PROBLEM-BASED LEARNING CONTEXTUALIZED WITH SOCIO-SCIENTIFIC ISSUES TO IMPROVE SCIENTIFIC LITERACY: A SYSTEMATIC REVIEW

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ABSTRAK

Skor PISA 2022 menunjukkan bahwa literasi sains siswa Indonesia masih berada di bawah rata-rata OECD, sehingga diperlukan strategi pembelajaran yang menghubungkan konsep sains dengan pengambilan keputusan berbasis bukti dalam kehidupan sehari-hari. Penelitian ini bertujuan untuk menyintesis bukti empiris mengenai efektivitas Problem-Based Learning (PBL) yang diintegrasikan dengan Socio-Scientific Issues (SSI) dalam meningkatkan literasi sains siswa. Penelitian menggunakan metode Systematic Literature Review (SLR) dengan mengacu pada tahapan Kitchenham dan kerangka seleksi PRISMA. Artikel ditelusuri melalui database Scopus dan Google Scholar menggunakan kombinasi kata kunci berbahasa Inggris dan Indonesia yang berkaitan dengan PBL, SSI, dan literasi sains. Kriteria inklusi meliputi artikel jurnal terindeks Sinta 1-4 atau Scopus, diterbitkan pada tahun 2016-2025, ditulis dalam bahasa Inggris atau Indonesia, dan secara eksplisit mengintegrasikan PBL, SSI, dan literasi sains. Dari 788 artikel awal, 20 artikel memenuhi kriteria untuk dianalisis. Hasil sintesis menunjukkan bahwa penelitian PBL-SSI meningkat tajam pada tahun 2025, didominasi jenjang pendidikan menengah, dan sebagian besar menggunakan desain kuasi-eksperimen dengan analisis N-Gain dan uji-t. Temuan ini menunjukkan bahwa SSI menyediakan konteks autentik, sedangkan PBL menyediakan proses inkuiri terstruktur untuk memperkuat penalaran ilmiah siswa.

Kata kunci : Problem-Based Learning; Socio-Scientific Issues; Scientific Literacy; Systematic Literature Review

ABSTRACT

The 2022 PISA results show that Indonesian students obtained an average science score of 383, which remains *below the OECD average of 485. This gap indicates that many students still struggle to explain scientific phenomena and apply scientific evidence to everyday decision-making. As a pedagogical response, Problem-Based Learning (PBL) integrated with Socio-Scientific Issues (SSI) has been proposed to support the development of functional scientific literacy. This study aims to synthesize empirical evidence on the effect of PBL contextualized with SSI on scientific literacy through a Systematic Literature Review (SLR). The review followed Kitchenham's procedures and the PRISMA selection framework, covering review planning, literature searching, article screening, data extraction, and* *synthesis. Articles were retrieved from Scopus and Google Scholar using English and Indonesian search strings related to PBL, SSI, and scientific literacy. The inclusion criteria were indexed journal articles (Sinta 1–4 or Scopus), published from 2016 to 2025, written in English or Indonesian, and explicitly integrating PBL, SSI, and scientific literacy. From 788 initial records, 20 articles met the criteria for analysis. The findings show a sharp increase in publications in 2025, with most studies conducted at the secondary education level. Methodologically, the reviewed studies were dominated by quasi-experimental designs using N-Gain and t-tests. The synthesis indicates that PBL contextualized with SSI generally has a positive effect on scientific literacy, especially on students' ability to interpret data and scientific evidence. This model is effective because SSI provides authentic and socially relevant problems, while PBL offers a structured inquiry process that supports evidence-based reasoning.*

INTRODUCTION

Scientific literacy has become a central goal of modern science education because students are expected not only to understand scientific concepts but also to apply scientific knowledge in solving problems, evaluating information, and making responsible decisions. In the PISA framework, scientific literacy includes the ability to explain scientific phenomena, evaluate and design scientific inquiry, and interpret data and evidence scientifically (OECD, 2019; OECD, 2023b). This view is consistent with broader perspectives in science education, which define scientific literacy as the capacity to ask and answer science-related questions, explain and predict phenomena, and evaluate scientific information in public life (National Research Council, 1996; DeBoer, 2000).

The urgency of improving scientific literacy is especially relevant in Indonesia. In PISA 2022, Indonesian students achieved an average science score of 383, while the OECD average was 485. Only 34% of Indonesian students reached at least Level 2 proficiency, compared with the OECD average of 76% (OECD, 2023a; OECD, 2023b). These results indicate that many students still have difficulty using scientific knowledge as a basis for evidence-based reasoning in real-life situations. This condition is consistent with recent studies showing that students' scientific literacy in Indonesia remains below the expected level and requires more serious pedagogical intervention (Kamari et al., 2025). Therefore, science learning requires instructional approaches that connect abstract concepts with meaningful problems and guide students to reason with data and evidence.

Problem-Based Learning (PBL) is one instructional model that can support this goal. PBL begins with meaningful problems and requires students to investigate information, discuss possible explanations, and formulate evidence-based solutions (Savery, 2006). The model has been widely adapted in science education because it integrates conceptual understanding with higher-order thinking skills through active inquiry and collaborative problem solving. Its emphasis on problem solving, self-directed learning, collaboration, and motivation is closely related to scientific literacy competencies (Hmelo-Silver, 2004). However, the effectiveness of PBL depends on the quality of its implementation, including the openness of the problem, the inquiry structure, and the teacher's role as a facilitator (Barrows, 1986).

Socio-Scientific Issues (SSI) can strengthen PBL by providing authentic contexts that contain scientific, social, ethical, and sometimes controversial dimensions. SSI requires informal reasoning because the problems often cannot be solved by relying on a single fact, formula, or fixed procedure (Sadler, 2004). SSI also positions science within public life and encourages students to evaluate scientific claims that affect society (Zeidler et al., 2005). Thus, SSI is relevant for developing functional scientific literacy because it integrates conceptual understanding, argumentation, ethical consideration, and evidence-based reasoning (Zeidler et al., 2009).

The integration of PBL and SSI forms a coherent instructional design. SSI provides socially relevant and scientifically meaningful problems, while PBL provides a learning syntax involving problem orientation, investigation, collaboration, solution presentation, and evaluation. Previous studies generally report that SSI-based or PBL-SSI learning improves scientific literacy, although the magnitude of improvement varies depending on educational level, intervention design, learning material, and assessment instrument (Husniyyah et al., 2023; Kurnia et al., 2025; Sari et al., 2025; Wisdayana et al., 2025). For example, Husniyyah et al. (2023) reported that SSI-based learning improved students' scientific literacy from a low to a moderate category, while Wisdayana et al. (2025)

showed that SSI-based teaching materials supported higher levels of scientific literacy and critical thinking. Sari et al. (2025) further found that a problem-based learning model supported by knowledge mapping was more effective than standard PBL and conventional learning. However, Kurnia et al. (2025) reported that PBL did not significantly affect students' scientific literacy at the elementary school level. These mixed findings indicate that the effectiveness of PBL-SSI may depend on implementation quality, student level, learning context, and the instruments used to measure literacy outcomes.

This study therefore conducts a Systematic Literature Review (SLR) to synthesize empirical evidence on PBL contextualized with SSI and its relationship with scientific literacy. Unlike previous reviews that discuss PBL or SSI separately, this study positions PBL and SSI as an integrated instructional design. The review addresses three research questions: (1) What are the publication trends and research characteristics of PBL-SSI studies related to scientific literacy? (2) What measurement methods and empirical findings are reported in previous studies? (3) What opportunities and future research directions can be identified from the reviewed literature?

METHOD

This study used a Systematic Literature Review (SLR) as the main methodological framework. The review procedure followed Kitchenham (2004), which includes planning the review, conducting the review, and reporting the synthesis. The article selection process was organized using the PRISMA framework to ensure transparency and replicability (Page et al., 2021).

Articles were retrieved from Scopus and Google Scholar, as both databases provide broad coverage of international and Indonesian educational research. The English search string was: ("problem-based learning" OR "problem based learning") AND ("socio-scientific issue*" OR "socioscientific issue*") AND ("scientific literacy" OR "science literacy"). The Indonesian search string was: ("Problem Based Learning" OR PBL) AND ("Sosiosaintifik" OR SSI) AND "Literasi Sains". These keywords were selected because they directly represent the three core concepts of the review: PBL, SSI, and scientific literacy (Snyder, 2019).

The inclusion criteria were journal articles indexed in Sinta 1–4 or Scopus, published between 2016 and 2025, written in English or Indonesian, and substantively integrating PBL, SSI, and scientific literacy in one study. Articles were excluded when they discussed PBL, SSI, or scientific literacy separately; were written in languages other than English or Indonesian; were non-journal publications; or did not meet the indexing requirement. Non-journal publications were excluded because peer-reviewed journal articles provide a more reliable basis for academic synthesis (Kelly et al., 2014).

The initial search identified 400 records from Google Scholar and 388 records from Scopus. After removing 69 duplicates, 11 articles written in languages other than English or Indonesian, and 80 non-journal publications, the remaining records were screened manually based on title and abstract relevance. This process yielded 22 relevant articles. Two articles were later excluded because they did not meet the indexing criterion. Thus, 20 articles were included as the final corpus. Data were extracted based on publication year, educational level, research design, SSI dimension, scientific literacy indicator, analysis technique, main findings, and future research suggestions.

DISCUSSION

This section presents the findings and discussion based on the three research questions. The analysis covers publication trends and research characteristics, measurement methods and empirical findings, and future research directions related to PBL contextualized with SSI in improving scientific literacy. Although the inclusion period was set from 2016 to 2025, the final corpus consisted of 20 articles published between 2018 and 2025. These articles were analyzed descriptively by identifying recurring patterns in publication year, educational level, research design, SSI context, scientific literacy indicators, data analysis techniques, main findings, and future research suggestions. The reviewed articles are presented in Table 1.

Table 1. Reviewed Articles Included in the Synthesis

No.	Author	Main SSI/PBL Context	Main Finding

1.	Hernani et al. (2024)	Global warming SSI	Scientific literacy in relation to global warming
2.	Aristina & Isnaeni (2022)	PBL module	Science literacy and independent learning
3.	Rohmaya et al. (2023)	Chemistry e-LKPD with SSI	PBL-SSI improved science literacy
4.	Arthamena et al. (2025)	PBL-SSI in chemistry	Improved science process skills
5.	Muntari et al. (2024)	SSI-based e-module	Improved scientific literacy
6.	Nurtamara & Widyastuti (2023)	SSI argumentation	Improved evidence-based argumentation
7.	Khairrunisa et al. (2025)	Ecosystem SSI	Improved scientific literacy
8.	S. W. Putri et al. (2025)	SSI-ESD chemistry	Fostered chemical literacy and awareness
9.	Sariningrum et al. (2018)	Global warming	Improved science literacy
10.	Azizah et al. (2021)	Acid-base SSI	Positive effect on scientific literacy
11.	Utami et al. (2025)	Wetland SSI	Enhanced literacy and collaboration
12.	Husniyyah et al. (2023)	SSI learning	Improved scientific literacy
13.	A. J. H. Putri et al. (2025)	Chemical literacy	PBL-SSI effective for chemical literacy
14.	Hestiana & Rosana (2020)	Junior high SSI	Affected literacy and problem solving
15.	Purnamasari et al. (2025)	Socioscientific contexts	Improved literacy and argumentation
16.	D. P. Putri et al. (2018)	Climate change	Improved literacy on climate change
17.	Lubis et al. (2022)	Local wisdom SSI	PBL with SSI was effective
18.	Kusumaningsih et al. (2025)	SSI science e-module	Improved critical thinking and literacy
19.	Salsabilla & Manalu (2025)	Ecosystem PBL	Influenced scientific literacy
20.	Rubini et al. (2019)	SSI in PBL	Enhanced science literacy

The reviewed articles show that research on PBL contextualized with SSI has developed unevenly but has increased in recent years. Between 2018 and 2024, the number of publications remained relatively low, ranging from one to three articles per year. In 2025, the number increased sharply to eight articles. This increase may reflect growing academic attention to instructional approaches that connect science learning with real-world problems, especially after the release of the PISA 2022 results and the stronger emphasis on contextual and problem-based learning in recent curriculum reform (OECD, 2023b; Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2023).

Most studies were conducted at the secondary education level, especially senior high school, which accounted for 11 of the 20 reviewed articles. Junior high school appeared in eight articles, while higher education appeared in only one article. This pattern is reasonable because PISA assesses 15-year-old students, making secondary education a strategic stage for strengthening students' scientific literacy (OECD, 2023b). At this level, students are expected to develop stronger abilities to explain scientific phenomena, interpret evidence, and evaluate scientific inquiry. The dominance of secondary-level research also reflects the urgency of improving Indonesian students' scientific literacy performance, as also reflected in previous studies involving secondary students (Hernani et al., 2024; Muntari et al., 2024; Rubini et al., 2019; Sariningrum et al., 2018).

In terms of research design, the reviewed studies were dominated by quasi-experimental methods, which appeared in 14 of the 20 articles. This indicates that PBL contextualized with SSI has mostly been examined as an instructional intervention in existing classroom settings. Quasi-experimental designs allow researchers to compare experimental and control classes through pretest-posttest differences, N-Gain scores, and inferential statistical tests, as shown in several reviewed studies (Lubis et al., 2022; Putri et al., 2025; Rubini et al., 2019). A smaller number of studies used Research and Development, descriptive quantitative, or mixed-method designs. The dominant research characteristics are summarized in Table 2.

Table 2. Dominant Research Characteristics

Category	Dominant Result	Frequency	Interpretation

Publication year	2025	8/20	Research increased sharply in 2025.
Educational level	Senior high school	11/20	Most studies targeted secondary education.
Research design	Quasi-experiment	14/20	Most studies measured intervention effectiveness.
Scientific literacy indicator	PISA framework	13/20	PISA was the main literacy reference.
SSI dimension	Environment/Ecology	17 appearances	Environmental issues dominated SSI contexts.
Analysis technique	N-Gain and t-test	5 articles each	Improvement and significance were commonly tested.

Regarding measurement, the PISA scientific literacy framework was the most frequently used reference, appearing in 13 of the 20 reviewed articles. This framework measures students' ability to explain scientific phenomena, evaluate and design scientific investigations, and interpret data and evidence scientifically (OECD, 2019; OECD, 2023b). Five articles used indicators adjusted from previous research, one article used an existing scientific literacy indicator without major modification, and one article used Vision III scientific literacy. The limited use of Vision III suggests that broader dimensions of scientific literacy, such as ethical participation, socio-political engagement, and action-oriented literacy, remain difficult to measure through conventional written tests (Kusumaningsih et al., 2025).

The reviewed articles used various data analysis techniques. Descriptive N-Gain and t-tests were the most frequently used techniques, each appearing in five articles. The remaining studies used MANOVA in four articles, Mann-Whitney and Wilcoxon tests in two articles, descriptive scientific literacy scores in two articles, One-way ANOVA in one article, and Wilcoxon test in one article. N-Gain was commonly used to measure the magnitude of students' improvement after the intervention, while t-tests were used to determine whether the differences between experimental and control groups were statistically significant. However, some studies reported only descriptive N-Gain scores without inferential testing. This weakens claims about effectiveness because descriptive improvement alone does not show whether the observed difference is statistically meaningful. More complex analyses, such as MANOVA and One-way ANOVA, were used in studies involving multiple dependent variables or more than two comparison groups.

Overall, the reviewed articles generally reported that PBL contextualized with SSI had a positive effect on students' scientific literacy. This effect can be explained by the complementary roles of SSI and PBL. SSI provides authentic problems with scientific and social relevance, while PBL guides students through structured inquiry, evidence collection, discussion, and solution development. As a result, students are encouraged to move beyond memorization and use scientific knowledge to analyze problems, evaluate evidence, and justify decisions. This finding is consistent with previous studies reporting that SSI-based and PBL-SSI learning can improve scientific literacy, argumentation, and science-related reasoning (Husniyyah et al., 2023; Khairrunisa et al., 2025; Lubis et al., 2022; Rubini et al., 2019).

Among the scientific literacy indicators, interpreting data and evidence scientifically appeared to be the most responsive competency, followed by explaining scientific phenomena. This finding is understandable because SSI-based learning requires students to read information, compare evidence, evaluate claims, and draw conclusions. Explaining scientific phenomena also improved because SSI contexts help students connect abstract scientific theories with observable events. However, several articles reported only total literacy scores or aggregate N-Gain values, making it difficult to identify which specific literacy dimensions improved most strongly. This indicates that future studies should report scientific literacy results by indicator rather than only presenting total scores.

Future research opportunities remain open. Only a small number of the reviewed articles explicitly stated directions for further research, while most did not provide specific recommendations. Suggested directions include investigating internal student variables, examining factors that influence the success or failure of literacy improvement, expanding SSI topics, and developing PBL-SSI learning through e-modules or Learning Management Systems. These directions are important because current studies are still concentrated on environmental themes and conventional classroom interventions. Future studies should therefore explore broader SSI contexts, such as health, biotechnology, food security, energy, socio-technological risks, and policy-related scientific issues, while also applying stronger statistical validation and technology-supported learning designs.

CONCLUSION

This systematic review of 20 articles published between 2016 and 2025 shows that research on PBL contextualized with SSI and scientific literacy has increased in recent years, with a sharp rise in 2025. Most studies were conducted at the secondary education level, used quasi-experimental designs, and focused on environmental or ecological SSI contexts. The PISA scientific literacy framework was the dominant measurement reference, while N-Gain and t-tests were the most commonly used analysis techniques. These findings indicate that previous research has mainly positioned PBL-SSI as an instructional intervention to improve students' scientific literacy through contextual and evidence-based learning.

The synthesis shows that PBL integrated with SSI generally has a positive effect on scientific literacy. The strongest reported improvement was associated with students' ability to interpret data and scientific evidence, followed by their ability to explain scientific phenomena. This suggests that SSI provides meaningful real-world contexts that encourage students to evaluate information and justify decisions, while PBL provides a structured inquiry process that guides students in analyzing problems and constructing evidence-based explanations. Therefore, the integration of PBL and SSI can be considered a relevant instructional approach for strengthening scientific literacy, particularly in science learning that aims to connect concepts with real-life issues.

This review has several limitations. The publication range was limited to 2016–2025, only English and Indonesian articles were included, and the final corpus was dominated by studies from the Indonesian context. In addition, several reviewed studies relied on descriptive N-Gain without sufficient inferential validation, which limits the strength of effectiveness claims. Future research should diversify SSI topics beyond environmental issues, examine internal student variables, use stronger statistical validation, and develop technology-supported

PBL-SSI learning tools such as e-modules and Learning Management Systems. These directions are important to broaden the applicability of PBL-SSI and to provide stronger empirical evidence for its contribution to scientific literacy development.

REFERENCES

Aristina, R., & Isnaeni, W. (2022). Development of PBL-Based Module to Facilitate Students' Science Literacy and Independence Skills. *Unnes Science Education Journal*, *11*(1), 1–8. https://doi.org/10.15294/usej.v11i1.47365

Arthamena, V. D., Ayubi, M., Atun, S., & Putri, S. E. (2025). Effectiveness of a Problem-Based Learning Model Integrated with Socio-Scientific Issues to Improve Science Process Skills of High School Students. *JKPK (Jurnal Kimia Dan Pendidikan Kimia)*, *10*(1), 203–219. https://doi.org/10.20961/jkpk.v10i1.92581

Azizah, D. N., Irwandi, D., & Saridewi, N. (2021). Pengaruh Model Pembelajaran Problem Based Learning Berkonteks Socio Scientific Issues Terhadap Kemampuan Literasi Sains Siswa pada Materi Asam Basa. *JRPK: Jurnal Riset Pendidikan Kimia*, *11*(1), 12–18. https://doi.org/10.21009/jrpk.111.03

Barrows, H. S. (1986). A taxonomy of problem-based learning methods. *Medical Education*, *20*(6), 481–486. https://doi.org/10.1111/j.1365-2923.1986.tb01386.x

DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching*, *37*(6), 582–601. https://doi.org/https://doi.org/10.1002/1098-2736(200008)37

Hernani, H., Depi, S. S., Hidayat, L. N., Nurhadi, A. R., Supriatna, A., Tias, B., & Wafi, W. (2024). Analysis of Scientific Literacy of Senior High School Students in Relation to Global Warming as a Socio-Scientific Issue. *Journal of Educational Chemistry (JEC)*, *6*(2), 85–94. https://doi.org/10.21580/jec.2024.6.2.21881

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Husniyyah, A. A., Erman, E., Purnomo, T., & Budiyanto, M. (2023). Scientific Literacy Improvement Using Socio-Scientific Issues Learning. *IJORER : International Journal of Recent Educational Research*, *4*(4), 447–456. https://doi.org/10.46245/ijorer.v4i4.303

Kamari, A., Arifin, Z., Sukarmin, S., & Saputro, S. (2025). The effect of inquiry-based learning on students' critical thinking skills in science education: A systematic review and meta-analysis. *Eurasia Journal of Mathematics, Science and Technology Education*, *21*. https://doi.org/10.29333/ejmste/15988

Kelly, J., Sadeghieh, T., Adeli, K., & Biochemistry, C. (2014). *Peer review in scientific publications: benefits, critiques, & a survival guide*.

Kementerian Pendidikan, Kebudayaan, Riset, dan T. (2023). *Siaran pers/nota resmi tentang hasil PISA 2022 dan pemaknaannya bagi pemulihan pembelajaran*. https://www.kemendikdasmen.go.id/siaran-pers/8990-peringkat-indonesia-pada-pisa-2022-naik-5-6-posisi-dibanding?

Khairrunisa, A. N., Yusup, I. R., & Paujiah, E. (2025). Improving students' scientific literacy through a problem-based learning model integrated with socio-scientific issues on ecosystem learning. *Biosfer*, *18*(2), 276–289. https://doi.org/10.21009/biosferjpb.55744

Kitchenham, B. (2004). *Procedures for Performing Systematic Reviews*.

Kurnia, R., Rumanta, M., & Rokhiyah, I. (2025). THE INFLUENCE OF PROBLEM-BASED LEARNING AND CREATIVE THINKING ABILITY ON SCIENTIFIC LITERACY OF FOURTH GRADE STUDENTS AT SDN 137 CIJEROKASO, BANDUNG CITY. *Jurnal Ilmiah Pendidikan Dasar*, *10*.

Kusumaningsih, N. K. H., Pujani, N. M., & Tika, I. N. (2025). Efektivitas E-modul IPA bermuatan SSI dengan Model PBL utk Meningkatkan Keterampilan Berpikir Kritis dan Literasi Sains Peserta Didik SMP. *Jurnal Penelitian Pendidikan IPA*, *11*(8), 977–988. https://doi.org/10.29303/jppipa.v11i8.12300

Lubis, S. P. W., Suryadarma, I. G. P., Paidi, & Yanto, B. E. (2022). The Effectiveness of Problem-based learning with Local Wisdom oriented to Socio-Scientific Issues. *International Journal of Instruction*, *15*(2), 455–472. https://doi.org/10.29333/iji.2022.15225a

Muntari, M., Rahmayanti, B. F., & Andayani, Y. (2024). Effectiveness of Socio-Scientific Issue (SSI) Based Science E-Modules to Increase Students' Scientific Literacy. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 1901–1906. https://doi.org/10.29303/jppipa.v10i4.5257

National Research Council. (1996). *National Science Education Standards (Chapter: Overview)*. National Academies Press. https://doi.org/https://doi.org/10.17226/5174

Nurtamara, L., & Widyastuti, D. A. (2023). The Improving evidence-based argumentation on socioscientific issues through problem-based learning in science students. *Biosfer*, *16*(2). https://doi.org/10.21009/biosferjpb.35534

OECD. (2019). *PISA 2018 Assessment and Analytical Framework*.

OECD. (2023a). *PISA 2022 Results: Factsheets*.

OECD. (2023b). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*. OECD Publishing.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. In *The BMJ* (Vol. 372). BMJ Publishing Group. https://doi.org/10.1136/bmj.n71

Putri, A. J. H., Susilowati, E., & Mulyani, S. (2025). Socio-Scientific Issue Application in the PBL Model: Is that Effective in Improving Chemical Literacy? *Jurnal Inovasi Pendidikan IPA*, *11*(1), 296–307. https://doi.org/10.21831/jipi.v11i1.77351

Putri, S. W., Handayani, S., & Ramadanty, R. (2025). Integrating Problem-Based Learning and SSI-ESD Context to Foster Chemical Literacy and Environmental Awareness in Secondary Education. *Jurnal Pendidikan MIPA*, *26*(3), 1988–2002. https://doi.org/10.23960/jpmipa.v26i3.pp1988-2002

Rohmaya, N., Suardana, I. N., & Tika, I. N. (2023). Efektifitas E-LKPD Kimia SMA/MA dengan Model Pembelajaran Berbasis Masalah Berkonteks Isu-isu Sosial Sains dalam Meningkatkan Literasi Sains Peserta Didik. *JURNAL PENDIDIKAN MIPA*, *13*(1), 25–33. https://doi.org/10.37630/jpm.v13i1.825

Rubini, B., Ardianto, D., Setyaningsih, S., & Sariningrum, A. (2019). Using Socio-scientific Issues in Problem Based Learning to Enhance Science Literacy. *Journal of Physics: Conference Series*, *1233*(1). https://doi.org/10.1088/1742-6596/1233/1/012073

Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, *41*(5), 513–536. https://doi.org/https://doi.org/10.1002/tea.20009

Sari, I. N., Mahanal, S., & Prabaningtyas, S. (2025). *The role of complexity science problem-based learning with gitmind : Enhancing scientific literacy and collaboration skills of state senior high school*. *10*(01), 280–290.

Sariningrum, A., Bibin Rubini, H., & Ardianto, D. (2018). PEMBELAJARAN BERBASIS MASALAH (PBL) DENGAN KONTEKS SOCIOSCIENTIFIC ISSUES PADA MATERI PEMANASAN GLOBAL UNTUK MENINGKATKAN LITERASI SAINS SISWA. In *Journal of Science Education And Practice* (Vol. 2). https://journal.unpak.ac.id/index.php/jsep

Savery, J. R. (2006). *Overview of Problem-based Learning : Definitions and Distinctions*. *1*(1).

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Wisdayana, N., Achyani, & Aththibby, A. (2025). Teaching Materials Based on Socio Scientific Issues: An Effective Strategy to Improve Science Literacy and Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *11*, 346–354. https://doi.org/10.29303/jppipa.v11i4.10786

Zeidler, D. L., Florida, S., Nichols, B. H., & Florida, S. (2009). *Socioscientific Issues : Theory and Practice*. *21*(2), 49–58.

Zeidler, D. L., Sadler, T. D., Simmons, M. L., & Howes, E. V. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education*, *89*(3), 357–377. https://doi.org/https://doi.org/10.1002/sce.20048