CER 1(3) (2025)

Current Educational Review

https://journals.balaipublikasi.id/cer

Trends in Research on Problem-Based Learning (PBL) Model in Enhancing Scientific Literacy

Inayatil Baqy[1*], Agus Abhi Purwoko[1,2], Rudyat Telly Savalas[2], Aris Doyan[1,3]

[1] Master of Science Education, Universitas Mataram, Mataram, West Nusa Tenggara, Indonesia.
[2] Department of Chemistry Education, Universitas Mataram, Mataram, West Nusa Tenggara, Indonesia.
[3] Department of Physics Education, Universitas Mataram, Mataram, West Nusa Tenggara, Indonesia.

Received: May 15, 2025
Revised: August 29, 2025
Accepted: September 25, 2025
Published: September 30, 2025

Corresponding Author:
Inayatil Baqy
inayatil.baqy13@gmail.com

DOI: 10.56566/cer.v1i3.402

Abstract: Problem-Based Learning (PBL) is an effective instructional model for encouraging students to think critically, solve contextual problems, and develop scientific literacy through investigation and analysis activities. This study aims to examine the trends and development of research related to the application of the PBL model in enhancing students' scientific literacy through a bibliometric approach over the period 2016–2025. A descriptive bibliometric analysis was conducted on 1,000 documents retrieved from Google Scholar using Publish or Perish and Dimensions.ai software. The data were analyzed using VOSviewer to map keyword co-occurrence, visualize topic trends (overlay visualization), and assess research density (density visualization). The results reveal a significant increase in publications after 2019, with prominent clusters focusing on STEM integration, critical thinking skills, learning effectiveness, and the role of teachers in promoting scientific literacy. The overlay visualization further highlights a growing emphasis on creative thinking skills, contextual approaches, and scientific literacy in recent research. This study recommends further exploration of underrepresented aspects, such as digital literacy, scientific attitudes, and interdisciplinary approaches grounded in local wisdom.

Keywords: Bibliometrics; Problem based learning; Science Learning; Science Literacy; VOSviewer.

Introduction

The 21st century is an era where the dynamics of scientific, technological, and social growth occur very quickly (Kimianti & Prasetyo, 2019). In this century, people who have scientific knowledge and knowledge of the latest technological issues are needed (Turiman et al., 2012). The world of education is required to be able to adapt to the challenges of the globalization era through efforts to equip students with various skills in order to survive and compete at the global level (Sariningrum et al., 2018). 21st-century learning not only focuses on mastering knowledge, but also emphasizes the development of skills that individuals need to be able to adapt and succeed in an increasingly complex and globally interconnected society (Bray et al., 2023). Science literacy is important for individuals to understand environmental issues and problems of modern society that depend on advances in science and technology (Rahayuni, 2016).

The learning process not only emphasizes students' ability to memorize concepts or rely on memory alone, but also demands a connection between the concepts understood and everyday life situations, known as aspects of science literacy (Qomaliyah et al., 2016). Science literacy is the ability to use scientific knowledge to identify problems, draw conclusions based on evidence, and understand and make decisions about nature and changes that occur due to human activities (Ardiyanti et al., 2019). Scientific literacy emphasizes the importance of thinking and action skills, which include mastering and applying scientific reasoning to recognize and address social issues. It has become a major focus in science education and serves as a key indicator of the quality of science education at the national level. (Aradia et al., 2024). Scientific literacy

How to Cite:
Baqy, I., Purwoko, A. A., Savalas, L. R. T., & Doyan, A. (2025). Trends in Research on Problem-Based Learning (PBL) Model in Enhancing Scientific Literacy. *Current Educational Review*, *1*(3), 131–141. https://doi.org/10.56566/cer.v1i3.402

is important for students to understand the environment, health, economy, modern social issues, and technology. Therefore, measuring scientific literacy is essential to assess students' literacy levels, with the aim of achieving high or adequate scientific literacy. This, in turn, can improve the quality of education in Indonesia and enable it to compete with other countries (Pratiwi et al., 2019).

Several previous studies have indicated that students' scientific literacy levels in Indonesia remain relatively low (Afni et al., 2018; Fuadi et al., 2020; Saraswati et al., 2021; Masfuah et al., 2021). Students in Indonesia often struggle to connect scientific concepts with everyday life and to provide scientific explanations for the phenomena they study. Data on students' scientific literacy skills were obtained from scientific literacy tests using indicators proposed by PISA in 2015, which consist of four interrelated main dimensions: competencies (scientific processes), scientific knowledge or content, scientific contexts, and attitudes. (Jufri, 2017). Data from Balitbang Kemdikbud (2011) indicate that only 29% of students have mastery of the content aspect, 34% in the scientific process aspect, and 32% in the context of applying science in daily life (Fakhriyah et al., 2017). Based on the results of PISA 2015, Indonesian students' performance was still considered low, with an average science score ranking 62nd out of 69 countries. In PISA 2018, Indonesia's science score was recorded at 396, placing it 75th out of 80 participating countries. These data indicate that the quality of science education in Indonesia remains far behind compared to OECD member countries (Ermawati et al., 2024; Merta et al., 2020). The low level of scientific literacy among Indonesian students is partly due to the lack of attention to sociocultural contexts. In addition, many aspects of content, context, and processes in learning have yet to be fully utilized as sources for developing the domains of scientific literacy (Dewi et al., 2019).

Scientific literacy can be developed in students through learning activities that involve the discovery of scientific facts, concepts, laws, and principles. In this process, students should be provided with stimuli in the form of questions presented in various formats such as tables, written explanations, or other structures to encourage their active engagement (Muzijah et al., 2020). One of the factors directly related to the learning process and contributing to the low level of students' scientific literacy is the choice of teaching methods and instructional models used by teachers (Gorghiu et al., 2015). The low level of scientific literacy among students in Indonesia is influenced by various factors, including the curriculum, the selection of teaching methods and instructional models by teachers, the availability of facilities and infrastructure, learning resources, and other related aspects. Among these factors, one that is directly related to the student learning process and has a significant impact on the low level of scientific literacy is the selection of teaching methods and instructional models used by teachers (Aiman et al., 2020). In addition, the learning process has not fully engaged students actively, with limited student participation in learning activities (Lendeon & Poluakan, 2022). Learning should also be student-centered, where the teacher acts as a facilitator while students take an active role as the main subjects in seeking and processing information, solving problems, and understanding concepts.

The selection of an instructional model plays a crucial role in developing students' scientific literacy and therefore should be a primary focus in the implementation of the learning process. An effective strategy for promoting scientific literacy is learning that connects subject matter to real-world scientific contexts, including issues or problems occurring in the surrounding environment (Hafizah & Nurhaliza, 2021; Rafi'y et al., 2023). One of the instructional models that aligns with this approach is Problem-Based Learning (PBL), which encourages students to think critically and solve problems based on contextual situations (Ariana et al., 2023; Azizah et al., 2021). This model is considered an effective learning approach to help improve students' scientific literacy skills (Yang et al., 2020).The Problem-Based Learning (PBL) model presents contextual problems to stimulate students' curiosity, thereby encouraging them to actively seek information as part of the problem-solving process (Daryanes et al., 2023; Hartati, 2016; Yusuf et al., 2023). The PBL model can develop aspects of students' scientific literacy through investigative activities and analytical processes (Fauziah et al., 2019; Rubini et al., 2019). This learning model is designed to facilitate students in learning scientific concepts through solving real-world problems that are relevant to daily life (Cahyanto et al., 2024). According to Kang & Lee (2023), Problem-Based Learning (PBL) provides opportunities for students to actively engage in the process of understanding, analyzing, and solving complex problems. This approach encourages active participation, collaboration, critical thinking, and problem-solving skills. To optimize the implementation of the Problem-Based Learning model, instruction should not be limited to a single textbook but supported by various learning resources to help students master competencies, solve problems, and enhance scientific literacy (Kaniyah et al., 2022).

Several studies have shown that the PBL model is effective in improving students' scientific literacy (Alatas & Fauziah, 2020; Khasanah, 2023; Kurniawati & Hidayah, 2021). The study by Utami & Setyaningsih

(2022) showed that PBL effectively enhances scientific literacy among junior high school students. This aligns with the study by Restiani et al. (2023), which indicated that the Problem-Based Learning (PBL) model integrated with local wisdom is more effective in improving students' scientific literacy compared to conventional learning models. The syntax of this learning model enables students to participate more actively by finding solutions to problems.

Method

This study employs a descriptive analytical method with a bibliometric approach aimed at identifying and describing research trends related to the Problem-Based Learning (PBL) model and its impact on scientific literacy in learning. The data were obtained from Google Scholar using the Publish or Perish and Dimensions.ai applications to search for keywords related to the influence of Problem-Based Learning on scientific literacy skills. Data analysis was conducted using VOSviewer, which included (1) keyword clustering (co-occurrence), (2) overlay visualization to identify emerging trends, and (3) density visualization to map the density of research themes. This study analyzed 1,000 documents indexed in Google Scholar from 2016 to 2025.

Result and Discussion

This study aims to describe the research trends on Problem-Based Learning (PBL) to improve scientific literacy skills based on articles published from 2016 to 2025. Figure 1 illustrates the trend in the number of publications addressing the topic of Problem-Based Learning (PBL) in relation to scientific literacy. Overall, there is a significant year-to-year increase, especially between 2018 and 2021. In 2016, approximately 600 articles were published, with gradual increases in 2017 and 2018, reaching nearly 700 and 900 publications, respectively. The growth trend showed a sharp rise starting in 2019 with more than 1,300 publications, followed by a significant increase to around 1,900 in 2020, and a temporary peak in 2021 with over 2,400 publications.

However, the graph shows a slight decline in 2022, with the total number of publications dropping to around 2,150. This trend reversed in 2023, rising again to reach its highest peak in 2024 with approximately 3,300 publications. A sharp decline is observed in 2025, where the number of publications drastically falls to fewer than 1,000. This decrease likely does not reflect a waning researcher interest in the topic, but rather results from incomplete data accumulation since 2025 was still ongoing when the graph was exported in May 2025.

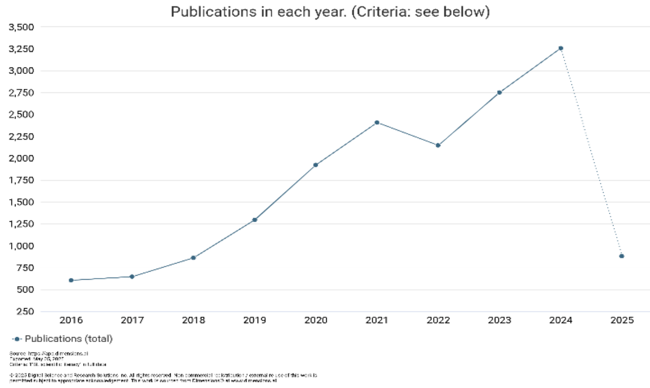


Figure 1. Article Publication Trend

Overall, the graph illustrates that the topic of Problem-Based Learning (PBL) within the context of science literacy has received increasing scholarly attention over the past decade. The notable rise in publications, particularly after 2019, reflects an enhanced awareness of the significance of problem-based learning approaches in improving students' science literacy. This trend also aligns with the global emphasis on 21st-century education, which necessitates the integration of critical thinking skills with relevant and contextualized learning experiences.

Table 1. Publication Type

Publication Type	Publication
Article	9,535
Chapter	5,534
Edited Book	3,412
Monograph	982

Based on Table 1, regarding types of publications related to PBL in the context of science literacy, it can be observed that scientific articles dominate the literature contribution with the highest number of publications, totaling 9,535 works. This dominance reflects that the PBL approach to science literacy remains a primary focus in academic research and is highly favored by the scientific community for dissemination in accredited journals. It also indicates that this topic is considered relevant and timely in addressing the challenges of modern science education, which demands critical thinking skills and evidence-based decision making.

Other types of publications, such as book chapters (5,534 publications) and edited books (3,412 publications), occupy the next positions in the dissemination of knowledge about PBL and science literacy. The large number of book chapters indicates that the PBL approach is not only discussed individually in scientific articles but also integrated as an important part of the broader discourse in science education books. This suggests a growing, deeper, and collaborative understanding within the academic community regarding the implementation of PBL across various educational levels and cultural contexts. Meanwhile, the number of monographs recorded at 982, although relatively fewer, still demonstrates a significant contribution in providing in-depth and comprehensive studies on the PBL model. Monographs typically offer theoretical perspectives or results from longitudinal studies that are more detailed compared to regular journal articles, thus their existence further strengthens the foundational scientific understanding of PBL in shaping science literacy.

This trend indicates that although scholarly articles remain the primary medium for disseminating research findings with the highest number of publications, the substantial number of book chapters and edited books published reflects a shift toward a more integrative and holistic approach in discussing PBL-based science literacy. This underscores that the PBL approach is viewed not only as a classroom teaching strategy but also as an evolving and expanding conceptual framework across diverse educational contexts globally.

Table 2 presents the source titles publication sources with the highest number of studies on Problem-Based Learning (PBL) and science literacy. It is evident that publications are distributed across various journals and proceedings spanning multiple disciplines. The journal with the highest number of publications is *Jurnal Penelitian Pendidikan IPA*, with 483 publications and 1,328 citations, resulting in an average of 2.75 citations per article. This indicates that the journal serves as a primary platform for disseminating PBL-based research in the context of science education, particularly in Indonesia, while also reflecting its relevance and credibility within the academic community.

Table 2. Source Titles

Name	Publications	Citations	Citaions mean
Jurnal Penelitian Pendidikan IPA	483	1,328	2.75
Advances in Social Science, Education and Humanities Research	316	414	1.31
Lecture Notes in Computer Science	246	1,297	5.27
Encyclopedia of the UN Sustainable Development Goals	235	488	2.08
BULLETIN of the L N Gumilyov Eurasian National University PEDAGOGY PSYCHOLOGY SOCIOLOGY Series	219	7	0.03
Journal of Physics Conference Series	186	1,486	7.99
Integration of Education	171	565	3.30
NWU Self-Directed Learning Series	170	259	1.52
Education Sciences	135	2,173	16.10
Lecture Notes in Networks and Systems	134	317	2.37

Although the journal dominates in terms of quantity, *Education Sciences* ranks highest in impact quality, with an average citation of 16.10 from 135 publications and a total of 2,173 citations. This indicates that despite having fewer publications, the journal's impact on the scientific community is significantly greater. It is followed by the *Journal of Physics Conference Series* with a mean citation of 7.99 and Lecture Notes in Computer Science with a mean citation of 5.27. These sources suggest that research on PBL and science literacy also extends into the fields of technology and international scientific conferences.

On the other hand, journals such as *Advances in Social Science, Education and Humanities Research* and *NWU Self-Directed Learning Series* show relatively stable contributions in terms of both the number of publications and their impact, although with lower average citations (1.31 and 1.52, respectively). Meanwhile, the *BULLETIN of the L.N. Gumilyov Eurasian National University PEDAGOGY PSYCHOLOGY SOCIOLOGY Series* has a considerable number of publications (219), but its impact factor is very low (0.03), indicating limited citation potential or a lack of relevance of its articles within the global community. This data reveals a dual trend in publication patterns: on one side, there is a preference among researchers for local or national publication outlets with high frequency but moderate impact; on the other side, there are reputable international journals that, although having fewer publications, possess significantly greater academic influence. The implication of this trend highlights the importance of considering not only the quantity but also the quality and reach of publications when formulating dissemination strategies for PBL-based research aimed at developing science literacy.

Based on the data in Table 3, there are ten key publications that serve as important references in research on Problem Based Learning (PBL) and its relevance to science literacy and critical thinking skills. The most cited article was written by Kokotsaki, Menzies, and Wiggins (2016), with 2,491 citations. This article is a comprehensive literature review on PBL that demonstrates the effectiveness of this approach in enhancing student engagement and learning outcomes, thereby providing a strong theoretical foundation for the development of problem-based science learning. In second place, the study by Almulla (2020), which received 1,030 citations, discusses the effectiveness of PBL in increasing student engagement in learning, an important aspect of active and meaningful science literacy.

Table 3. Top 10 Citations

Cites/year	Year	Author	Title
2491	2016	D Kokotsaki, V Menzies, A Wiggins	Project-based learning: A review of the literature
1030	2020	MA Almulla	The effectiveness of the project-based learning (PBL) approach as a wy to engage students in learning
962	2020	PA Kamil, E Putri, S Ridha, S Utaya	Promoting environmental literacy through a green project: a case study at adiwiyata school in Banda Aceh City
885	2021	SKW Chu, RB Reynolds, NJ Tavares, M Notari	21st century skills development through inquiry-based learning from theory to practice
715	2022	S Boss, J Krauss	Reinventing prohect-based learning: Your field guide to real-world projects in the digital age
440	2021	P Kwangmuang, S Jarutkamopolong	The development of learning innovation to enhance higher order thinking skills for students in Thailand junior high schools
411	2021	D Aguilera, J Ortiz-Revilla	STEM vs. STEAM education and student creativity: A systematic literaturre review
227	2023	M Maros, M Korenkova, M Fila, M Levicky	Project-based learning an its effectiveness: evidence from Slovakia
181	2023	DM Anggraeni, BK Prahani, N Suprapto	Systematic review of problem based learning research in fostering critical thinking skills

The study by Kamil et al. (2020), which received 962 citations, explored the implementation of PBL in the context of environmental education at Adiwiyata schools. It demonstrated how a project-based approach can support the development of environmental literacy as an integral part of science literacy. Meanwhile, the article by Chu et al. (2021), with 885 citations, highlighted the development of 21st-century skills through inquiry-based learning, a concept closely related to PBL that emphasizes scientific thinking processes. The publication by Boss and Krauss (2022), which garnered 715 citations, provided a practical guide to implementing PBL in real-world projects and digital environments, underscoring the relevance of PBL to the demands of modern, technology-based learning.

The study by Kwangmuang and Jarutkamopolong (2021) emphasized instructional innovation aimed at enhancing higher-order thinking skills (HOTs), which are closely linked to science literacy, and has received 440 citations. This is followed by Aguilera and Ortiz-Revilla (2021), with 411 citations, who examined the comparison between STEM and STEAM education in relation to student creativity, reinforcing the argument that interdisciplinary learning through PBL and contextual science approaches can stimulate students' creative and scientific thinking abilities. Two articles from 2023 also appear on this list: Zhang and Ma (248 citations), who used a meta-analytic approach to assess the impact of PBL on student learning outcomes, and Maros et al. (227 citations), who evaluated the effectiveness of PBL in Slovakia. Although relatively recent, both publications reflect the growing global interest in implementing PBL across various educational contexts. Lastly, the article by Anggraeni, Prahani, and Suprapto (2023), with 181 citations, specifically reviewed problem-based learning as a means of improving critical thinking skills through a systematic review, directly highlighting the strong relationship between PBL and science literacy. Overall, these publications reinforce that Problem-Based Learning (PBL) is a relevant, contextual, and provenly effective approach for supporting the development of science literacy. This is achieved through the enhancement of critical thinking skills, creativity, student engagement, and the integration of environmental and technological issues.

Figure 2 illustrates the distribution of the number of publications based on research categories related to the implementation of Problem-Based Learning (PBL) in strengthening science literacy. The data show that the "Education" category significantly dominates, with a total of 9,460 publications, far exceeding other categories. This indicates that PBL is most widely explored within educational contexts, ranging from primary to higher education levels, as it is a pedagogical approach that directly supports the development of critical thinking skills, problem-solving abilities, and conceptual understanding, all of which are core pillars of science literacy.

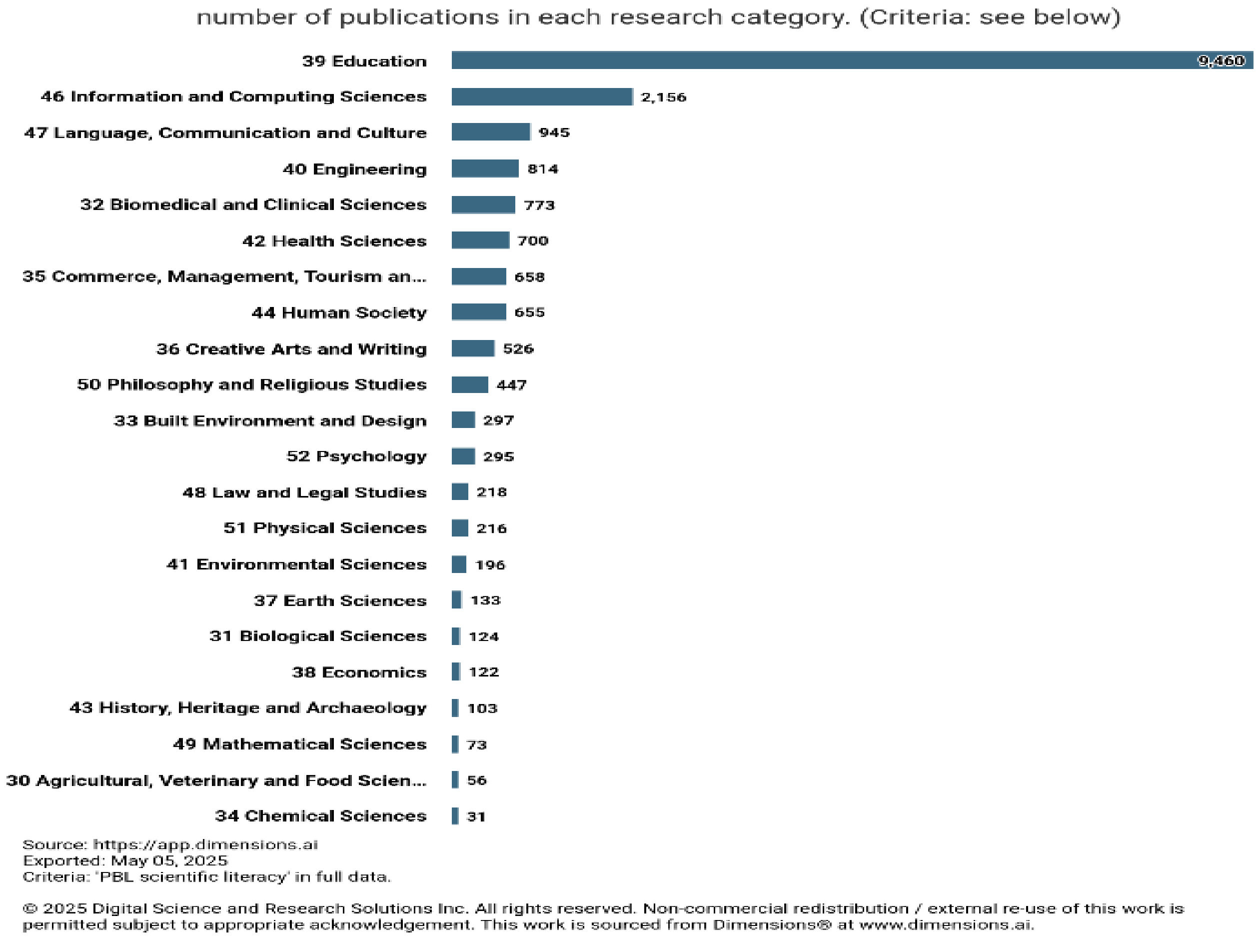


Figure 2. Research Categories

A considerable contribution is also evident from the categories "Information and Computing Sciences" with 2,156 publications and "Language, Communication and Culture" with 945 publications. The involvement of these fields indicates that PBL has expanded towards the digitalization of education and the strengthening of media literacy as well as scientific communication. This is relevant in the context of 21st-century learning, which demands the integration of content mastery and technological competencies. Meanwhile, the application of PBL is also prominent in STEM fields such as engineering (814 publications), biomedical and clinical sciences (773), and health sciences (700). These fields have long utilized the PBL approach, especially in case-based learning, laboratory practice, and real-world problem solving in professional contexts.

However, there is a noticeable tendency that pure natural sciences fields such as "Chemical Sciences" (31 publications), "Agricultural, Veterinary and Food Sciences" (56), and "Mathematical Sciences" (73) still contribute relatively little to the development of PBL and science literacy literature. These fields actually have great potential to apply PBL in scientific experiments, laboratory explorations, and context-based eco-pedagogical approaches rooted in local contexts. This gap can be seen as a strategic opportunity for more innovative and integrated research, especially in the development of teaching materials such as ethno-STEM based e-modules that combine PBL, local culture, and science literacy enhancement. In addition, there are contributions from social-humanities fields such as "Philosophy and Religious Studies" (447), "Creative Arts and Writing" (526), and "History, Heritage and Archaeology" (103), indicating that PBL is beginning to be used to connect science with societal values, culture, and history. These findings confirm that the trend of applying PBL to science literacy is not limited to exact sciences and technology, but also extends into interdisciplinary areas. Therefore, future research directions can emphasize the importance of cross-disciplinary collaboration in building science literacy that is relevant to the socio-cultural contexts of learners.

The following is a visualization of bibliometric analysis results using VOSviewer, which maps the network of keyword co-occurrences from the literature studies collected through Publish or Perish. Figure 3 shows several keyword clusters distinguished by color. Based on the analysis using VOSviewer, a total of 56 keyword items were identified, grouped into five clusters. Each cluster represents a set of keywords that frequently appear together in the analyzed articles.

Cluster 1 (green) includes keywords such as science literacy, student's scientific literacy, science learning, learning model, effectiveness, and ability, indicating a focus on students' science literacy skills and the effectiveness of learning models in enhancing them. This shows a strong relationship between science literacy, learning outcomes, and learning models. Cluster 2 (blue) includes STEM, technology, mathematics, engineering, and STEM literacy. This indicates the integration of science literacy within the context of STEM education, including elements of technology and engineering. Cluster 3 (red) includes PBL model, critical thinking skill, science process skill, scientific attitude, and others. This cluster illustrates the direct connection between the PBL model and the development of critical thinking skills, scientific attitudes, and science process skills. It confirms that PBL supports science literacy through problem-based learning that challenges higher-order thinking skills.

Meanwhile, Cluster 4 (yellow) includes effectiveness, PBL approach, teacher, model, and learning model. This cluster highlights the role of teachers, learning approaches, and the overall effectiveness of models in the context of improving student abilities. Cluster 5 (purple) includes reading, competency, education, and science education. This shows the connection of science literacy with basic literacy skills such as reading and general competencies, emphasizing that the development of science literacy also requires a strong literacy foundation. Overall, this bibliometric map indicates that the PBL model is closely linked to strengthening science literacy through the integration of innovative learning approaches, critical thinking skills, and interdisciplinary education.

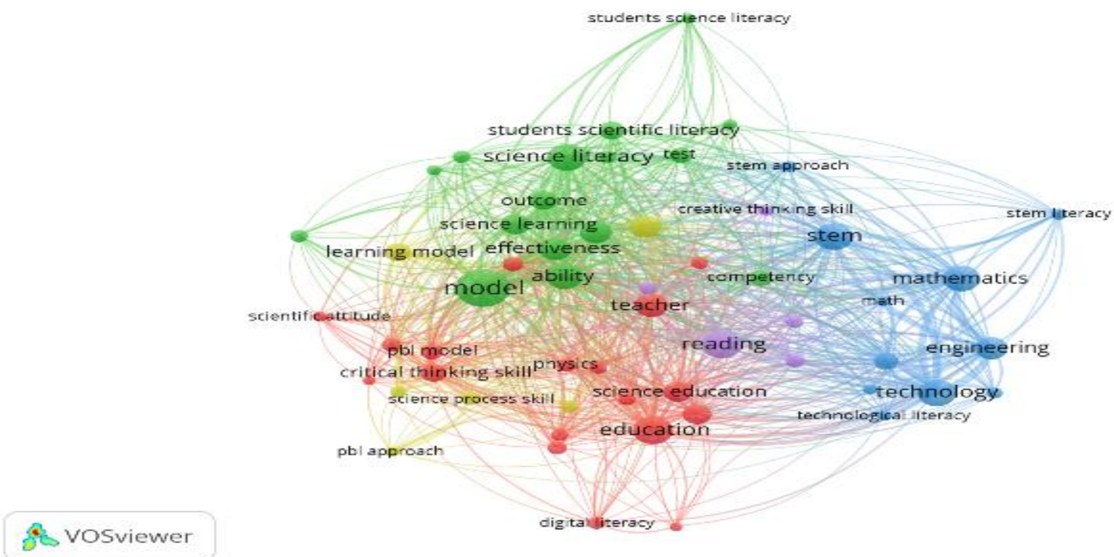
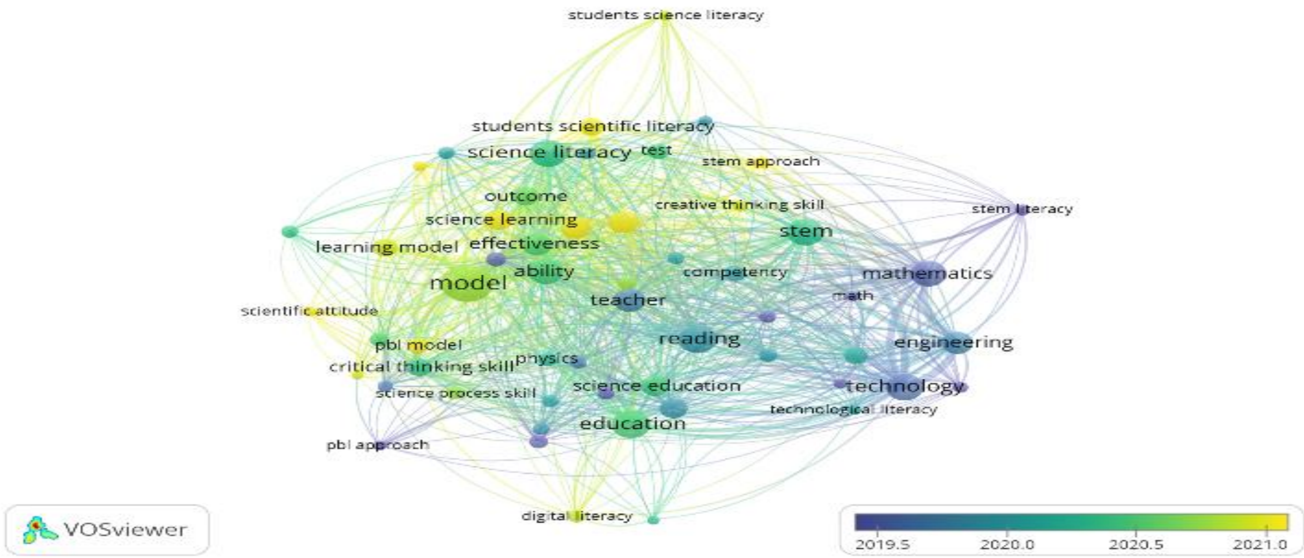


Figure 3. Network visualization

Figure 4 shows the results of overlay visualization using VOSviewer software, which identifies trends in the novelty of research topics related to the relationship between the PBL model and science literacy. This visualization presents a color gradient from blue to yellow, with blue indicating earlier studies and yellow indicating more recent ones, based on the year of publication, thereby illustrating the dynamic development of research topics between 2019 and 2021. Topics highlighted in yellow, such as "student's science literacy," "science literacy test," "science learning," "creative thinking skill," and "STEM approach," indicate that recent research has increasingly focused on higher-order thinking skills and the evaluation of student learning outcomes within the context of science literacy.



Gambar 4. Overlay visualization

This indicates that researchers have increasingly focused on examining how the PBL model is not only used as an active learning strategy but also as an approach capable of enhancing scientific reasoning and preparing students to face the challenges of the twenty-first century. Meanwhile, topics such as technology, education, and digital literacy appear in bluish-purple shades, suggesting that although these topics remain relevant, they have been extensively discussed in earlier studies and tend to have a well-established research foundation. Keywords such as critical thinking skill, science process skill, and teacher show a transition from green to yellow, indicating that the role of teachers and the development of process and critical thinking skills continue to receive consistent attention in recent literature.

Overall, this bibliometric map indicates a shift in research focus from conceptual approaches toward more applied and evaluative approaches, in line with the demand for innovative learning based on the PBL model to comprehensively enhance science literacy. These findings can serve as a foundation for future researchers to explore problem-based learning designs that are not only contextual but also adaptive to the evolving science literacy and contemporary needs.

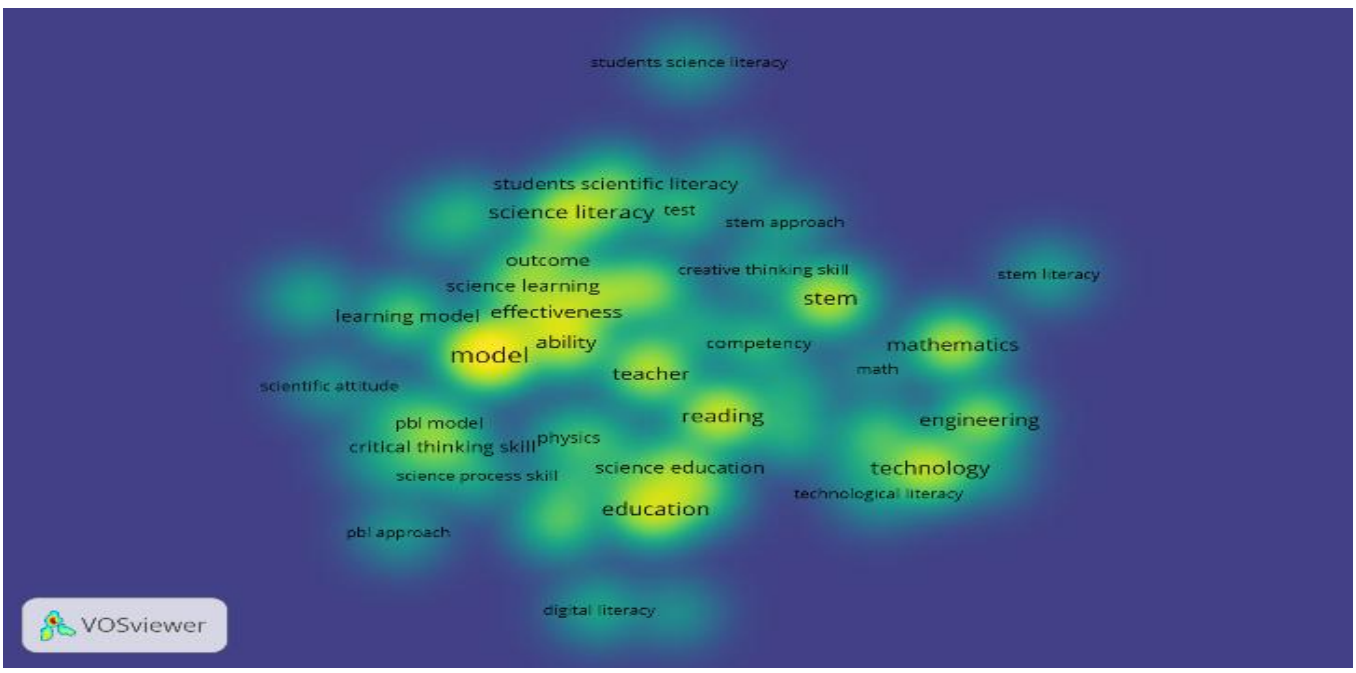


Figure 5. Density visualization

The density visualization (Figure 5) generated using VOSviewer provides an overview of the intensity of research conducted in the domain of science literacy and PBL-based learning. In the map, areas highlighted in bright yellow indicate keywords with high frequency of occurrence and strong connections to other keywords, while areas colored green to blue represent lower frequency and density.

Keywords such as "model," "education," "teacher," "science literacy," and "technology" appear in areas of high brightness, indicating that these topics have been extensively studied and have been central to numerous previous studies. This suggests that the use of learning models, particularly in the context of science education, remains a dominant theme in the development of students' science literacy. Meanwhile, keywords like "digital literacy," "PBL approach," and "scientific attitude" appear in darker areas, indicating that although these topics have appeared in the literature, their intensity remains relatively low. This presents opportunities for further research to explore these themes more deeply, especially considering the importance of digital literacy and scientific attitudes in 21st-century learning.

High density is also observed in keywords such as "mathematics," "engineering," and "technology" indicates the relevance of the STEM approach in strengthening science literacy through problem-based learning models. These findings show that interdisciplinary integration within the STEM framework is a popular and promising approach to comprehensively enhance science literacy. This opens opportunities to promote more innovative, contextual, and transformative research. The STEM approach can be designed to be more adaptive to global and local issues, such as environmental sustainability, the development of 21st-century skills, and the critical and creative use of digital technology in learning. Therefore, this density map provides valuable information for researchers to understand the main focuses of previous studies as well as potential gaps that can be further explored, such as the integration of digital aspects, scientific attitudes, and technological literacy within PBL models to support holistic science literacy.

Conclusion

Based on the bibliometric analysis covering the period from 2016 to 2025, it can be concluded that the Problem-Based Learning (PBL) model holds high relevance and continues to develop as an effective approach to enhancing students' science literacy skills. Publication trends show a significant increase since 2019, reflecting a growing awareness of the importance of integrating 21st-century skills into the learning process. Keyword cluster visualization reveals strong associations between PBL and the development of critical thinking skills, learning effectiveness, the role of teachers, and the STEM approach. Overlay analysis indicates that recent studies have begun to focus more on evaluative and contextual aspects of science literacy, while density visualization shows a dominance of research on general themes such as education and learning models. Nevertheless, there remain opportunities for further development in topics such as digital literacy and scientific attitudes. Therefore, this study recommends that future research adopt more contextual, interdisciplinary, and locally based approaches to advance science literacy through the PBL model.

Acknowledgments
The authors would like to express their gratitude to all parties who have provided support throughout the process of writing this article. Special appreciation is extended to Prof. Dr. Agus Abhi Purwoko and Dr. rer. nat. Lalu Rudyat Telly Savalas as supervising lecturers, as well as Prof. Aris as the course instructor for Scientific Writing, for their guidance, constructive feedback, and discussions. All forms of contribution and support have been invaluable in the completion of this article.

Author Contributions
Conceptualization and review design, I.B.; literature collection and analysis, I.B.; initial draft writing, I.B.; manuscript review and editing, A.A.P., L.R.T.S., and A.D.; validation and supervision, A.A.P., L.R.T.S., and A.D.; project administration, I.B.

Funding
This literature review received no external funding

Conflicts of Interest
The authors declare no conflict of interest.

References

Afni, N., Agung, M., Fitk, R., Sunan, U., & Yogyakarta, K. (2018). Literasi Sains Peserta Didik Kelas V di MIN Tanuraksan Kebumen. *Al-Bidayah : Jurnal Pendidikan Dasar Islam*, *10*(1), 47–68. https://doi.org/10.14421/AL-BIDAYAH.V10I1.129

Aiman, U., Amelia Ramadhaniyah Ahmad, R., & Studi Pendidikan Guru Sekolah Dasar, P. (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/10.51494/JPDF.V1I1.195

Alatas, F., & Fauziah, L. (2020). Model problem based learning untuk meningkatkan kemampuan literasi sains pada konsep pemanasan global. *JIPVA*

(Jurnal Pendidikan IPA Veteran), *4*(2), 102–113. https://doi.org/10.31331/JIPVA.V4I2.862

Aradia, F. F., Fitri, R., & Helendra, H. (2023). The Effect of Problem Based Learning Models on High School Biology Science Literacy Ability. Symbiotic: Journal of Biological Education and Science, 4(1), 10-17. https://doi.org/10.32939/symbiotic.v4i1.83

Ardiyanti, Y., Suyanto, S., & Suryadarma, I. G. P. (2019). The role of students science literacy in Indonesia. *Journal of Physics: Conference Series*, *1321*(3), 032085. https://doi.org/10.1088/1742-6596/1321/3/032085

Ariana, S. D., Putri, H. E., & Rahayu, P. (2023). Pengaruh Model Problem Based Learning (PBL) terhadap Kemampuan Literasi Sains Siswa dalam Pembelajaran IPA di Kelas V SD | AS-SABIQUN. *AS-SABIQUN: Jurnal Pendidikan Islam Anak Usia Dini*, 1359–1370. https://doi.org/10.36088/assabiqun.v5i5.3882

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. *Jurnal Riset Pendidikan Kimia (JRPK)*, *11*(1), 12–18. https://doi.org/10.21009/JRPK.111.03

Bray, D. A., Girvan, D. C., & Chorcora, E. N. (2023). Students' perceptions of pedagogy for 21st century learning instrument (S-POP-21): Concept, validation, and initial results. *Thinking Skills and Creativity*, *49*, 101319. https://doi.org/10.1016/J.TSC.2023.101319

Cahyanto, B., Luthfiyah Srihayuningsih, N., Aulia Nikmah, S., Habsia, A., Islam Malang, U., Ibtidaiyah Negeri, M., & Malang, K. (2024). Implementasi Model Pembelajaran Problem Based Learning (PBL) Berbantuan Lkpd untuk Meningkatkan Literasi Sains Siswa. *Ibriez Jurnal Kependidikan Dasar Islam Berbasis Sains*, *9*(2), 263–278. https://doi.org/10.21154/IBRIEZ.V9I2.664

Daryanes, F., Darmadi, D., Fikri, K., Sayuti, I., Rusandi, M. A., & Situmorang, D. D. B. (2023). The development of articulate storyline interactive learning media based on case methods to train student's problem-solving ability. *Heliyon*, *9*(4), e15082. https://doi.org/10.1016/j.heliyon.2023.e15082

Dewi, C. A., Khery, Y., & Erna, M. (2019). An ethnoscience study in chemistry learning to develop scientific literacy. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 279–287. https://doi.org/10.15294/jpii.v8i2.19261

Ermawati, E., Komarayanti, S., & Purwaningsih, S. (2024). Implementasi Pembelajaran Diferensiasi dengan Model PBL untuk Meningkatkan Literasi Sains Siswa Kelas X.2 SMAN Rambipuji. *Jurnal Biologi*, *1*(2), 1–11. https://doi.org/10.47134/BIOLOGY.V1I2.1957

Fakhriyah, F., Masfuah, S., Roysa, M., Rusilowati, A., & Rahayu, E. S. (2017). Student's Science Literacy in the Aspect of Content Science? *Jurnal Pendidikan IPA Indonesia*, *6*(1), 81–87. https://doi.org/10.15294/jpii.v6i1.7245

Fauziah, N., Andayani, Y., & Hakim, A. (2019). Improving Student Science Literacy Through Problem-Based Learning Oriented to Green Chemistry in Reaction Rate Concept. *J. Pijar MIPA*, *14*(2), 31–35. https://doi.org/10.29303/jpm.v14i2.1203

Fuadi, H., Robbia, A. Z., Jamaluddin, J., & Jufri, A. W. (2020). Analisis Faktor Penyebab Rendahnya Kemampuan Literasi Sains Peserta Didik. *Jurnal Ilmiah Profesi Pendidikan*, *5*(2), 108–116. https://doi.org/10.29303/JIPP.V5I2.122

Gorghiu, G., Drăghicescu, L. M., Cristea, S., Petrescu, A.-M., & Gorghiu, L. M. (2015). Problem-based Learning - An Efficient Learning Strategy in the Science Lessons Context. *Procedia - Social and Behavioral Sciences*, *191*, 1865–1870. https://doi.org/10.1016/J.SBSPRO.2015.04.570

Hafizah, E., & Nurhaliza, S. (2021). Implementasi Problem Based Learning (PBL) terhadap Kemampuan Literasi Sains Siswa. *Quantum: Jurnal Inovasi Pendidikan Sains*, *12*(1), 1–11. http://dx.doi.org/10.20527/quantum.v12i1.9497

Hartati, R. (2016). Peningkatan Aspek Sikap Literasi Sains Siswa SMP melalui Penerapan Model Problem Based Learning pada Pembelajaran IPA Terpadu. *EDUSAINS*, *8*(1). https://doi.org/10.15408/es.v8i1.1796

Jufri, W. (2017). Belajar dan Pembelajaran Sains : Modal Dasar Menjadi Guru Profesional. *Pustaka Reka Cipta*, *176*, 201.

Kang, Y., & Lee, I. (2023). The Effect of Mixed Reality-based HoloPatient in Problem-based Learning Contexts. *Clinical Simulation in Nursing*, *82*, 101438. https://doi.org/10.1016/J.ECNS.2023.101438

Kaniyah, Y., Purnamasari, I., & Siswanto, J. (2022). Pengembangan E-Modul Pembelajaran IPA berbasis Problem Based Learning untuk Meningkatkan Kemampuan Literasi Sains Peserta Didik. *Jurnal Kualita Pendidikan*, *3*(2), 101–108. https://doi.org/10.51651/JKP.V3I2.302

Khasanah, U. (2023). Peningkatan Literasi Sains Peserta Didik Melalui Model Pembelajaran Problem Based Learning (PBL) pada Pembelajaran Biologi Konsep Sistem Imun di Kelas Xi Sma Negeri 5 Kota Serang. *Mimbar Kampus: Jurnal Pendidikan Dan Agama Islam*, *23*(1), 250–256.

https://doi.org/10.47467/mk.v23i1.4044

Kimianti, F., & Prasetyo, Z. K. (2019). Pengembangan E-Modul IPA Berbasis Problem Based Learning untuk Meningkatkan Literasi Sains Siswa. *Kwangsan: Jurnal Teknologi Pendidikan*, *7*(2), 91. https://doi.org/10.31800/jtp.kw.v7n2.p91--103

Kurniawati, K., & Hidayah, N. (2021). Pengaruh Pembelajaran Problem Based Learning Berbasis Blended Learning terhadap Kemampuan Literasi Sains. *Bioedusiana: Jurnal Pendidikan Biologi*, *6*(2), 184–191. https://doi.org/10.37058/bioed.v6i2.3090

Lendeon, G. R., & Poluakan, C. (2022). Pengaruh Model Problem Based Learning (PBL) Terhadap Kemampuan Literasi Sains Siswa. *SCIENING : Science Learning Journal*, *3*(1), 14–21. https://doi.org/10.53682/slj.v3i1.1076

Masfuah, S., Fakhriyah, F., Wilujeng, I., & Rosana, D. (2021). The Content Validity of Scientific Literacy-Based Diagnostic Assessment. *Proceedings of the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS 2020)*, *528*, 684–691. https://doi.org/10.2991/ASSEHR.K.210305.099

Merta, I. W., Artayasa, I. P., Kusmiyati, K., Lestari, N., & Setiadi, D. (2020). Profil Literasi Sains dan Model Pembelajaran dapat Meningkatkan Kemampuan Literasi Sains. *Jurnal Pijar Mipa*, *15*(3), 223–228. https://doi.org/10.29303/JPM.V15I3.1889

Muzijah, R., Wati, M., & Mahtari, S. (2020). Pengembangan E-modul Menggunakan Aplikasi Exe-Learning untuk Melatih Literasi Sains. *Jurnal Ilmiah Pendidikan Fisika*, *4*(2), 89. https://doi.org/10.20527/jipf.v4i2.2056

Pratiwi, S. N., Cari, C., & Aminah, N. S. (2019). Pembelajaran IPA Abad 21 dengan Literasi Sains Peserta didik. *Jurnal Materi Dan Pembelajaran Fisika (JMPF)*, *9*(1), ISSN: 2089-6158. https://doi.org/10.20961/JMPF.V9I1.31612

Qomaliyah, E. N., Sukib, S., & Loka, I. N. (2016). Pengaruh Model Pembelajaran Inkuiri Terbimbing Berbasis Literasi Sains terhadap Hasil Belajar Materi Pokok Larutan Penyangga. *Jurnal Pijar Mipa*, *11*(2), 105–109. https://doi.org/10.29303/JPM.V11I2.111

Rafi'y, M., Irawan, F., & Harahap, D. G. S. (2023). Pengembangan Bahan Ajar Interaktif Berbasis Problem Based Learning untuk Meningkatkan Kemampuan Literasi Sains Peserta Didik. *Indo-MathEdu Intellectuals Journal*, *4*(2), 669–682. https://doi.org/10.54373/IMEIJ.V4I2.243

Rahayuni, G. (2016). Hubungan Keterampilan Berpikir Krtis dan Literasi Sains pada Pembelajaran IPA Terpadu dengan Model PBM dan STM. *Jurnal Penelitian Dan Pembelajaran IPA*, *2*(2), 131–146. https://doi.org/10.30870/JPPI.V2I2.926

Restiani, N. L. D., Margunayasa, I. G., & Paramita, M. V. A. (2023). Improving Scientific Literacy of Elementary School Students through Problem-Based Learning Model with Balinese Local Wisdom. *Jurnal Ilmiah Sekolah Dasar*, *7*(4), 590–598. https://doi.org/10.23887/JISD.V7I4.62080

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), 012073. https://doi.org/10.1088/1742-6596/1233/1/012073

Saraswati, Y., Indana, S., & Sudibyo, E. (2021). Science Literacy Profile of Junior High School Students Based on Knowledge, Competence, Cognitive, and Context Aspects. *IJORER : International Journal of Recent Educational Research*, *2*(3), 329–341. https://doi.org/10.46245/IJORER.V2I3.118

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. *JOURNAL OF SCIENCE EDUCATION AND PRACTICE*, *2*(2), 35–46. https://doi.org/10.33751/JSEP.V2I2.1705

Turiman, P., Omar, J., Daud, A. M., & Osman, K. (2012). Fostering the 21st Century Skills through Scientific Literacy and Science Process Skills. *Procedia - Social and Behavioral Sciences*, *59*, 110–116. https://doi.org/10.1016/j.sbspro.2012.09.253

Utami, F. P., & Setyaningsih, E. (2022). Kemampuan Literasi Sains Peserta Didik Menggunakan Pembelajaran Problem Based Learning pada Materi Sistem Ekskresi. *Journal of Educational Learning and Innovation (ELIa)*, *2*(2), 240–250. https://doi.org/10.46229/ELIA.V2I2.470

Yang, H., Liu, Y., Liu, J., Wang, J., Wang, S., Jiang, J., -, al, Nordin, N., Ali Samsudin, M., Hadi Harun -, A., Nurtanto, M., Fawaid, M., & Sofyan, H. (2020). Problem Based Learning (PBL) in Industry 4.0: Improving Learning Quality through Character-Based Literacy Learning and Life Career Skill (LL-LCS). *Journal of Physics: Conference Series*, *1573*(1), 012006. https://doi.org/10.1088/1742-6596/1573/1/012006

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/10.51878/SECONDARY.V3I1.1971