

Scientific Literacy Research in Physics Education: A Comprehensive Bibliometric Analysis and Future Research Directions

**Indri Maya Ariana¹, Khofifatur Risma Faradillah¹, Muhammad Ghiyats Naufal¹,
Adrian Bagas Damarsha¹, Titin Sunarti^{1*}, and Hanandita Veda Saphira²**

¹Department of Physics Education, Universitas Negeri Surabaya, Surabaya, Indonesia

²Faculty of the Arts, Social Sciences and Humanities, University of Wollongong,
Wollongong, Australia

*titinsunarti@unesa.ac.id

Article Info	Abstract
Article history: Received: December 13, 2025 Accepted: April 4, 2026 Published: June 29, 2026 Keywords: Bibliometric Physics education Scientific literacy This article is licensed under a Creative Commons Attribution-NonCommercial- NoDerivatives 4.0 International License © 2026 Berkala ilmiah Pendidikan Fisika	Science literacy is an essential 21st-century competency that encompasses not only an understanding of scientific concepts but also critical thinking skills, environmental awareness, and the ability to address global issues. Although attention to science literacy is increasing, research in this field remains fragmented and lacks comprehensive mapping. This study offers novelty through the application of bibliometric analysis to map trends, contributions, directions, and opportunities for science literacy research in the context of education. Data were collected from the Scopus database for the period 2014–2024 using the keywords “scientific literacy” and “education,” then analyzed with RStudio software and bibliometric visualization. The results show a significant upward trend in publications since 2017, with Indonesia making the dominant contribution. Future research directions are moving towards integrating scientific literacy with digital technology, understanding the nature of science and its relevance to global issues such as socio-scientific issues and global warming, and developing critical thinking skills. Thus, scientific literacy is positioned not only as a cognitive domain but also as a strategic tool for students to face the dynamics and challenges of the modern world. The results of this study have important implications for the development of a more contextual, innovative, and digitally integrated curriculum and for guiding future research that links science literacy with cross-cutting issues such as environment, technology, society, culture, and local wisdom to enrich perspectives and research directions.
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INTRODUCTION

Science literacy is one of the essential skills that must be developed in the 21st century to face the challenges of globalization (Afnan et al., 2023; Devi et al., 2025; Rahayu et al., 2022). The development of science literacy in this era is not only limited to reading and writing skills but also includes critical thinking, environmental awareness, and global citizenship, so that it can play a strategic role in science education to nurture students who are rational, creative, innovative, and competitive at the global level (Khanum & Haleem, 2023). In addition, science literacy is also seen as a key element in education because competence in science and technology is one of the main foundations for the success of citizens in this modern era (Asrizal & Festiyed, 2020). The hope is that science literacy can

become a 21st-century competency that equips future generations with critical and innovative thinking skills so that they are able to face global challenges. Therefore, science literacy is not only a learning objective but also a fundamental foundation for preparing future generations to face the demands of a complex modern world ([Karimah et al., 2021](#); [Novia et al., 2024](#)).

Despite high expectations for science literacy, various international studies indicate that students' science literacy achievements remain low ([Dewi et al., 2021](#)). The Programme for International Student Assessment (PISA) report consistently shows that many countries, including Indonesia, face serious challenges in improving student science literacy ([Romli et al., 2024](#); [Wu, 2025](#)). Indonesian students' science literacy achievements from PISA results from 2000 to 2018 are still in the low category because the scores are consistently below the international average ([Murti et al., 2024](#)). These results indicate that the methods and models used in the implementation of learning processes and activities have not been fully effective in fostering the expected scientific skills ([Putri et al., 2025](#); [Sholikah & Pertiwi, 2021](#)). On the other hand, the number of scientific publications related to learning strategies, assessment, and science integration continues to increase significantly ([Gligorea et al., 2023](#)). This shows that academics and researchers are paying close attention to the issue of science literacy in education ([Howell & Brossard, 2021](#); [Kintan et al., 2024](#)).

The increasing attention to research on science literacy has not been fully matched by a comprehensive mapping of developments in this field ([Li & Guo, 2021](#)). Most research is still fragmented, limited to specific aspects such as learning strategies, assessment, or curriculum implementation without providing a comprehensive overview, resulting in an unclear direction for the development of science literacy research globally and regionally ([Fortus et al., 2022](#); [Hadiastriani & Djarot, 2024](#)). This condition emphasizes the need for a knowledge map that can show the main trends, significant contributions, and interrelationships between fields in science literacy research ([Tasquier et al., 2022](#)). Without clear mapping, the risk of research duplication and loss of focus on relevant issues is even greater ([Hammer et al., 2023](#)).

In this context, bibliometric analysis is very important because this method is able to present a knowledge map that reveals the interrelationships between topics, author collaboration networks, and the role of journals and institutions in shaping the research landscape ([Lubis & Winoto, 2025](#); [Yan & Zhiping, 2023](#)). Despite its great potential, bibliometric studies on science literacy are still relatively limited ([Pranckutė, 2021](#)). The main challenge that arises is the absence of a comprehensive and systematic database that can be used as a reference by researchers and education practitioners, so that the mapping of trends and directions in science literacy research has not been carried out optimally ([Ritmayanti & Dasari, 2025](#)). Therefore, a systematic approach is needed to provide a comprehensive overview of the direction, opportunities, and challenges of science literacy research in the future ([Qi et al., 2021](#)).

The time span of 2014-2024 was selected to capture the most recent developments in scientific literacy research in education. This period reflects a decade in which global education has increasingly emphasized 21st-century skills, digital learning integration, and the influence of international assessments such as PISA. In bibliometric studies, a ten-year timeframe is commonly used to provide a representative overview of current research trends while ensuring sufficient publication data for analysis. Therefore, focusing on this period allows this study to identify contemporary trends, emerging topics, and collaboration patterns in scientific literacy research.

Based on these issues, this study focuses on answering two main questions, namely:

RQ1: What are the trends and contributions to science literacy research in education?

RQ2: What are the directions and opportunities for science literacy research in the future

based on the results of the bibliometric analysis?

Based on these research questions, an approach is needed that can provide a comprehensive overview of the development of science literacy research in terms of trends, contributions, and directions for development. Bibliometric analysis is considered relevant because it can systematically map publication patterns, citation relationships, and collaboration networks, thereby providing a comprehensive understanding of the science literacy research landscape ([Johnson et al., 2022](#)). Therefore, this study aims to analyze trends and contributions of science literacy research in education, map collaboration networks and emerging topics, and identify future directions and opportunities for science literacy research based on bibliometric analysis results.

The novelty of this study lies in the application of systematic bibliometric analysis to scientific publications related to science literacy in the field of education. Bibliometric analysis is an effective approach for mapping and understanding the landscape of science literacy research as a whole ([Rojas-Sánchez et al., 2023](#)). This method is used to analyze scientific publications, citation patterns, and research trends, enabling researchers to evaluate literature developments, identify influential journals and researchers, and uncover patterns of collaboration in science literacy research ([López-Medina et al., 2022](#); [Salazar-Sepúlveda et al., 2023](#)). Its application in the field of science literacy can provide an overview of the direction of research, the dominant methods used, trending topics, and the contributions of countries and institutions to the development of science literacy globally ([Amarulloh & Aswie, 2024](#); [Ho et al., 2023](#)). In addition, this analysis enables the evaluation of publication trends, key keywords, and collaboration networks between researchers, thereby helping researchers identify developments and aspects that require further research ([Linnenluecke et al., 2020](#)). Thus, this study not only offers a comprehensive overview of the development of science literacy but also provides strategic directions for future research.

METHODS

This study was conducted using a literature review method with a bibliometric approach. The use of this method aims to produce specific conclusions in the research to be conducted. Literature review plays an important role in the development of research before entering the field research stage, so that the scope of the research can be optimized ([Linnenluecke et al., 2020](#)). Bibliometric analysis enables researchers to identify publication trends, influential authors, and research gaps that are relevant to the topic being studied ([Johnson, et al., 2022](#)). This approach helps reduce bias and increases the ability to adapt to emerging research trends in the research discussion ([Page et al., 2021](#)). The following presents the research design in Figure 1.

Data collection for this study was conducted by accessing the SCOPUS International Journal database, covering the period from 2014 to 2024. The documents were identified using two primary keywords in the search: "scientific literacy" and "education." To ensure the relevance of the retrieved documents, the Article Title, Abstract, and Keywords (TITLE-ABS-KEY) search feature was utilized, focusing on identifying documents directly related to the research topic. The data retrieval was conducted in a single session in August 2025, maintaining consistency due to the regular updates of the SCOPUS database.

The search query used was as follows: (TITLE-ABS-KEY ("scientific literacy")) AND TITLE-ABS-KEY ("education")). The search results were then exported in Microsoft Excel format (.csv) to facilitate subsequent data processing. The next stage of data processing involved additional filtering based on the relevance of the keywords found in document references. This process was organized into three main stages: identification,

filtering, and selection of relevant documents.

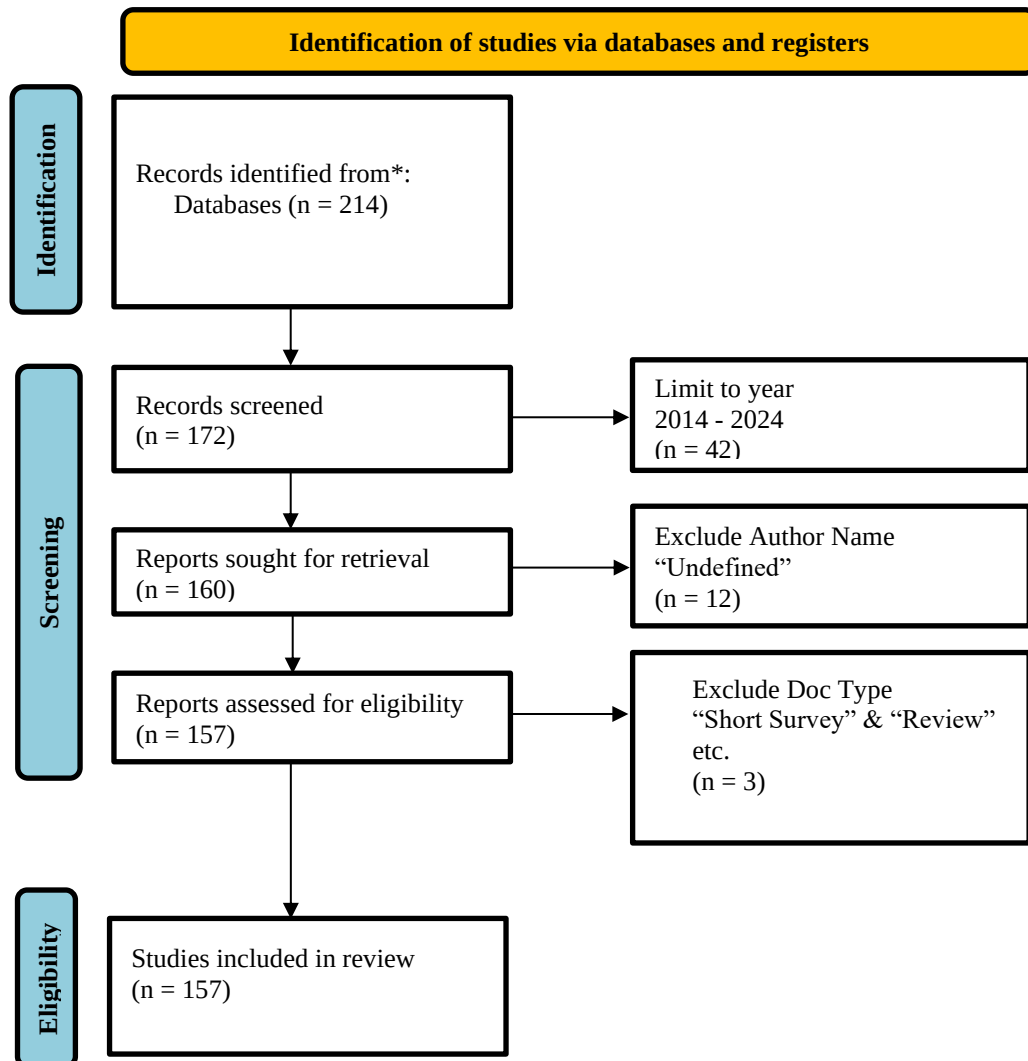


Figure 1 Research design

The identification phase initially yielded 214 documents. During the screening phase, documents with incomplete metadata, duplicates, and authors listed as "Undefined" were removed. Further, a feasibility check was conducted, excluding document types such as editorials, review articles, and short communications. After completing these stages, 157 documents were deemed suitable for further analysis. The final stage of data analysis was performed using RStudio software and the Systematic Content Review (SCR) method to analyze the thematic literature.

For the sake of transparency and replicability, the entire search process, including the databases used, search queries, search features (TITLE-ABS-KEY), data collection time (Agustus 2025), and filtering criteria, was documented in detail so that other researchers could replicate the search process with the same configuration.

RESULTS AND DISCUSSION

Figure 2 shows that publications related to science literacy in education fluctuated but tended to increase throughout the period 2014–2024. In 2014–2016, the number of publications was relatively low and stable (around 3–5 articles per year). However, starting in 2017, there was a significant increase, with a sharp jump in 2018–2019 to more than 20 articles published. The peak in publications occurred in 2021 with the highest number of articles, indicating increased researcher interest in the topic of science literacy in line with the development of 21st-century global issues. Publications declined sharply in 2022 but rose again in 2023–2024 and remained at a relatively stable level.

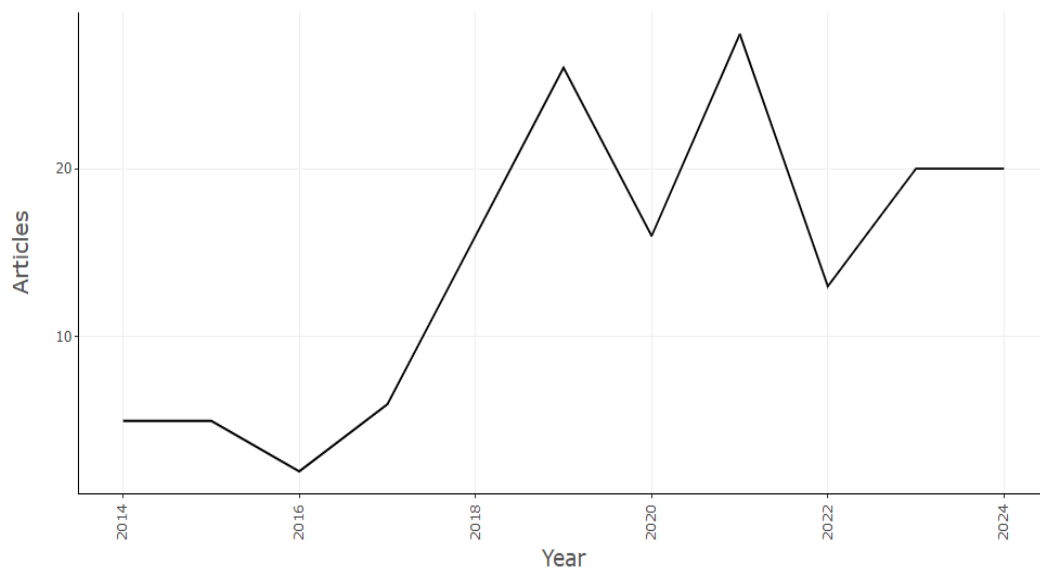


Figure 2 Research trend from scopus database

Figure 3 shows a Sankey diagram connecting the merged keywords, descriptions, and index terms. From this diagram, a thematic pattern of science literacy research can be obtained. The diagram shows several dominant themes in science literacy research. The most frequently appearing keyword is “scientific literacy,” followed by “physics,” “learning systems,” “students,” and “teaching.” The keyword “scientific literacy” is connected to other terms such as science literacy, teaching, and students. This shows that science literacy is often studied in relation to the learning process and the development of student competencies. The keywords “physics” and “physics learning” are linked to the terms “physics education” and “science education.” This indicates that there is a special focus on science literacy in the field of physics, both in the context of learning and the development of science literacy. In addition, the keywords “learning systems” and “teaching” are linked to the terms “education” and “science education.” This confirms that learning systems are an important focus in science literacy research. Interestingly, although still relatively infrequent, new keywords such as “digital literacy,” “education computing,” and “nature of science” have emerged. This pattern indicates that scientific literacy is not only positioned as a conceptual understanding but also as a competency closely linked to learning processes in physics education. In the context of the OECD/PISA framework, this reflects the development of scientific competencies, particularly in explaining phenomena and interpreting data. Therefore, physics education plays a strategic role in fostering scientific literacy through inquiry-based and problem-based learning approaches.

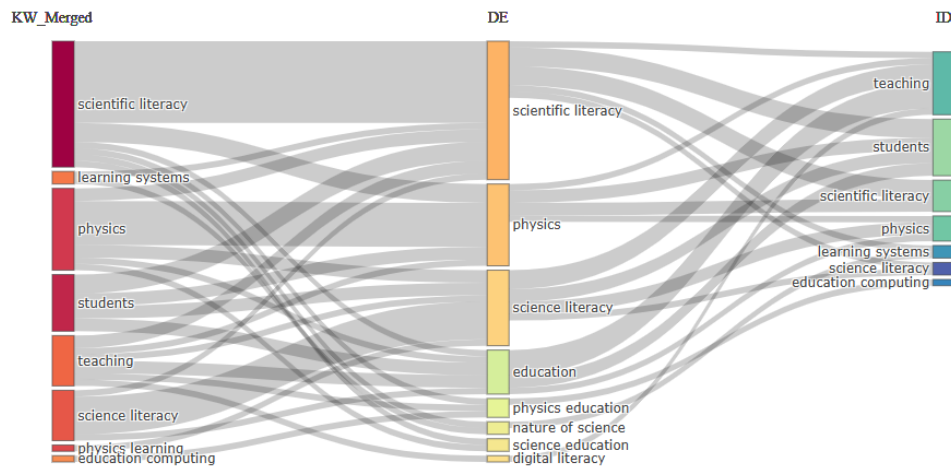


Figure 3 Thematic structure of scientific literacy research

The graph in Figure 4 shows that the Journal of Physics: Conference Series is the most dominant publication source with 64 documents. This position indicates that the topic of science literacy is widely studied and published through conference forums, especially those related to physics education. The second source is AIP Conference Proceedings, which made a significant contribution with 18 documents. Meanwhile, publications in scientific journals were relatively few, as can be seen in the graph, with Education Sciences, Jurnal Pendidikan IPA Indonesia, and Research in Science and Technological Education each containing only 3 articles.

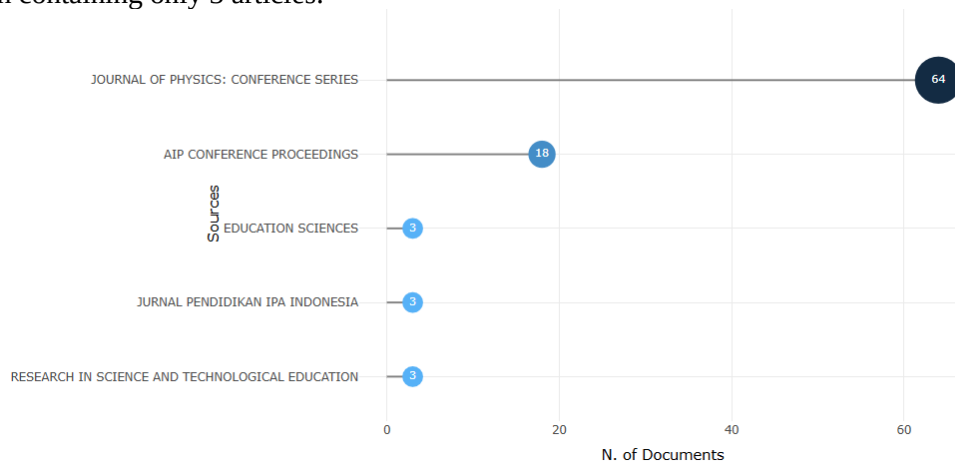


Figure 4 Most publication sources graph

The graph in Figure 5 shows that research on science literacy in education is dominated by several leading researchers. Prahani is listed as the author with the highest number of publications, namely seven documents. This position confirms Prahani's role in the development of science literacy studies, particularly in the fields of science and physics education. Next in line, Sunarti contributed five publications, while Afrizon, Wibowo, and Yuliati each produced four publications. Although the number of publications is smaller, their presence shows that there are other groups of researchers who are consistently exploring the theme of science literacy.

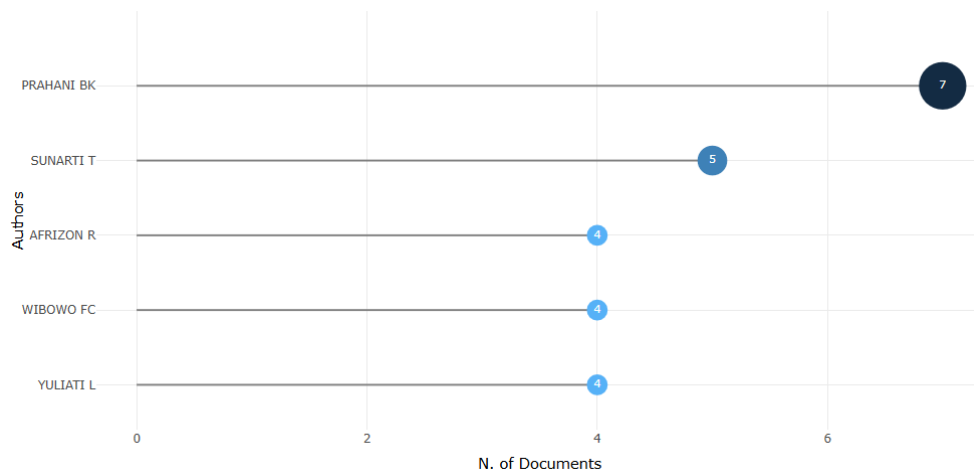


Figure 5 The top productive of authors

Figure 6 shows the productivity of authors based on time period, with contributions to science literacy research in education varying among authors. Prahani has maintained a consistent position with publications spread out from 2018 to 2024. The highest level of productivity was shown in 2021, which is illustrated by a large circle and dark color. Sunarti also showed relatively even publication involvement with the highest level of productivity in 2018. Meanwhile, Afrizon appeared to be active starting in 2020 and continued in the following year with the highest level of productivity in 2023. Meanwhile, Wibowo appears to have been active since 2021 with the highest productivity level, but his productivity level was low in the following year. Yuliati showed publication involvement with the highest productivity level in 2018 compared to the following year.

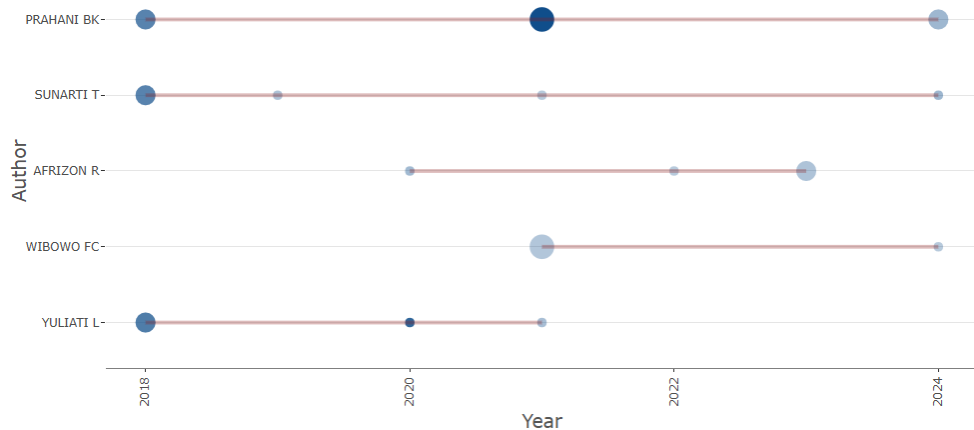


Figure 6 Authors' productivity by year

Figure 7 shows the institutions with the highest number of publications related to science literacy research. The graph shows that the contribution of science literacy research in education in Indonesia is dominated by universities that have a strong foundation in science education. Surabaya State University is listed as the institution with the highest number of publications, namely 25 articles. This position confirms the role of these universities as centers for science literacy studies, especially through the contributions of their authors. Next is Padang State University with 20 articles, followed by the Indonesia University of Education with 19 articles. Below them, Malang State University produced 16 articles, while Jakarta State University produced 14 articles. Although the number of

publications is low compared to the previous three universities, the existence of these institutions reflects that research on this topic is beginning to spread. In the future, it is hoped that there will be cross-institutional collaboration from developing countries to expand the study.

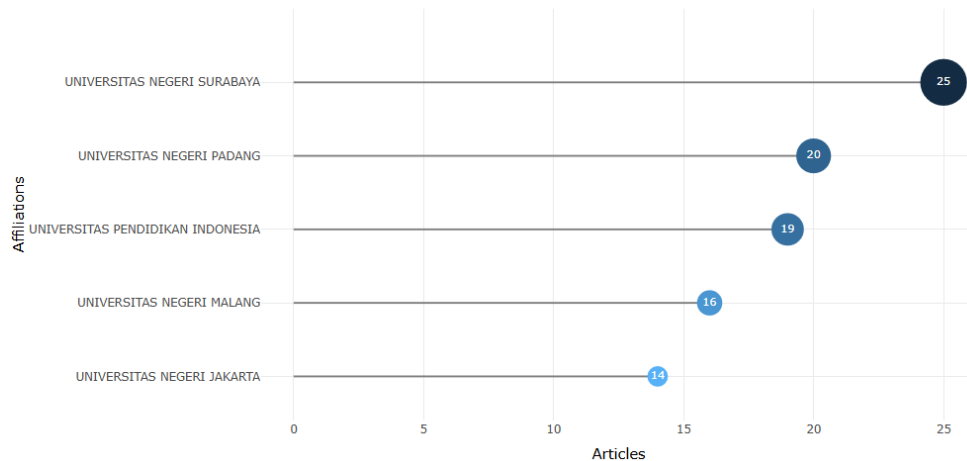


Figure 7. Most Productive Affiliation Graph

Figure 8 shows the documents with the highest number of global citations related to science literacy research in the context of education. The article written by [Fakhriyah et al. \(2017\)](#) in the Indonesian Journal of Science Education ranks first with 46 global citations. This indicates that this work is a major reference and has a significant influence on science literacy research. The next position is occupied by [Parno et al. \(2020\)](#) in the Indonesian Journal of Science Education with 31 citations and [Bellova et al. \(2018\)](#) in Research in Science & Technological Education with 30 citations. Meanwhile, the article by [Foti et al. \(2021\)](#) in Universe received 28 citations, and [Yuliati et al. \(2018\)](#) in the Journal of Physics Conference Series received 25 citations. Overall, this data shows that science literacy research in Indonesia has high visibility globally.



Figure 8 The top citation

Figure 9 shows the results of Vosviewer's analysis of dominant keywords. The results show several clusters related to science literacy. The keyword “scientific literacy” occupies the most dominant position as the main focus of the research. This keyword is connected to various supporting concepts, and it is strongly linked to the terms “physics,” “physics learning,” and “problem-based learning,” indicating that science literacy is often applied in

physics learning using innovative approaches. The green cluster emphasizes aspects of socio-scientific issues, science learning, teaching materials, critical thinking, and science evidence. This reflects a shift in science research towards the integration of social issues with more applied science learning. The red cluster relates to the realm of general education and pedagogy, while the purple cluster relates to inquiry-based learning and STEM. Interestingly, the interconnection of keywords such as “global warming,” “higher school,” and “Indonesia” shows that science literacy research is also linked to global issues.

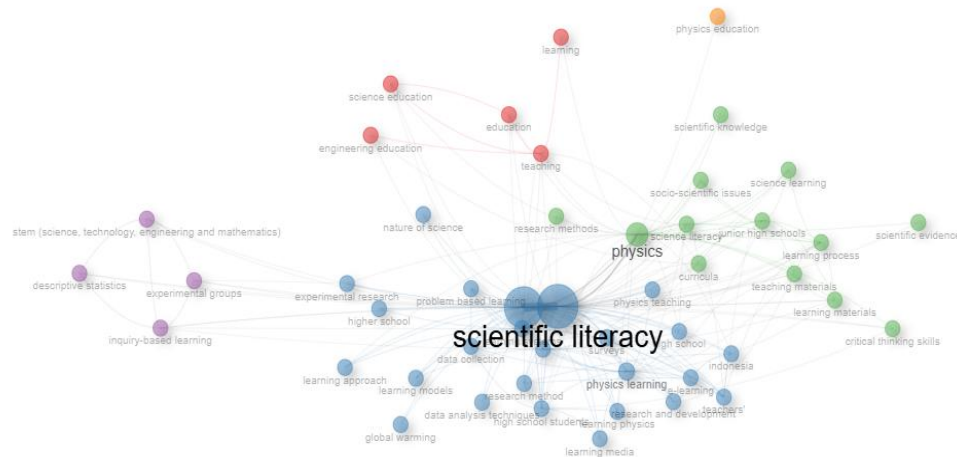


Figure 9 Keyword trends and visualization

Figure 10 shows the thematic evolution in which science literacy research shifted focus between the periods 2014–2021 and 2022–2024. In 2014–2021, research focused on general topics such as physics education, science education, teaching, and scientific literacy. These themes emphasized the field of science education in general, in terms of concepts, learning processes, and pedagogical applications. Entering the period of 2022–2024, science literacy research began to connect with more specific and contextual themes, such as curricula, e-learning, education computing, the nature of science, and physics. This shift indicates that science literacy studies do not stand alone but are closely related to developments in educational technology. This transition pattern also reflects a shift from traditional approaches to more modern, interdisciplinary, and 21st-century needs-based research.

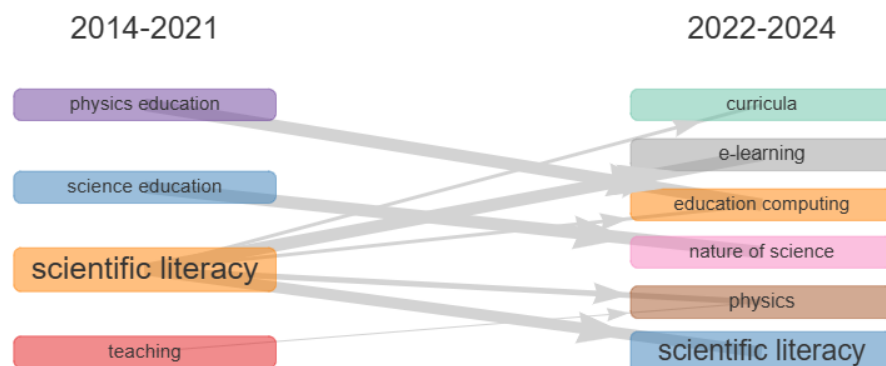


Figure 10 Thematic evolution

Figure 11 is a world map showing the distribution of productivity of publications related

to science literacy by country. It can be seen that science literacy research has a fairly wide reach, covering various continents, from North America, Europe, and Asia to Australia. The most prominent country is Indonesia, which is shown in dark blue, indicating the highest number of publications compared to other countries. This shows that Indonesia has attention and commitment to developing science literacy studies, especially in the context of education. This productivity can be attributed to various factors, such as the existence of national education policies that emphasize the importance of science literacy. Apart from Indonesia, other countries are also productive, including the United States, China, Austria, Brazil, Germany, and Turkey. This indicates that science literacy has become a global issue that has received attention in various education systems. However, this dominance needs to be interpreted critically. The high number of publications from Indonesia may not necessarily indicate higher research quality but rather reflect a strong national policy emphasis on scientific literacy, especially in response to low PISA performance. Additionally, many publications are disseminated through conference proceedings, which may have lower impact compared to indexed journals. Therefore, future efforts should focus on improving research quality, strengthening international collaboration, and increasing publication in high-impact journals to enhance global competitiveness.

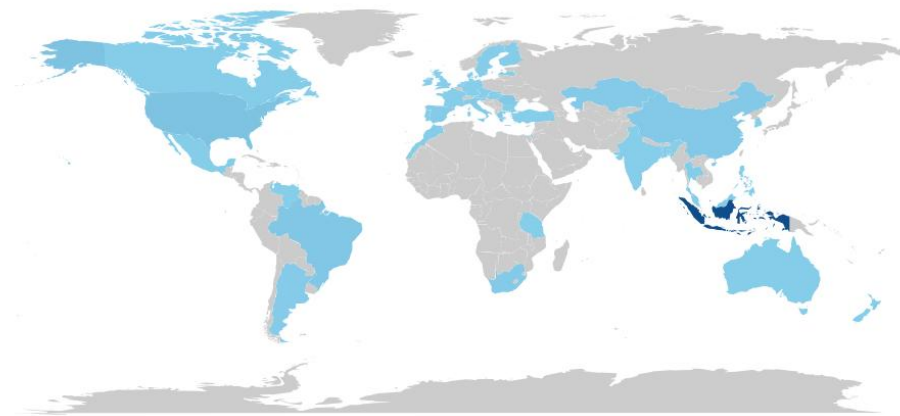


Figure 11 Map plot productive countries

Figure 12 shows a world map depicting patterns of international collaboration in science literacy research. The research collaboration between Indonesia and Thailand depicted in the map visualization shows a strategic relationship at the Southeast Asian regional level. Both countries have education systems with similar challenges, such as improving the quality of science learning, integrating technology into the learning process, and strengthening 21st-century skills through science literacy. This cooperation is important because it allows for the exchange of contextual perspectives. For example, the application of science literacy in competency-based curricula in Indonesia can be compared with the rapidly developing STEM-based learning model in Thailand. Thus, the results of this collaboration not only strengthen academic findings but also provide relevant practical recommendations for both countries.

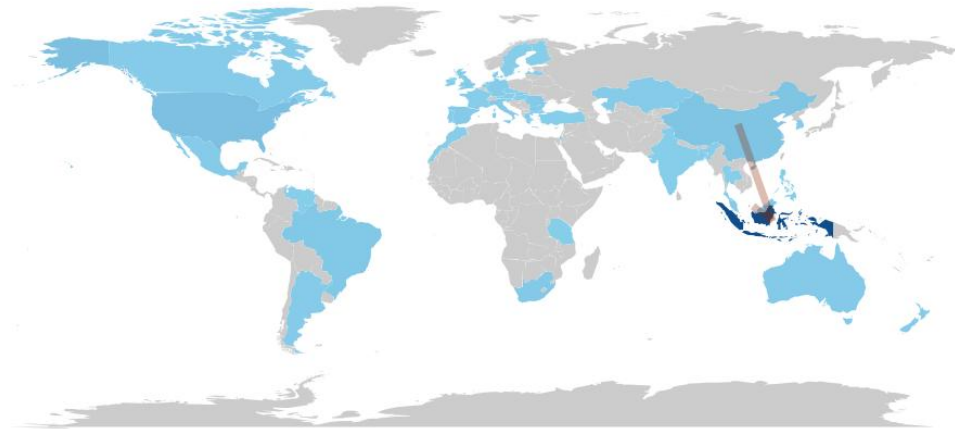


Figure 12 Map plot collaboration between countries

To provide a stronger theoretical foundation, this study adopts the scientific literacy framework proposed by the OECD/PISA, which conceptualizes scientific literacy into three main dimensions: (1) scientific knowledge, (2) scientific competencies (explaining phenomena, evaluating evidence, and interpreting data), and (3) attitudes toward science. This framework serves as a global benchmark for assessing students' readiness to engage with real-world scientific issues. Therefore, the interpretation of the bibliometric findings in this study is aligned with these dimensions, particularly in the context of physics education. Analysis of publication trends shows a significant increase in science literacy research since 2017, with peak productivity in 2019 and 2021. The surge in publications can be attributed to growing global awareness of the importance of science literacy in facing 21st-century challenges such as climate change, pandemics, and technological developments ([Vizzotto, 2025](#)). Fluctuations in 2022 are likely to be influenced by external factors such as changes in education policy or a shift in research focus to pandemic-related issues ([Pokhrel & Chhetri, 2021](#)). In terms of publications, the contribution of national journals is also significant, demonstrating Indonesia's capacity to advance science literacy studies in the global arena ([Kadir et al., 2025](#)). At the institutional level, Indonesian universities also show dominance. This fact demonstrates that publications from Indonesia have international reach, thereby contributing significantly to the global scientific conversation on science literacy ([Susongko et al., 2024](#)). Researchers hope that this positive trend will continue with a more even distribution across countries, including developing regions such as Southeast Asia. In the future, science literacy research is expected to focus not only on conceptual aspects but also on pedagogical innovation, digital technology integration, and its relevance to global issues such as sustainable development goals (SDGs) ([Wulan et al., 2025](#)). Thus, science literacy can be an important foundation in shaping a society that is critical, reflective, and ready to face global dynamics ([Sari et al., 2025](#)).

Analysis of the direction of science literacy research shows that, although still relatively limited in intensity, new keywords such as "digital literacy," "education computing," and "nature of science" have emerged. The emergence of these themes indicates future research directions, particularly the integration of science literacy with digital technology and an emphasis on understanding the nature of science. Thus, science literacy research can move into a broader realm, not only related to knowledge transfer but also to individual readiness to face the challenges of the 21st century ([Nalle et al., 2025](#)). This is in line with the demands of 21st-century education, where science literacy is no longer limited to understanding scientific concepts but also includes the ability to use digital technology to

explore, analyze, and apply science in everyday life.

Research opportunity analysis shows that keyword visualization reveals that science literacy is increasingly closely linked to global issues such as socio-scientific issues, global warming, and critical thinking skills. This opens up broader research opportunities, especially in linking science literacy with sustainability and environmental issues and strengthening critical thinking and problem-solving skills in students ([Li & Guo, 2021](#)). Overall, future science literacy research opportunities can be directed at three main focuses: (1) developing innovative learning approaches (e.g., PBL, inquiry, STEM) ([Mulyono et al., 2024](#); [Saraiva et al., 2025](#)), (2) strengthening higher-order thinking competencies ([Dye, 2023](#); [Palines & Cruz, 2021](#)), (3) relevance to local and global issues such as socio-scientific ([Haviz et al., 2024](#); [Rahayu & Alsulami, 2024](#)). Thus, research opportunities can be focused so that science literacy is not only a cognitive competency but also a provision for students to face the challenges of the 21st century.

Another important finding emerging from the bibliometric visualization is the dominance of several core keywords such as "scientific literacy," "physics," "physics learning," and "problem-based learning." This indicates that research on scientific literacy is strongly integrated with the field of physics education and innovative learning approaches. The appearance of clusters related to socio-scientific issues, critical thinking, and inquiry-based learning suggests that researchers increasingly view scientific literacy not only as conceptual understanding but also as the ability to analyze real-world problems using scientific reasoning. This pattern reflects a pedagogical shift in science education toward contextual learning that connects scientific concepts with societal and environmental issues, enabling students to develop deeper analytical and decision-making skills ([Tasquier et al., 2022](#)). This approach aligns with the OECD/PISA framework, which emphasizes the importance of scientific competencies that extend beyond knowledge to include the ability to explain phenomena, evaluate evidence, and make informed decisions on socio-scientific issues.

Furthermore, the visualization of international collaboration and thematic evolution reveals that scientific literacy research is gradually becoming more interdisciplinary and globally connected. Collaboration between countries such as Indonesia and Thailand indicates the growing importance of regional partnerships in addressing shared educational challenges, particularly in improving science learning quality and integrating digital technology into education. At the same time, the thematic transition toward topics such as e-learning, education computing, and the nature of science suggests that future research will increasingly emphasize the integration of digital tools and technological innovation in developing scientific literacy. This transformation highlights the need for education systems to adapt to digital-era learning environments while ensuring that scientific literacy remains relevant to contemporary global challenges ([Howell & Brossard, 2021](#)).

CONCLUSION

Based on the results of the research conducted, it can be concluded that science literacy research has shown a significant upward trend since 2017, with Indonesia making a dominant contribution. The surge in publications is related to growing global awareness of the importance of science literacy in facing 21st-century challenges such as climate change, pandemics, and technological developments. The direction and opportunities for future research are moving into a broader realm, not only in understanding scientific concepts but also in integration with digital technology, emphasis on the nature of science, and its relevance to global issues such as socio-scientific issues, global warming, and critical thinking skills. This opens up space for the development of innovative learning approaches, the strengthening of higher-order thinking skills, and the application of science literacy as

strategic preparation for students to comprehensively face the dynamics and challenges of the modern world. The findings prove that science literacy studies are strengthening their position as a strategic field of research in science education, especially in Indonesia. However, this study is limited to bibliometric analysis based on selected indexed publications, which focuses on publication patterns and citation relationships and does not examine the substantive quality or pedagogical effectiveness of the analyzed studies. Despite this limitation, the results of this study have important implications for the development of a more contextual, innovative, and digitally integrated curriculum and for guiding future research that links science literacy with cross-cutting issues such as environment, technology, society, culture, and local wisdom to enrich perspectives and research directions. This study also aligns with the OECD/PISA framework, emphasizing scientific competencies like explaining phenomena and making informed decisions on socio-scientific issues, reinforcing the role of science literacy in preparing students for global challenges.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Methodology: MGN; Article draft: IMA, KRF, MGN, ABD; Conception: IMA, TS; Analysis: IMA, TS; Writing/Revising: IMA, KRF, MGN, ABD, HVS.

AI DISCLOSURE STATEMENT

In the development of this research, Gemini was employed to assist in drafting and refining the academic language. All generated content underwent rigorous verification and modification by the authors to align with technical standards and maintain the intellectual originality of this work. The authors assume full accountability for the accuracy and final presentation of the manuscript.

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AUTHOR PROFILES



Name: Indri Maya Ariana
 Email: indri.22053@mhs.unesa.ac.id
 Expertise: Asessment Learning Physics, Learning Media Physics
 Affiliation: Universitas Negeri Surabaya
 Orcid ID: <https://orcid.org/0009-0007-0099-8113>
 Google Scholar: <https://scholar.google.com/citations?user=PT-BQeEAAAAJ&hl=id>



Name: Khofifatur Risma Faradillah
 Email: khofifatur.22045@mhs.unesa.ac.id Expertise: Asessment Learning Physics
 Affiliation: Universitas Negeri Surabaya
 Google Scholar: https://scholar.google.com/citations?user=Tg_YT-YAAAAJ&hl=id&oi=ao



Name: Muhammad Ghiyats Naufal
 Email: muhammadnaufal.22042@mhs.unesa.ac.id
 Expertise: Physics Learning Media, Local Wisdom-Based Learning Media, Game-Based Media.
 Affiliation: Universitas Negeri Surabaya
 Google Scholar: <https://scholar.google.com/citations?user=gKSjduIAAAAJ&hl=id>



Name: Adrian Bagas Damarsha
Email: 24031635009@mhs.unesa.ac.id
Expertise: Etnophysics, Learning Media Physics
Affiliation: Universitas Negeri Surabaya
Orcid ID: <https://orcid.org/0009-0001-8065-3997>
Google Scholar:
<https://scholar.google.com/citations?user=8h2aMmQAAAAJ&hl=id>
Scopus ID:
<https://www.scopus.com/authid/detail.uri?authorId=59150786200>



Name: Hanandita Veda Saphira
Email: hanandita.saphira346@uowmail.edu.au
Faculty of the Arts, Social Sciences and Humanities
Affiliation: University of Wollongong
Google Scholar:
<https://scholar.google.com/citations?user=e2xauJUAAAAJ&hl=en>
Scopus ID:
<https://www.scopus.com/authid/detail.uri?authorId=57881887700>



Name: Titin Sunarti
Email: titinsunarti@unesa.ac.id
Expertise: Physics Education
Affiliation: Universitas Negeri Surabaya
Orcid ID: <https://orcid.org/0009-0005-2430-1603>
Google Scholar ID:
<https://scholar.google.com/citations?user=xVhEK0kAAAAJ&hl=id&oi=ao>
Scopus ID:
<https://www.scopus.com/authid/detail.uri?authorId=57201671106>