



Trends Research Project Based Learning (PjBL) Model to Improve Students' Science Literacy in Science Learning: A Bibliometric Analysis (2015-2024)

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Abstract: This study examines research trends on the Project-Based Learning (PjBL) model in improving students' scientific literacy in science education from 2015 to 2024. Using descriptive and analytical methods, data were collected from Google Scholar-indexed publications via tools like Publish or Perish and Dimension.ai. The PRISMA guidelines were applied to assess document quality, and bibliometric analysis with VOSviewer software was used to map keywords. Results indicate a significant rise in PjBL research from 2015 to 2023, with a decline in 2024. Scientific articles dominate the publications, highlighting PjBL's effectiveness in enhancing scientific literacy. Frequent keywords such as "STEM PjBL," "critical thinking skill," and "technology" emphasize the integration of technology and critical thinking in education. This study provides insights into PjBL's development and suggests integrating local approaches with technology to further improve students' scientific literacy.

Keywords: Bibliometric analysis; PjBL; Science education; Scientific literacy

Introduction

Improving the standards and quality of education is a strategic step taken by the government to face the challenges of the rapidly developing era of globalization (Moshtari & Safarpour, 2024). In this era, globalization demands human resources who are not only academically intelligent, but also skilled in various aspects of 21st-century skills, such as critical, creative, collaborative thinking, and have good scientific literacy (Mulyadi et al., 2023; Munandar et al., 2024; Susilawati et al., 2023). Scientific literacy is one of the main competencies because it allows individuals to understand various scientific phenomena, think logically, and make the right decisions based on scientific evidence (Yacoubian, 2018; Holbrook & Rannikmae, 2007; Januarti et al., 2024; Susilawati et al., 2025). This ability is not only important for everyday life, but also essential in forming a society that is able to

adapt to change and face future challenges (Saputra, 2024).

As a basis for the formation of competitive human resources, increasing scientific literacy has become one of the main priorities in education policies in many countries, including Indonesia (Martin, 2019; Sholikah & Pertiwi, 2021). Science literacy helps students develop the ability to apply scientific concepts relevant to everyday life, as well as improve critical thinking and problem-solving skills (Suwono et al., 2023; Sunandar et al., 2022; Sinaga et al., 2017). With good science literacy, students are expected to be able to think systematically, solve problems with a scientific approach, and actively participate in a society that is increasingly dependent on science and technology (Valladares, 2021; DeBoer, 2000; Rasa et al., 2024).

The importance of scientific literacy in the education curriculum is in line with the demands of the modern era, where society is expected to be able to

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understand scientific concepts related to everyday life (Tsaparlis, 2013; Kollas & Halkia, 2020; Stuckey et al., 2013). Scientific literacy is not only about mastering scientific knowledge, but also about how students can apply that knowledge to solve problems, critically evaluate information, and make informed and evidence-based decisions (Sari et al., 2024; Coppi et al., 2023). Thus, mastery of scientific literacy is the main benchmark in assessing the quality of a country's education, as seen in the Program for International Student Assessment (PISA). However, the results of the 2018 PISA survey showed that Indonesia was ranked 71st out of 79 countries in terms of science literacy with an average score of Indonesian students reaching 389 with an average score from the OECD of 489. This reflects serious challenges in the science education system in Indonesia (OECD, 2019). The main obstacle to improving science literacy in Indonesia lies in the teaching methods that are still traditional and lack variety (Setiawan et al., 2023). One-way learning tends to make students only memorize concepts without really understanding and applying them. This learning model is less effective in building critical and creative thinking skills that are needed in science literacy (Dewi et al., 2023; Ulu-Aslan & Baş, 2023). Therefore, innovation is needed in learning methods that are able to integrate scientific concepts with relevant hands-on practice, so that students can participate more actively and develop their thinking skills independently (Hmelo-Silver, 2004; Martín-García et al., 2024).

Project Based Learning (PjBL) is present as one solution to overcome this problem. This project-based learning model encourages students to learn through direct experience by carrying out projects that are relevant to real life, allowing them to engage in a more active and meaningful learning process (Karan & Brown, 2022). PjBL not only helps students understand scientific concepts more deeply, but also hones critical thinking, problem-solving, collaboration, and communication skills (Trisdiono et al., 2019; AlAli, 2024). Various studies have shown that the application of PjBL in science learning can improve students' scientific literacy in a more effective way than conventional methods (Kurt & Akoglu, 2023; Rusmansyah et al., 2023).

Given the importance of the PjBL model in improving science literacy, this study aims to review research trends related to the implementation of PjBL in science learning during the period 2015 to 2024. This literature review aims to provide a deeper understanding of the effectiveness of the PjBL model, the latest innovations that have been implemented, and the challenges and opportunities faced in its implementation. Thus, the results of this review are expected to be a reference for the development of more

innovative and effective educational practices in improving students' science literacy in Indonesia and provide significant contributions to future education policies.

Method

This research method is descriptive and analytical, which aims to understand and describe research trends in the project-based learning (PjBL) model to improve students' scientific literacy in science learning. The data used in this study were obtained from information sources indexed by Google Scholar using analysis tools such as Publish or Perish and Dimension.ai. To conduct a search in Google Scholar, keywords related to research trends in the PjBL model to improve scientific literacy in science learning were used.

In this study, the analysis was carried out on 1,000 documents that had been indexed by Google Scholar between 2015 and 2024. The Google Scholar database was chosen as a source for document search because Google Scholar applies consistent standards in selecting documents to be included in its index, and displays more documents than other databases, especially in the field of educational research (Hallinger & Chatpinyakoo, 2019; Hallinger & Nguyen, 2020; Zawacki-Richter et al., 2019). The use of Google Scholar also allows researchers to get a broader picture of scientific publications, conference articles, and other reference materials related to the PjBL model in science learning. To filter the data that has been collected through Publish or Perish, researchers use the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This process includes the stages of identification, selection, and evaluation of document quality, which are carried out to ensure that only documents that are relevant and in accordance with the research topic are included in the analysis. The selection stage includes the removal of irrelevant documents, as well as the evaluation of document quality based on the number of citations and content relevance. After the screening stage, the data were analyzed using bibliometric analysis and content analysis methods to identify research trends, main themes, and emerging patterns in the use of the PjBL model to improve students' science literacy. Bibliometric analysis was carried out with the help of software such as VOSviewer to visualize the relationship between keywords that are frequently used in research, so that it can show developing trends and areas that need further exploration. The results of this analysis are expected to provide a comprehensive picture of the effectiveness of the PjBL model, the innovations that have been implemented, as well as the challenges and

opportunities that exist in developing students' scientific literacy through this approach.

Result and Discussion

This study aims to describe research trends on scientific literacy in science learning conducted from 2015 to 2024. Research documents on scientific literacy trends are taken from scientific publications indexed by Dimensions.ai. Figure 1 below shows the publication trend on the PjBL model to improve scientific literacy in science learning from 2015 to 2024.

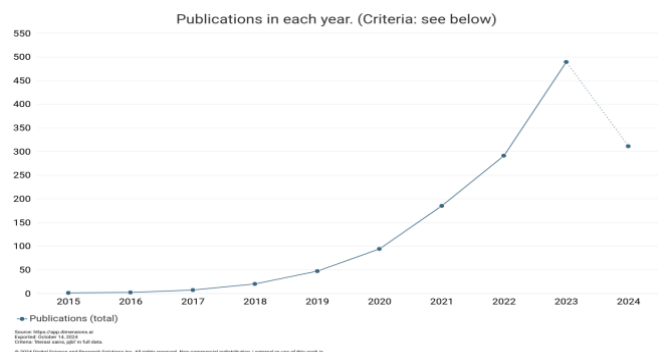


Figure 1. Research trends in PjBL models to improve scientific literacy

Figure 1. shows that the research trend on scientific literacy in science learning from 2015 to 2023 has increased significantly every year. In 2022, the number of publications peaked with more than 500 publications. However, this trend shows a slight decline in 2024. The continuous increase from 2015 to 2023 reflects the growing interest among academics and education practitioners in scientific literacy as one of the important competencies in the 21st century.

In 2015, publications related to scientific literacy in science learning were relatively few, and since then have continued to increase along with the increasing awareness of the importance of scientific literacy in equipping students with critical thinking, analytical, and problem-solving skills. This increasing research trend shows a consistent effort to understand the best ways to improve students' scientific literacy, as well as the development and innovation of effective science learning approaches.

The decreasing trend in 2024 may reflect several factors, such as a shift in research focus to newer areas, changes in educational policy, or challenges in implementing science literacy programs at different levels of education. However, the overall trend shows a significant increase, providing evidence that science literacy continues to be a relevant and important topic in global science education. Also presented below is Table 1, which displays research on PjBL models for improving science literacy by publication type.

Table 1. Trends in PjBL Models to Improve Science Literacy Based on Publication Type

Publication Type	Publications
Article	1,340
Edited Book	60
Proceeding	23
Chapter	12
Preprint	2

Based on Table 1, it is known that research on the PjBL model to improve scientific literacy in science learning from 2015 to 2024 is found in 5 types of publications. The form of articles is the most numerous type of publication, with 1,340 documents, followed by edited books with 60 documents, proceedings with 23 documents, chapters with 12 documents, and preprints with 2 documents.

The trend of research on the PjBL model to improve scientific literacy in the form of articles is the most numerous type of publication compared to other types of publications. This shows that scientific articles are the dominant media in disseminating research results related to the PjBL model to improve scientific literacy. Articles are chosen because they allow researchers to present their findings comprehensively and can reach a wider audience through scientific journals published in print and online.

Meanwhile, the least numerous type of publication is preprints, which only record 2 documents. Although the number of preprints is relatively low, they provide a platform for sharing research results quickly before going through a rigorous peer-review process. Edited books and proceedings also play a role in supporting the dissemination of research results by compiling multiple studies into a single volume or reporting the results of conferences on the topics of scientific literacy and project-based learning models.

Overall, these data indicate that scientific literacy through the PjBL model has become a significant concern in the academic community, with a primary focus on article publications. The dominance of articles as a form of publication reflects the need to convey scientific information in a more formal and structured manner, as well as the importance of scientific literacy as a core competency that students must have in the 21st century. This trend indicates that there is a growing understanding of the importance of scientific literacy, which can be developed through various methods, including interactive and project-based PjBL models (Nurhayani & Nurhafizah, 2022; Hartini, 2017; Nuraini et al., 2023). Table 2 is also presented below, which displays the ten (10) main sources of research trends on PjBL models to improve scientific literacy that are often cited by other researchers on this matter.

Table 2. Top 10 Sources Title Trend of PjBL Model Trends to Improve Scientific Literacy Research in (2015-2024)

Name	Publications	Citations	Citations Mean
Jurnal Penelitian Pendidikan IPA	130	315	2.42
Advances in Social Science, Education and Humanities Research	67	77	1.15
Journal of Physics Conference Series	31	312	10.06
Jurnal Basicedu	27	176	6.52
Edukatif Jurnal Ilmu Pendidikan	23	34	1.48
Jurnal Ilmiah Profesi Pendidikan	17	17	1.00
Jurnal Pendidikan Sains Indonesia	17	99	5.82
JPBI (Jurnal Pendidikan Biologi Indonesia)	14	174	12.43
Jurnal Inovasi Pendidikan IPA	13	265	20.38
AKSIOMA Jurnal Program Studi Pendidikan Matematika	13	23	1.77

The figure and table show that research related to the PjBL model to improve scientific literacy has grown significantly. Jurnal Penelitian Pendidikan IPA is the primary source with the highest number of publications (130) and a total of 315 citations, indicating a great interest in this topic. However, despite having fewer publications, the Journal of Physics Conference Series has the highest average citation (10.06), indicating the quality and impact of the articles published there. Jurnal Inovasi Pendidikan IPA also stands out with a fairly high average citation of 20.38, despite having only 13 publications. This shows that articles published in this journal have a great influence and are often referred to

by other researchers in scientific literacy studies using the PjBL model. Overall, these data reflect that the PjBL model to improve scientific literacy remains a relevant and growing topic in the academic realm. This trend indicates a continued interest in the use of PjBL as an effective learning method. However, there is still room for further exploration in terms of innovation and new approaches to expand the impact and application of this model in science education in the future. Also presented below is Table 3, which displays the ten (10) most frequently cited article titles in research on PjBL models to improve scientific literacy.

Table 3. Top 10 Citations on Trend of PjBL Model Trends to Improve Scientific Literacy Research in (2015-2024)

Cites/year	Year	Author	Title
7.00	2023	Y Wahyu, AL Edu, A Helmon	STEM-based PjBL Learning Model with Manggaraians Indigenous Science Content to Improve Science Literacy: is it Effective?
34.00	2023	R Rusmansyah, L Leny, HN Sofia	Improving students' scientific literacy and cognitive learning outcomes through ethnoscience-based PjBL model
11.00	2022	EW Winarni, M Karpudewan, B Karyadi, Gumono	Integrated PjBL-STEM in Scientific Literacy and Environment Attitude for Elementary School
7.50	2022	I Wardah, K Septaria, K Mahbubah, H Mubarak	The Effect of Project Based Learning (PjBL) Model on Students' Science Literacy in Social Studies Subjects
20.00	2023	N Nuraini, IH Asri, N Fajri	Development of Project Based Learning with STEAM Approach Model Integrated Science Literacy in Improving Student Learning Outcomes
39.00	2016	J Afriana, A Permanasari, A Fitriani	Project based learning integrated to stem to enhance elementary school's students scientific literacy
5.00	2023	N Nuraini, F Nurul Fajri,	Development of Project Based Learning With STEAM Approach Model in Improving the Science Literacy Ability of High School Students
3.25	2020	M Muhibbuddin, N Yustina, Safrida	Implementation Of Project-Based Learning (PjBL) Model In Growth And Development Learning To Increase The Students' Science Literacy And Critical Thinking Skills
4.00	2023	DA Fauziah, E Erman, E Susiyawati, M Budiyanto	Implementation of project-based learning models to improve science literacy of junior high school students
3.33	2021	M Marjanah, E Pandia, Nursamsu	Development of Practicum Instruction Module Based on Project Based Learning (PjBL) Integrated with Science Process Skills and Scientific Literacy

The research data shows that the integration of PjBL with STEM or STEAM approaches in improving scientific literacy has become a major focus of research in recent years. The article by J. Afriana et al. in 2016 was

the most cited, with 39 citations per year, highlighting the effectiveness of this approach in elementary school education.

Research conducted by R. Rusmansyah et al. in 2023, which emphasized the use of ethnoscience in PjBL to improve scientific literacy and cognitive learning outcomes, also showed a high number of citations (34 citations per year), indicating a great interest in project-based learning innovations that incorporate local cultural elements. In addition, the work of N. Nuraini et al. in 2023 on the development of a PjBL model with a STEAM approach showed that this innovation not only contributed to improving scientific literacy but also provided significant results in improving overall student learning outcomes.

Table 4. Keywords on Trend PjBL Model Trends to Improve Science Literacy Research in (2015-2024)

Terms	Occurrences	Relevance
Creativity	3	3.29
Inquiry	3	3.11
Data	3	2.39
Critical thinking skill	5	1.78
Ethnoscience	3	1.66
PISA	3	1.36
Student science process skill	3	1.35
STEM PjBL	5	1.13
Technology	5	1.08
PBL	4	0.91

Overall, this trend illustrates that research on PjBL continues to grow with a variety of innovative

approaches that not only improve scientific literacy but also enrich students' learning experiences. This phenomenon shows the importance of research sustainability in developing learning models that are responsive to the challenges of 21st century education. Table 4 below displays the ten (10) most frequently used keywords in research on project-based learning (PjBL) models to improve science literacy. These keywords reflect important elements related to the implementation and success of PjBL in science education.

From the table above, it can be seen that the elements "Creativity" and "Inquiry" have high relevance in the context of PjBL, indicating the importance of creativity and inquiry processes as an integral part of project-based learning to improve scientific literacy. Both indicate that the PjBL method not only aims to improve understanding of scientific concepts but also to develop students' critical and creative thinking skills.

The terms "Critical thinking skills" and "Technology" also appear quite often and have significant relevance. This shows that the application of PjBL in scientific literacy often involves the use of technology to improve students' critical thinking skills. In addition, the element "STEM PjBL" confirms that the integration of STEM (Science, Technology, Engineering, and Mathematics) in the PjBL model plays an important role in improving students' scientific literacy, as reflected in various studies.

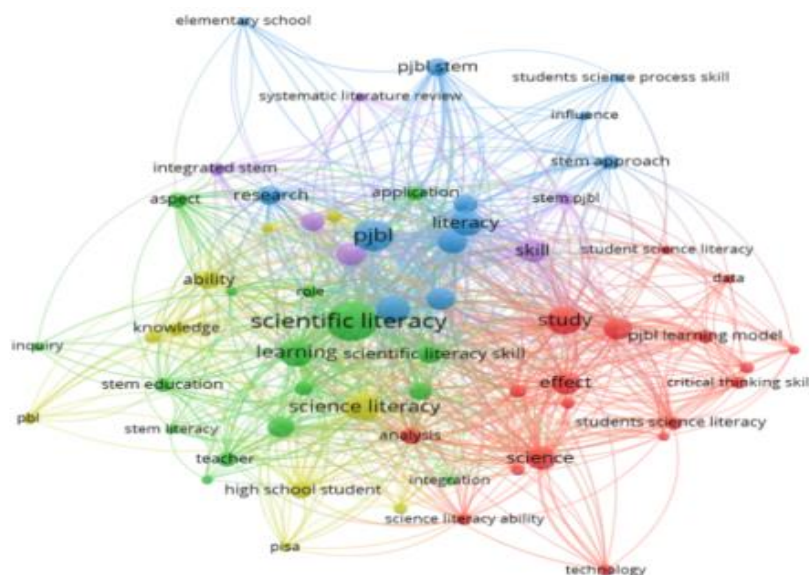


Figure 2. Network visualization on trend PjBL models to improve scientific literacy in science learning research

The emergence of the keyword "Ethnoscience" is also interesting because it shows a trend to associate scientific concepts with local knowledge or cultural wisdom in the context of science education, helping students understand science through their cultural context. This is in line with research results showing that

an ethnoscience-based approach can improve science literacy by making learning more relevant and easier for students to understand.

The use of the term "PISA" (Programme for International Student Assessment) shows that many studies on PjBL refer to this international assessment

standard to measure students' scientific literacy, thus ensuring that the learning model developed is able to compete at the global level.

Overall, the data visualization with a landscape map that includes the terms above offers a clear representation of the direction of research and application of PjBL in science education. This shows that the integration of elements such as creativity, technology, ethnoscience, and international standards such as PISA, all contribute to the development of an effective project-based learning model to improve scientific literacy.

The results of bibliometric mapping for the shared keyword network in articles related to the topic of project-based learning (PjBL) models to improve scientific literacy are shown in Figure 2. Figure 2 shows the results of bibliometric keyword mapping on research trends on PjBL models to improve scientific literacy. In the visualization, there are several keywords that are often used in research on scientific literacy with the PjBL approach, including integration with STEM and technology concepts. This network map illustrates the close relationship between various main keywords related to the PjBL model, such as "scientific literacy," "STEM PjBL," "inquiry," "critical thinking skills," and "technology," indicating research trends that emphasize the development of scientific thinking skills and the use of technology in project-based learning.

This visualization consists of five clusters with different colors, which show how related terms are connected to each other in research: The first cluster (red) includes words such as "PjBL learning model," "critical thinking skills," "technology," and "science." This cluster shows the focus of research on the

application of technology in PjBL to improve students' critical thinking skills and scientific literacy. The second cluster (green) contains keywords such as "scientific literacy," "STEM education," "knowledge," and "learning." This cluster emphasizes the importance of STEM integration in developing scientific literacy and enhancing students' scientific knowledge and skills through PjBL. The third cluster (blue) includes words such as "PjBL STEM," "students' science process skills," and "influence," indicating a project-based approach combined with STEM methods to enhance students' scientific process skills. The fourth cluster (yellow) displays terms such as "inquiry," "research," and "ability," indicating an inquiry-based approach in project-based teaching to enhance students' scientific understanding and abilities. The fifth cluster (purple) includes keywords such as "integrated STEM," "application," and "systematic literature review," which refer to a systematic review of the application and integration of STEM approaches in PjBL to develop scientific literacy.

This keyword network provides insight into recent research trends in the application of PjBL to improve scientific literacy, by showing how this approach is used to develop various scientific competencies, integrate technology and STEM, and improve students' critical and scientific thinking skills. The results of this analysis show some keywords that are often used in research on PjBL models for scientific literacy, and provide an overview of future research directions in this area. Furthermore, the results of the overlay visualization of research trends on PjBL models to improve scientific literacy in science learning are presented in Figure 3.

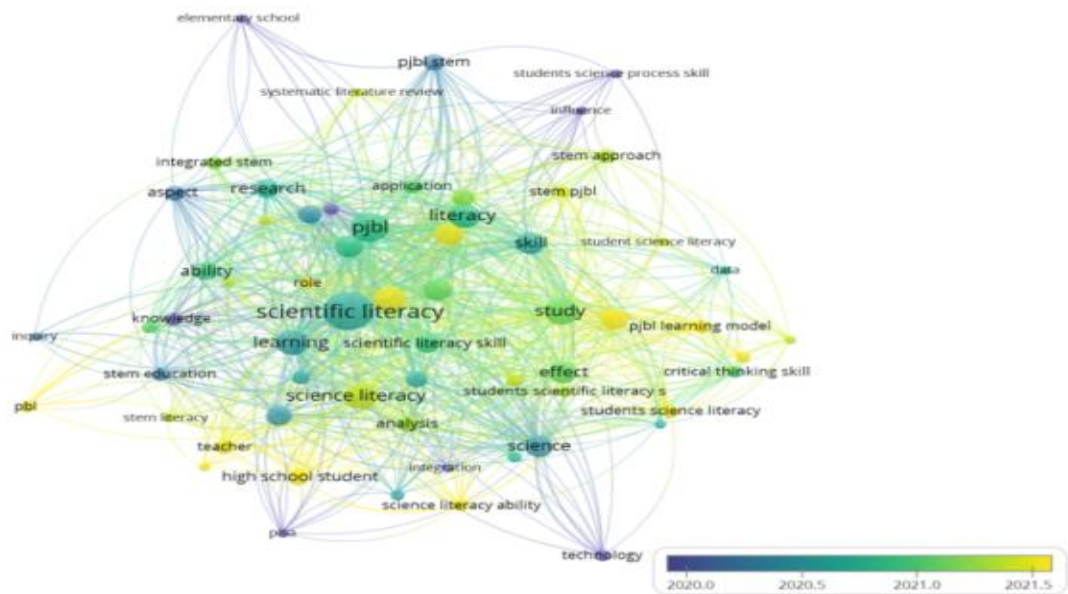


Figure 3. Overlay visualization on trend project-based learning (PjBL) models to improve scientific literacy in science learning research

The figure above shows the trend of keywords related to research on project-based learning (PjBL) models to improve scientific literacy in journals indexed by Google Scholar from 2020 to 2021. The theme trends in articles related to PjBL to improve scientific literacy are marked with different colors: purple, blue, turquoise, green, and yellow.

In Figure 3 it can be seen that in 2020, some keywords that were frequently used by researchers included "systematic literature review," "PISA," and "integrated STEM." The use of these words indicates a focus on integrating STEM methods in project-based learning and the importance of student understanding in the context of international evaluations such as PISA.

In 2021, keywords such as "critical thinking skills," "PjBL learning model," and "scientific literacy" became more dominant. This indicates an increasing interest in using PjBL to develop students' critical thinking skills and scientific literacy. In addition, themes such as "technology," "STEM PjBL," and "student science literacy" emphasize that technology and STEM approaches are an important part of developing science literacy through project-based learning.

Figure 3 also shows that the overlay visualization illustrates when keywords are used in research. The more recent the research, the brighter the color displayed in the overlay map. For example, keywords such as "technology," "STEM approach," and "PjBL STEM" appear more frequently in recent studies, indicating high relevance in project-based learning approaches to improve scientific literacy.

Research on project-based learning models to improve scientific literacy is one of the fastest growing research areas in recent years. This trend shows that the focus on the use of PjBL approaches with STEM and technology integration has become a major concern in improving students' scientific and critical thinking skills.

In addition, keywords for research on project-based learning models (PjBL) to improve scientific literacy are also presented based on density visualization. The figure below shows the density visualization. The density of the research theme is displayed in bright yellow, indicating the frequency of use of certain keywords in the literature. The brighter the color of a theme, the more research has been done on the theme, and conversely, the dimmer the color, meaning that the theme is rarely studied (Azis et al., 2023).

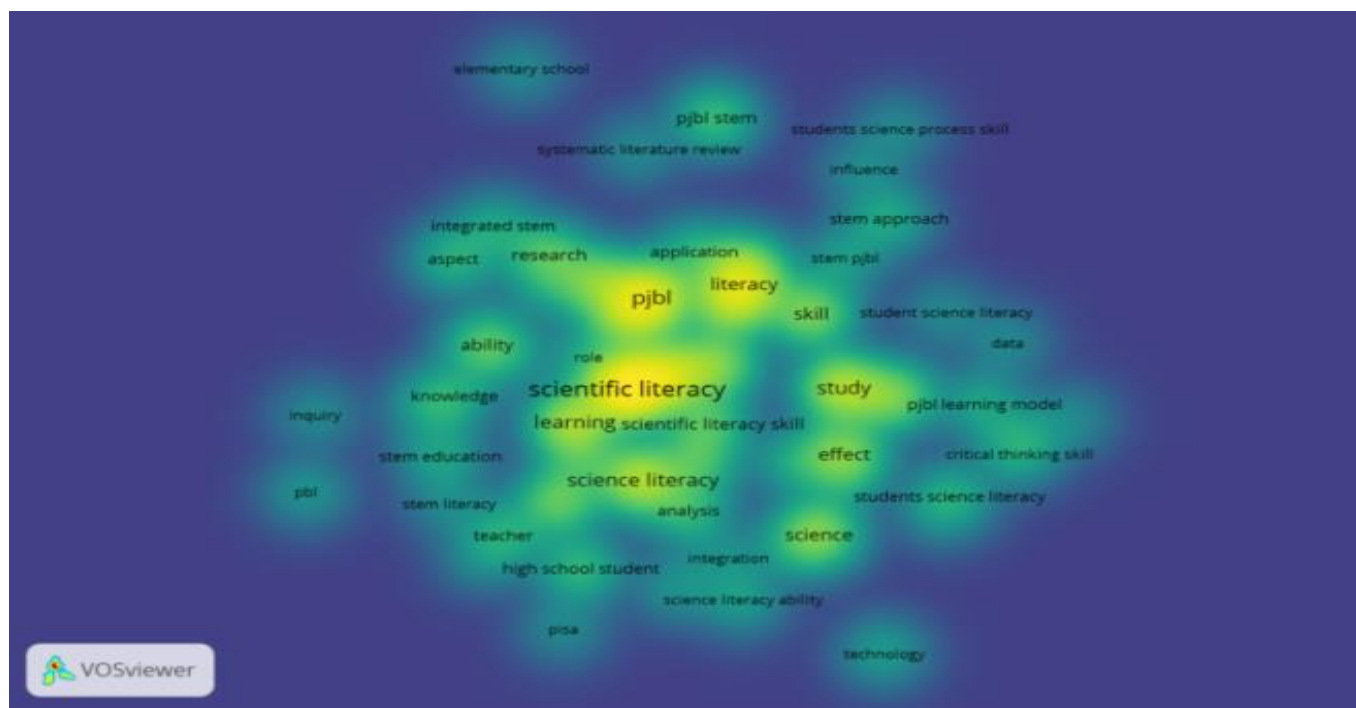


Figure 4. Density visualization on trend PjBL models to improve scientific literacy in science learning research

Some keywords with dim colors such as "inquiry," "technology," and "students science process skills," indicate that these themes have not been widely discussed in research. Therefore, these keywords can be opportunities for further research in the context of PjBL models for scientific literacy. In contrast, keywords marked in bright yellow such as "scientific literacy,"

"PjBL," and "STEM," are the most frequently appearing in related studies, reflecting the main focus of research on this topic.

Overall, research on project-based learning (PjBL) models to improve scientific literacy is highly relevant to the needs of 21st-century education. PjBL models help students develop critical thinking, investigation, and

collaboration skills through real-life projects that connect science concepts to everyday life situations (Ananda et al., 2023; Song et al., 2024; Suradika et al., 2023). By using PjBL, students have the opportunity to better understand scientific concepts while practicing scientific literacy skills, which are essential to prepare them for future global challenges (Bangun et al., 2023; Sholahuddin et al., 2023).

In the next few years, research on the PjBL model to improve science literacy is expected to continue to grow (Rusmansyah et al., 2023). One promising direction of development is to combine PjBL with a local or cultural context-based approach, such as the use of local wisdom in learning projects. For example, connecting science projects with traditional practices in the community can make it easier for students to understand scientific concepts because they can see real applications of the theories they learn (Yuliana et al., 2021; Sari et al., 2023). This local wisdom-based approach not only enriches students' learning experiences but also helps preserve and promote local culture. In this way, students can see the relevance of science learning in their daily lives, increasing their motivation and engagement in the learning process (Jana et al., 2024). In addition, the integration of local wisdom in PjBL also encourages students to develop critical and creative thinking skills when students try to find solutions to problems faced in their projects (Rahayu & Indriyanti, 2023). Thus, research trends in this area not only strengthen scientific literacy but also other crucial 21st-century skills, such as problem solving, communication, and collaboration.

Conclusion

This study reveals a significant trend in scientific literacy in science learning from 2015 to 2024, with a marked increase in publications until it peaked in 2022, before experiencing a slight decline in 2024. This increase reflects the increasing awareness of the importance of scientific literacy as an essential competency of the 21st century, as well as consistent efforts in understanding and developing effective learning approaches, such as the Project-Based Learning (PjBL) model. The data shows that scientific articles are the most dominant form of publication, with the number of publications reaching 1,340 documents, followed by other types of publications. This indicates that scientific articles are the main channel for disseminating research results related to the PjBL model. In addition, findings regarding frequently used keywords emphasize the focus on elements such as creativity, critical thinking, and STEM integration, which further emphasize the relevance of PjBL in the context of science education. This study confirms that the PjBL model continues to be an important and developing topic in the field of

scientific literacy, despite challenges in its implementation. The decline in the trend in 2024 could be due to a shift in research focus or changes in education policy. However, overall, interest in scientific literacy and the use of PjBL in science learning remains high, and there is still scope for further exploration of innovations in this learning model to improve the effectiveness of science education in the future.

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References

- Afriana, J., Permanasari, A., & Fitriani, A. (2016). Project based learning integrated to STEM to enhance elementary school's students' scientific literacy. *Jurnal Pendidikan IPA Indonesia*, 5(2), 261–267. Retrieved from <https://journal.unnes.ac.id/nju/jpii/article/view/5493>
- AlAli, R. (2024). Enhancing 21st Century Skills Through Integrated Stem Education Using Project-Oriented Problem-Based Learning. *Geojournal of Tourism and Geosites*, 53(2), 421–430. <https://doi.org/10.30892/gtg.53205-1217>
- Ananda, L. R., Rahmawati, Y., & Khairi, F. (2023). Critical thinking skills of Chemistry students by integrating design thinking with STEAM-PjBL. *Journal of Technology and Science Education*, 13(1), 352. <https://doi.org/10.3926/jotse.1938>
- Azis, S., Rozalinda, R., & Wira, A. (2023). Tren Dan Fokus Penelitian Inflasi Global: Sebuah Analisis Bibliometrik. *Journal of Economic, Business and Engineering (JEBE)*, 5(1), 10–22. <https://doi.org/10.32500/jebe.v5i1.5367>
- Bangun, W., Degeng, I. N. S., Praherdhiono, H., & Lestari, S. R. (2023). The effect of blended project-based learning for enhancing student's scientific literacy skills: An experimental study in University. *Pegem Journal of Education and Instruction*, 13(1), 223–233. <https://doi.org/10.47750/pegegog.13.01.24>
- Coppi, M., Fialho, I., & Cid, M. (2023). Developing a Scientific Literacy Assessment Instrument for Portuguese 3rd Cycle Students. *Education Sciences*,

- 13(9), 941.
<https://doi.org/10.3390/educsci13090941>
- 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/10.1002/1098-2736\(200008\)37:6<582::AID-TEA5>3.0.CO;2-L](https://doi.org/10.1002/1098-2736(200008)37:6<582::AID-TEA5>3.0.CO;2-L)
- Dewi, V. C., Kuswanti, N., & Prijono, B. (2023). Implementation of Problem-Based Learning Model based on Differentiated Learning to Improve Science Literacy Skills and Student Activities. *Jurnal Eksakta Pendidikan (JEP)*, 7(2), 225–238.
<https://doi.org/10.24036/jep/vol7-iss2/772>
- Faisal, & Martin, S. N. (2019). Science education in Indonesia: past, present, and future. *Asia-Pacific Science Education*, 5(1), 4.
<https://doi.org/10.1186/s41029-019-0032-0>
- Fauziah, D. A., Erman, E., Susiyawati, Enny, & Budiyanto, M. (2023). Implementation of project-based learning models to improve science literacy of junior high school students. *Jurnal Pijar Mipa*, 18(2), 176–182.
<https://doi.org/10.29303/jpm.v18i2.4795>
- Hallinger, P., & Chatpinyakoo, C. (2019). A Bibliometric Review of Research on Higher Education for Sustainable Development, 1998–2018. *Sustainability*, 11(8), 2401.
<https://doi.org/10.3390/su11082401>
- Hallinger, P., & Nguyen, V.-T. (2020). Mapping the Landscape and Structure of Research on Education for Sustainable Development: A Bibliometric Review. *Sustainability*, 12(5), 1947.
<https://doi.org/10.3390/su12051947>
- Hartini, A. (2017). Pengembangan perangkat pembelajaran model project based learning untuk meningkatkan kemampuan berpikir kritis siswa sekolah dasar. *ELSE (Elementary School Education Journal): Jurnal Pendidikan Dan Pembelajaran Sekolah Dasar*, 1(2a).
<https://doi.org/10.30651/else.v1i2a.1038>
- 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>
- Holbrook, J., & Rannikmae, M. (2007). The Nature of Science Education for Enhancing Scientific Literacy. *International Journal of Science Education*, 29(11), 1347–1362.
<https://doi.org/10.1080/09500690601007549>
- Jana, J., Hammidah, H., Chand, R., & Haselkorn, J. (2024). Community Spirit and Local Wisdom: Strengthening Character Education through the Ngarot Tradition in Social Studies Learning. *Journal of Social Knowledge Education (JSKE)*, 5(1), 9–20.
<https://doi.org/10.37251/jske.v5i1.888>
- Karan, E., & Brown, L. (2022). Enhancing Student's Problem-Solving Skills through Project-Based Learning. *Journal of Problem Based Learning in Higher Education*, 10(1), 74–87.
<https://doi.org/10.5278/ojs.jpblhe.v10i1.6887>
- Kollas, S., & Halkia, K. (2020). Scientific Literacy in Second Chance Schools: Training Science Teachers to Design Context-based Curricula. *Universal Journal of Educational Research*, 8(10), 4877–4890.
<https://doi.org/10.13189/ujer.2020.081060>
- Kurt, G., & Akoglu, K. (2023). Project-based learning in science education: A comprehensive literature review. *Interdisciplinary Journal of Environmental and Science Education*, 19(3), e2311.
<https://doi.org/10.29333/ijese/13677>
- Marjanah, M., Pandia, E., & Nursamsu, N. (2021). Development of Practicum Instruction Module Based on Project Based Learning (PjBL) Integrated with Science Process Skills and Scientific Literacy. *Jurnal Penelitian Pendidikan IPA*, 7(SpecialIssue), 104–111.
<https://doi.org/10.29303/jppipa.v7iSpecialIssue.874>
- Martín-García, J., Dies Álvarez, M. E., & Afonso, A. S. (2024). Understanding Science Teachers' Integration of Active Methodologies in Club Settings: An Exploratory Study. *Education Sciences*, 14(1), 106.
<https://doi.org/10.3390/educsci14010106>
- Moshtari, M., & Safarpour, A. (2024). Challenges and strategies for the internationalization of higher education in low-income East African countries. *Higher Education*, 87(1), 89–109.
<https://doi.org/10.1007/s10734-023-00994-1>
- Muhibbuddin, M., Yustina, N., & Safrida, S. (2020). Implementation Of Project-Based Learning (PjBL) Model In Growth And Development Learning To Increase The Students' Science Literacy And Critical Thinking Skills. *IJAEDU- International E-Journal of Advances in Education*, 6(16), 66–72.
<https://doi.org/10.18768/ijaedu.616008>
- Muliyadi, L., Doyan, A., Susilawati, Hamidi, Hakim, S., & Munandar, H. (2023). Training on Using PhET Virtual Media on Newton's Law of Gravity for Class X Students at Islamic Senior High School of Syaikh Abdurrahman Kotaraja, East Lombok. *Unram Journal of Community Service*, 1(1), 15–18.
 Retrieved from <https://journals.balaipublikasi.id/index.php/jcss/article/view/68>
- Munandar, H., Doyan, A., Susilawati, S., Hakim, S., Muliyadi, L., & Hamidi, H. (2024). Increasing Motivation to Study Physics Using PhET Media on

- Mechanical Energy Material. *MANDALIKA : Journal of Social Science*, 2(1), 1-5. <https://doi.org/10.56566/mandalika.v2i1.70>
- Nuraini, N., Asri, I. H., & Fajri, N. (2023). Development of Project Based Learning with STEAM Approach Model Integrated Science Literacy in Improving Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, 9(4), 1632-1640. <https://doi.org/10.29303/jppipa.v9i4.2987>
- Nuraini, N., Fajri, N., Asri, I. H., & Waluyo, E. (2023). Development of Project Based Learning With STEAM Approach Model in Improving the Science Literacy Ability of High School Students. *Jurnal Pendidikan Sains Indonesia*, 11(3), 639-653. <https://doi.org/10.24815/jpsi.v11i3.30934>
- Nurhayani, N., & Nurhafizah, N. (2022). Media dan Metode Pengembangan Literasi Anak Usia Dini di Kuttab Al Huffazh Payakumbuh. *Jurnal Basicedu*, 6(6), 9333-9343. <https://doi.org/10.31004/basicedu.v6i6.3598>
- OECD. (2019). *PISA 2018 Results (Volume I)*. OECD Publishing. <https://doi.org/10.1787/5f07c754-en>
- Rahayu, R., Sutikno, & Indriyanti, D. R. (2023). Ethnosains Based Project Based Learning Model with Flipped Classroom on Creative Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 9(8), 348-355. <https://doi.org/10.29303/jppipa.v9i8.3051>
- Rasa, T., Lavonen, J., & Laherto, A. (2024). Agency and Transformative Potential of Technology in Students' Images of the Future. *Science & Education*, 33(5), 1145-1169. <https://doi.org/10.1007/s11191-023-00432-9>
- Rusmansyah, R., Leny, L., & Sofia, H. N. (2023). Improving Students' Scientific Literacy and Cognitive Learning Outcomes through Ethnoscience-Based PjBL Model. *Journal of Innovation in Educational and Cultural Research*, 4(1), 1-9. <https://doi.org/10.46843/jiecr.v4i1.382>
- Saputra, H. (2024). Penguatan Kemampuan Peserta Didik Dalam Menghadapi Era Society 5.0 Melalui Pembelajaran Matematika. *BERSATU: Jurnal Pendidikan Bhinneka Tunggal Ika*, 2(2), 287-302. <https://doi.org/10.51903/bersatu.v2i2.640>
- Sari, F. P., Maryati, M., & Wilujeng, I. (2023). Ethnoscience Studies Analysis and Their Integration in Science Learning: Literature Review. *Jurnal Penelitian Pendidikan IPA*, 9(3), 1135-1142. <https://doi.org/10.29303/jppipa.v9i3.2044>
- Sari, I. N., Mahanal, S., & Setiawan, D. (2024). Implementation of a problem-based learning model assisted with scaffolding to improve scientific literacy and student cognitive learning outcomes. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, 6(1), 35. <https://doi.org/10.20527/bino.v6i1.17890>
- Setiawan, D., Ashari, R. B., Ansori, I., Fathurrahman, M., Kiptiyah, S. M., & Tyas, D. N. (2023). Actualization of Science Literacy in the Freedom Era of Studying in the City of Semarang. *Jurnal Penelitian Pendidikan IPA*, 9(9), 7238-7248. <https://doi.org/10.29303/jppipa.v9i9.4219>
- Sholahuddin, A., Anjuni, N., Leny, L., & Faikhamta, C. (2023). Project-Based and Flipped Learning in the Classroom: A Strategy for Enhancing Students' Scientific Literacy. *European Journal of Educational Research*, volume-12-(volume-12-issue-1-january-2023), 239-251. <https://doi.org/10.12973/euler.12.1.239>
- Sholikah, L., & Pertiwi, F. N. (2021). Analysis Of Science Literacy Ability Of Junior High School Students Based On Programme For International Student Assesment (PISA). *INSECTA: Integrative Science Education and Teaching Activity Journal*, 2(1), 95-104. <https://doi.org/10.21154/insecta.v2i1.2922>
- Sinaga, P., Kaniawati, I., & Setiawan, A. (2017). Improving secondary school students' scientific literacy ability through the design of better science textbooks. *Journal of Turkish Science Education*, 14(4), 92-107. Retrieved from <https://www.tused.org/index.php/tused/article/view/176/132>
- Song, X., Razali, A. B., Sulaiman, T., & Jeyaraj, J. J. (2024). Impact of Project-Based Learning on Critical Thinking Skills and Language Skills in EFL Context : A Review of Literature. *World Journal of English Language*, 14(5), 402. <https://doi.org/10.5430/wjel.v14n5p402>
- Stuckey, M., Hofstein, A., Mamlok-Naaman, R., & Eilks, I. (2013). The meaning of 'relevance' in science education and its implications for the science curriculum. *Studies in Science Education*, 49(1), 1-34. <https://doi.org/10.1080/03057267.2013.802463>
- Sunandar, A., Srihanaty, S., & Rahayu, H. M. (2022). Scientific Literacy Skills Of State High School Students In Singkawang City. *Jurnal Penelitian Pendidikan IPA*, 8(2), 767-772. <https://doi.org/10.29303/jppipa.v8i2.1350>
- Suradika, A., Dewi, H. I., & Nasution, M. I. (2023). Project-Based Learning and Problem-Based Learning Models in Critical and Creative Students. *Jurnal Pendidikan IPA Indonesia*, 12(1), 153-167. <https://doi.org/10.15294/jpii.v12i1.39713>
- Susilawati, Doyan, A., Rokhmat, J., & Muliyadi, L. (2023). Analysis Validation of Modern Physics Learning Media Based on Smartphone Integrated Project Based Learning to Improve Students' Creativity and Scientific Literacy. *Jurnal Penelitian Pendidikan IPA*, 9(10), 7888-7892. <https://doi.org/10.29303/jppipa.v9i10.5404>
- Susilawati, Doyan, A., Rokhmat, J., Muliyadi, L., Rizaldi,

- D. R., Fatimah, Z., Ikhsan, M., & Ardianti, N. R. (2025). Integration of Smartphone-Based Learning Media and Project-Based Learning to Enhance Creativity and Scientific Literacy in Physics. *International Journal of Information and Education Technology*, 15(7), 1449–1459. <https://doi.org/10.18178/ijiet.2025.15.7.2346>
- Suwono, H., Rofi'Ah, N. L., Saefi, M., & Fachrunnisa, R. (2023). Interactive socio-scientific inquiry for promoting scientific literacy, enhancing biological knowledge, and developing critical thinking. *Journal of Biological Education*, 57(5), 944–959. <https://doi.org/10.1080/00219266.2021.2006270>
- Trisdiono, H., Siswandari, S., Suryani, N., & Joyoatmojo, S. (2019). Multidisciplinary Integrated Project-based Learning to Improve Critical Thinking Skills and Collaboration. *International Journal of Learning, Teaching and Educational Research*, 18(1), 16–30. <https://doi.org/10.26803/ijlter.18.1.2>
- Tsaparlis, G., Hartzavalos, S., & Nakiboğlu, C. (2013). Students' Knowledge of Nuclear Science and Its Connection with Civic Scientific Literacy in Two European Contexts: The Case of Newspaper Articles. *Science & Education*, 22(8), 1963–1991. <https://doi.org/10.1007/s11191-013-9578-5>
- Ulu-Aslan, E., & Baş, B. (2023). Popular culture texts in education: The effect of tales transformed into children's media on critical thinking and media literacy skills. *Thinking Skills and Creativity*, 47, 101202. <https://doi.org/10.1016/j.tsc.2022.101202>
- Valladares, L. (2021). Scientific literacy and social transformation: Critical perspectives about science participation and emancipation. *Science & Education*, 30(3), 557–587. <https://doi.org/10.1007/s11191-021-00205-2>
- Wahyu, Y., Edu, A. L., & Helmon, A. (2023). STEM-based PjBL Learning Model with Manggaraians Indigenous Science Content to Improve Science Literacy: is it Effective? *Jurnal Penelitian Pendidikan IPA*, 9(10), 8263–8273. <https://doi.org/10.29303/jppipa.v9i10.4963>
- Wardah, I., Septaria, K., Mahbubah, K., & Mubarok, H. (2022). The Effect of Project Based Learning (PjBL) Model on Students' Science Literacy in Social Studies Subjects. *Jurnal Penelitian Dan Pengkajian Ilmu Pendidikan: E-Saintika*, 6(2), 108–119. <https://doi.org/10.36312/esaintika.v6i2.738>
- Winarni, E. W., Karpudewan, M., Karyadi, B., & Gumono, G. (2022). Integrated PjBL-STEM in Scientific Literacy and Environment Attitude for Elementary School. *Asian Journal of Education and Training*, 8(2), 43–50. <https://doi.org/10.20448/edu.v8i2.3873>
- Yacobian, H. A. (2018). Scientific literacy for democratic decision-making. *International Journal of Science Education*, 40(3), 308–327. <https://doi.org/10.1080/09500693.2017.1420266>
- Yuliana, I., Cahyono, M. E., Widodo, W., & Irwanto, I. (2021). The Effect of Ethnoscience-Themed Picture Books Embedded Within Context-Based Learning on Students' Scientific Literacy. *Eurasian Journal of Educational Research*, 21(92), 317–334. <https://doi.org/10.14689/ejer.2021.92.16>
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 39. <https://doi.org/10.1186/s41239-019-0171-0>