan Literasi Sains Siswa Pada Pembelajaran Kimia. *Jurnal Pendidikan Kimia Unkhair (JPKU)*, 4(1), 1–6.
<https://doi.org/https://doi.org/10.33387/jpku.v4i1.8403>
- Parno, Yuliati, L., Hermanto, F. ., & Ali, M. (2020). A Case Study On Comparison Of High School Students' Scientific Literacy Competencies Domain In Physics With Different Methods: Pbl-Stem Education, Pbl, And Conventional Learning. *Jurnal Pendidikan IPA Indonesia*, 9(2), 159–168.
<https://doi.org/10.15294/jpii.v9i2.23894>
- Patne, R., Kathalkar, S., Nagrare, A., & Shende, P. (2020). Improving Students's Scientific Literacy Through Problem Based Learning. *Journal of Nonlinear Analysis and Optimization*, 11(1), 28–34.
<https://doi.org/https://dx.doi.org/10.54076/judik.v2i02.257>
- Randan, S., Husain, H., & Allo, E. L. (2022). Analisis Ketercapaian Literasi Sains Peserta Didik Kelas XI MIPA 1 SMAN 4 Toraja Utara Ditinjau Dari Dimensi Pengetahuan Dan Sikap. *LEARNING: Jurnal Inovasi Penelitian Pendidikan Dan Pembelajaran*, 2(3), 278–283.
<https://doi.org/https://dx.doi.org/10.51878/learning.v2i3.1584>
- Rini, C. P., Hartantri, S. D., & Amaliyah, A. (2021). Analisis Kemampuan Literasi Sains Pada Aspek Kompetensi Mahasiswa Program Studi PGSD FKIP Universitas Muhammadiyah Tangerang. *Jurnal Pendidikan Dasar Nusantara*, 6(2), 166–179.
<https://doi.org/https://dx.doi.org/10.29407/jpdn.v6i2.15320>
- Suparya, I. K., Suastra, I. W., & Arnyana, I. B. P. (2022). Rendahnya Literasi Sains: Faktor Penyebab Dan Alternatif Solusinya. *Jurnal Ilmiah Pendidikan Citra Bakti*, 9(1), 153–166.
<https://doi.org/https://dx.doi.org/10.38048/jipcb.v9i1.580>
- Wahdaniyah, N., Agustini, R., & Tukiran, T. (2023). Analysis of Effectiveness PBL-STEM to Improve Student's Critical Thinking Skills. *IJORER: International Journal of Recent Educational Research*, 4(3), 365–382.
<https://doi.org/10.46245/ijorer.v4i3.312>
- Wasis, Rahayu, Y. S., Sunarti, T., & Indana, S. (2020). *HOTS & Literasi Sains Konsep, Pembelajaran, dan Penilaiannya*. Jombang: Kun Fayakun.
- Widiana, R., Maharani, A. D., & Rowdoh. (2020). Pengaruh Model Problem Based Learning terhadap Kemampuan Literasi Sains Siswa SMA. *Jurnal Ta'dib*, 23(1), 87–94.
<https://doi.org/https://dx.doi.org/10.62388/jpdp.v3i2.336>
- Yuliati, Y. (2017). Literasi Sains Dalam Pembelajaran IPA. *Jurnal Cakrawala Pendas.*, 3(2), 21–28.
<https://doi.org/https://doi.org/10.31949/jcp.v3i2.592>
- Yusuf, A. A. T. U., Husain, H., & Side, S. (2023). Pengaruh Model Problem Based Learning Terhadap Kemampuan Literasi Sains Peserta Didik Kelas XI MIA SMA Angkasa Maros. *SECONDARY: Jurnal Inovasi Pendidikan Menengah*, 3(1), 76–88.
<https://doi.org/https://dx.doi.org/10.51878/secondry.v3i1.1971>
- Zuhri, M. M., Adnan, & Saparuddin. (2023). Analisis Kemampuan Literasi Sains Peserta Didik Sma Kelas X IPA Di Kota Makassar Dalam Menyelesaikan Soal PISA. *Bioscientist: Jurnal Ilmiah Biologi*, 11(2), 1892–1902.
<https://doi.org/https://dx.doi.org/10.33394/bioscientist.v11i2.9384>
- Zulfa, E., Setiadi, D., Merta, I. W., & Sukarso, A. . (2022). Pengaruh Pembelajaran Problem Based Learning Berbasis Blended Learning dan Outcome Based Education terhadap Kemampuan Literasi Sains Biologi Siswa di SMAN 7 Mataram. *Jurnal Ilmiah Profesi Pendidikan*, 7(2b), 559–564.
<https://doi.org/https://dx.doi.org/10.33394/bioscientist.v11i2.9384>