A bibliometric mapping on scientific literacy in primary education (2000 – 2024)

I. YULIANA, B. JATMIKO, W. WIDODO, SURYANTI

ABSTRACT

The problem and the aim of the study. Scientific literacy emerged as a worldwide central focus of science education, especially in primary education. This study addresses a critical gap in the scientific literacy literature focusing on primary education from 2000 to 2024 using data from the Scopus database. It provides a distinct perspective from the prior studies by conducting a comprehensive bibliometric mapping analysis. By analyzing the knowledge structures, this article will enhance the empirical insights and contribute to a deeper conceptual understanding through bibliometrix application.

Research methods. The study employs the Scopus database to gather literature metadata and analyze the data with Bibliometrix software. By applying strict inclusion and exclusion criteria, the initial identification of 183 papers was refined to 105 for detailed analysis. The analysis, including co-citation, keyword co-occurrence, and collaboration network mapping, was used to explore scientific literacy research knowledge structures.

Results. The analysis reveals a 10.02% annual growth, with an average of 9.23 citations per document. Publications peaked in 2024, indicating rising interest, specifically in primary education. The thematic analysis highlights a strong connection between scientific literacy, science education, and teacher education, with key contributors shaping research trends. The USA leads in publications, while Australia shows the highest citation impact. Collaboration clusters remain focused on developed countries. It emphasizes interdisciplinary approaches and technology's role in advancing scientific literacy.

Conclusion. This study offers critical insights into scientific literacy research, identifying key themes and emerging trends. It provides practical implications for educators and policymakers by emphasizing strategies to promote scientific literacy within the framework of 21st-century skills. The findings can be a foundation for upcoming research and support more effective educational practice development.

KEYWORDS

bibliometric analysis, mapping research, primary education, scientific literacy, 21st-century skills

For Citation: Yuliana, I., Jatmiko, B., Widodo, W., & Suryanti (2025). A bibliometric mapping on scientific literacy in primary education (2000 – 2024). *Perspektivy nauki i obrazovania = Perspectives of Science and Education*, (4), 197–212. https://doi.org/10.32744/pse.2025.4.13

Received: 11 February 2025 | Approved: 12 April 2025 | Published: 31 August 2025

INTRODUCTION

In an increasingly technology-oriented society, UNESCO emphasizes the importance of scientific and technological literacy as a fundamental aspect of education [1]. This literacy encompasses a solid understanding of scientific concepts and the capacity to critically evaluate a world shaped by science and technology critically, thereby equipping individuals to navigate and thrive in modern life [2]. In the educational landscape, scientific literacy has emerged as a pivotal concern. The initial manifestations of that concept and its attendant implications have been traced to 1958. This temporal point was marked by an increase in the necessity of scientific knowledge among the public [3]. The World Economic Forum asserts that scientific literacy constitutes the foundational principle of 21st-century skills [4]. This assertion is substantiated by the empirical evidence of Millar's Twenty-First Century Science project [5]. PISA developed a framework for assessing scientific literacy, focusing on three key skills: recognizing scientific questions, explaining phenomena using scientific principles, and using scientific evidence to conclude [6]. Scientific literacy aims to help individuals use their knowledge and skills effectively in real-life situations. It involves analyzing problems, forming logical arguments, drawing informed conclusions, and thinking critically [7]. Similarly, Yuliana et al. defined scientific literacy as facilitating an understanding of science in real-life scenarios to make informed decisions based on evidence, identify questions, and conclude accordingly [8].

In 2022, the OECD updated PISA, a student evaluation project, in anticipation of the 2025 release. PISA now includes decision-making skills in its scientific literacy component [9]. These skills begin developing in primary school. For example, teachers can promote learning by encouraging students to communicate and collaborate with their peers [10]. Working together in meaningful situations helps students with strong scientific literacy apply their knowledge in new contexts [11; 12]. Students with scientific literacy clearly understand how science influences their daily lives and society. They recognize the connections between science, society, and the environment. Additionally, they use scientific knowledge to make informed decisions and solve everyday problems [13].

Academic studies on scientific literacy have substantial development theoretically and empirically. Several influential literature reviews have contributed to this domain. Yore et al. [14] analyzed 25 years of contributions from the International Journal of Science Education, highlighting its role in shaping scientific literacy research. In contrast, Miller focused explicitly on scientific literacy within the context of the US [15]. Roberts provided a comprehensive perspective in comparing science and scientific literacy through the lens of leading scholars [16]. Similarly, Allum et al. examined scientific literacy from cross-cultural perspectives [17]. Science and scientific literacy's distinct characteristics advocate redefining curricula to address current needs [16].

Moreover, bibliometric analysis provides a quantitative understanding of specific phenomena within the scientific literature [18; 19]. This method allows for investigating different aspects of academic research, such as new techniques, frameworks, ideas, and nomenclature found in the literature [20]. Furthermore, this study also helps to determine knowledge foundations and research fields within the intellectual outline of a scientific discipline [21; 22]. Regarding scientific literacy, bibliometric scrutiny can highlight important elements, including remarkable research papers, authoritative authors, and leading countries in the current literature [18; 23]. Li and Guo reviewed the literature on scientific literacy related to Socio-Scientific Issues published from 1980 to 2019 [21]. Effendi et al. examined 644 articles published from 2010 to 2018 using VosViewer [24]. However, these reviews examined only a limited selection of documents, which may have restricted the scope of their findings. Most previous studies on scientific literacy in primary education focused on articles published before 2020 and lacked an in-depth analysis. This research uses data visualization and network analysis tools to provide a more comprehensive and objective literature overview. It presents the findings of a bibliometric analysis, highlighting emerging trends and future research directions.

Unlike earlier studies, this bibliometric analysis stands out in several ways. First, it examines a significantly larger dataset of 105 articles published over the past two decades. This broader scope allows for a more thorough and up-to-date exploration of research trends in scientific literacy among primary school students. The key novelty of this study is its specific focus on scientific literacy in primary education—an area that has not been previously analyzed through a bibliometric lens. This study aims to address the following research questions:

1. What are the key characteristics and emerging trends in scientific literacy research?
2. Who are the leading authors, and what are the primary publication sources in scientific literacy studies?
3. How do the most frequently cited articles contribute to scientific literacy?
4. Which countries and institutions are the most active in publishing scientific literacy research?
5. What are the keyword trends, and how is scientific literacy research visually mapped?
6. What are the underlying knowledge structures within the field of scientific literacy?

MATERIALS AND METHODS

This study explores research on scientific literacy in primary education, using bibliometric mapping to analyze global publication trends. It examines key factors such as citations, authors, journals, institutions, countries, and keywords to provide insights into the field's development. Bibliometric analysis is a widely used statistical approach for evaluating extensive scientific data within a specific domain [25; 26]. Additionally, applying bibliometric methods can enhance the visibility and impact of research [27; 28]. Besides that, bibliometrics is a practical analytical framework for analyzing and mapping scientific knowledge, elucidating the evolution of research domains, and understanding large amounts of semi-structured data. Therefore, conducting in-depth bibliometric studies enables one to identify gaps, provide a holistic perspective, generate new ideas, and strengthen the position of contributions in relevant scientific contexts [29; 30].

The process of extracting bibliographic data through Scopus (http://www.scopus.com/) was conducted on December 16, 2024. The search string used was TITLE-ABS-KEY ("scientific" AND "literacy" AND "primary" AND "education" OR "elementary" AND "teacher" AND "education"). After gathering relevant documents, researchers categorized each based on the author's name, publication year, affiliation, country, and citation count. Initially, 183 documents related to scientific literacy were identified. The data collection process, outlined in Figure 1, follows the guidelines of the PRISMA framework [31].

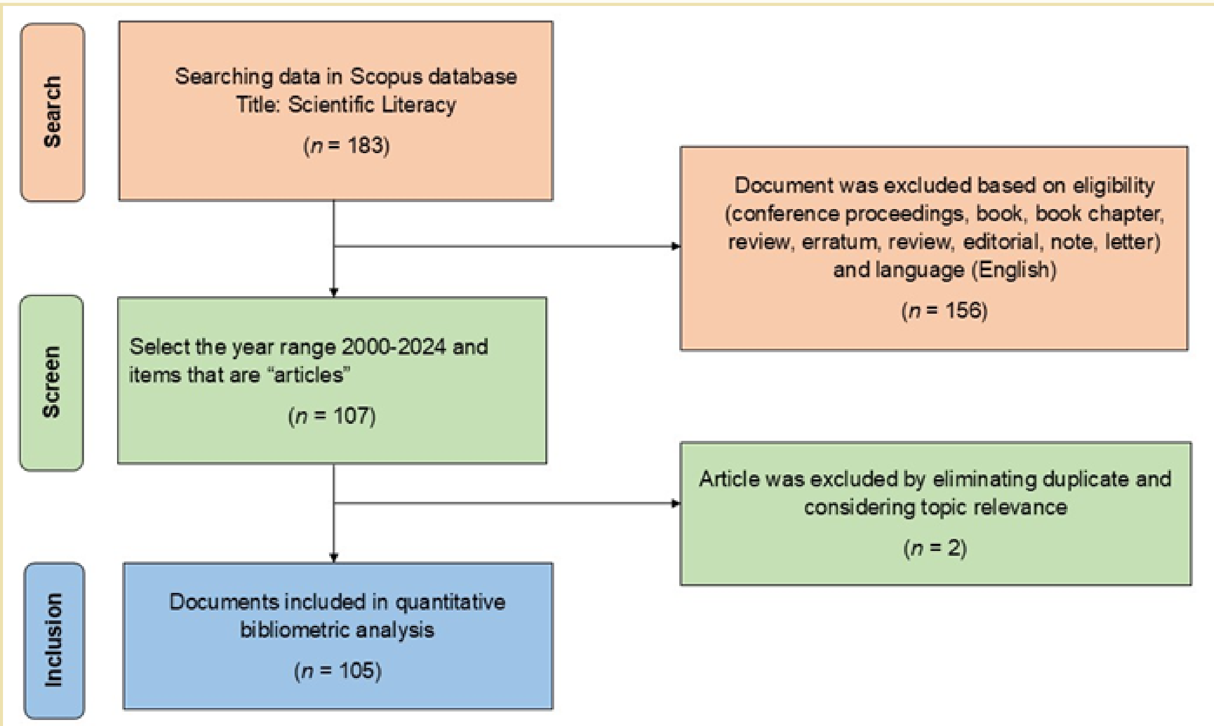

Figure 1 Article selection process and methods

On top of that, Scopus was selected due to its broader coverage of research papers compared to other scientific databases [32]. It covers various disciplines related to the globalization of higher education and offers direct access to bibliographic information [33]. Further, leveraging the Scopus database enables researchers to explore subjects that may not be readily available in the WoS database [29].

Table 1

Inclusion and exclusion criteria

Criteria	
Inclusion Criteria (IC)	Exclusion Criterion (EC)
IC1. Keyword search is limited to the title.	EC1. Papers issued under the year 2000
IC2. Papers focus on primary school and elementary school.	
IC3. All publications are included, regardless of publication date.	

The selection process began with filtering based on the specified publication years (2000–2024). It was limited to journal articles, as they are the most common and representative form of scientific research, and those are written in English. Next, duplicate entries are removed, and articles are screened for relevance to the research topic. One hundred five articles were selected and evaluated for this bibliometric study, following specific inclusion and exclusion criteria during the selection process (see Table 1).

The selected documents were extracted into a Microsoft Excel CSV file containing information on journal papers. This file was then imported into bibliometrix for data visualization and analyzed descriptively based on the research questions. The software offers a comprehensive set of analytical tools evaluating several bibliometric indicators [34]. This approach ensures reliable and comparable data analysis within scientific literacy in primary education.

RESEARCH RESULTS

Prominent information

Table 2 shows the primary information about scientific literacy literature from the Scopus database. It covers a timeframe from 2001 to 2024, encompassing 183 documents. The annual growth rate was 10.02%, and the average document age was 6.23 years. Each document was, on average, cited 9.23 times, significantly impacting research. The large variety of keywords suggests a broad potential for research exploration, further reflected in the extent of international collaboration, reaching 12.57%.

Table 2

Main information of bibliometric data

Description	Results
Timespan	2001:2024
Sources	143
Documents	183
Annual Growth Rate %	10.02
Document Average Age	6.23
Average citations per doc	9.23
References	7991
DOCUMENT CONTENTS	
Keywords Plus (ID)	390

Author's Keywords (DE)	548
AUTHORS	
Authors	514
Authors of single-authored docs	33
AUTHORS COLLABORATION	
Single-authored docs	35
Co-Authors per Doc	3.01
International co-authorships %	12.57

a. Publication trends

The distribution of scientific literacy publications has increased, as illustrated in Figure 2. However, the volume of publications fluctuated over time. The publication volume increased in 2019 and reached its highest peak in 2024 with 18 publications. It highlights the increasing attention to scientific literacy among scholars in primary schools.

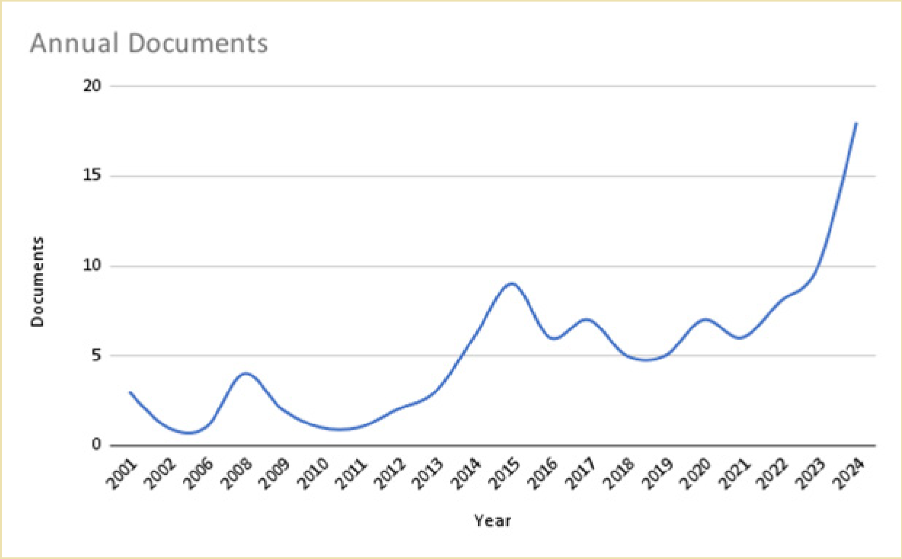

Figure 2 Annual production of scientific literacy

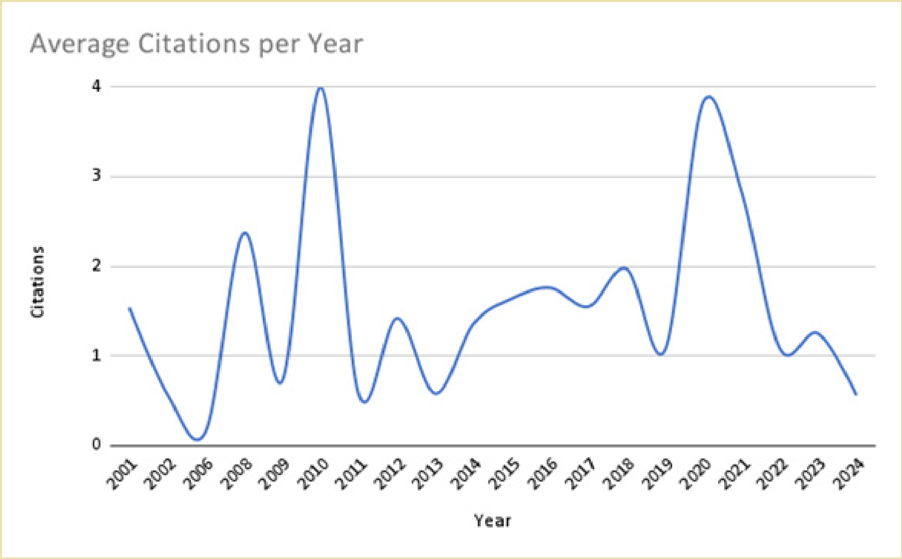

Figure 3 Average citations of scientific literacy literature (2001-2024)

In addition to the increasing trend in publications, evaluating the citation count per document is crucial for understanding their impact. Figure 3 illustrates the average annual citations for research on scientific literacy, which fluctuates throughout specific years, especially in 2009 and 2021. This graph aligns with the primary information, which shows an average of citations per document (9.23). This upward trend in publication volume provides a basis for exploring the thematic development of this domain, highlighting emerging focuses and evolving research priorities during the periods.

b. Thematic development

The Sankey Diagram in Figure 4 illustrates the evolution of key scientific literacy research themes and highlights the field's most influential authors. Frigerio et al. play a pivotal role in connecting different topics to specific research themes, such as "scientific literacy," "science education," and "teacher education" [35].

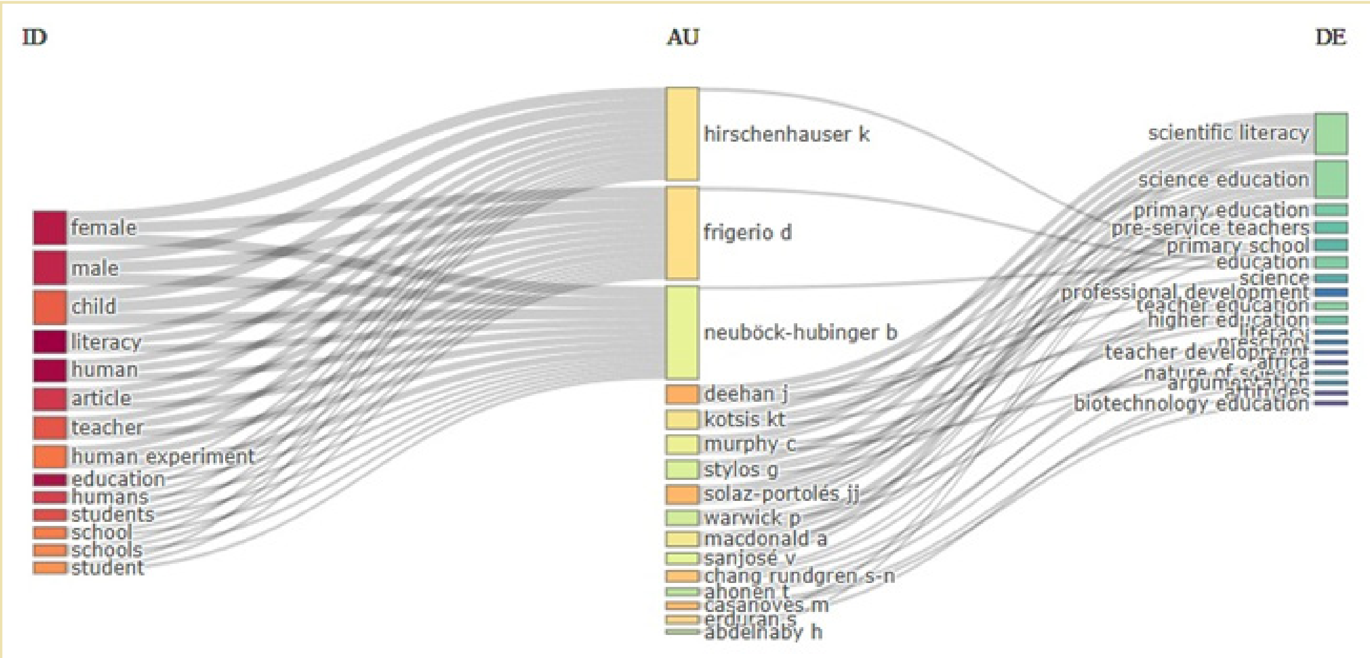

Figure 4 Thematic development using Sankey Diagram

The keywords used were sourced from previously published articles and were thematically developed by researchers. The diagram also shows how basic education, professional development, and scientific literacy are connected. This finding shows that scientific literacy studies are evolving and becoming more inclusive.

Authors' profile and source titles

a. Top author

Table 3 demonstrates the top 10 authors in scientific literacy studies. The authors with the most articles related to science education are "Deehan" [36] and "Deehan & MacDonald" [37; 38], followed by Solaz-Portolés, who discussed teacher assessment and understanding of science education in primary schools [39; 40]. On the other hand, the authors with the most impactful articles are Markic and Eilks [41], with h-index = 57 and total citation = 11.802, and Martín-Gámez and Erduran [7], with h-index = 52 and total citation 19.977. These authors have the highest total citations. This finding indicates that their contributions have been instrumental in shaping research trends and become a primary reference in scientific literacy, as reflected by the frequent citations of their works by other researchers.

Figure 5 presents the scientific publications authored by the top ten contributors. "Deehan" is a recent contributor to scientific literacy research, consistently publishing in this field. Besides that, "Solaz-Portolés" and "Erduran" have also been productive over many years. These authors consistently continue to develop scientific literacy, and the visualization represents the frequency of citations of their works, which is a good measure of the influence of each author's work. This distribution also reveals the evolving nature of research in scientific literacy.

Table 3

Leading Authors and their influence on scientific literacy studies

Authors	Articles	Articles Fractionalized	h-index	Total Citation
Deehan, J	3	2.00	8	266
Solaz-Portolés, Jj	3	0.92	24	2304
Casanoves, M	2	0.37	5	55
Chang Rundgren, S-N	2	1.00	15	953
Eilks, I	2	0.83	57	11802
Erduran, S	2	0.70	52	19977
Frigerio, D	2	0.37	13	812
Hirschenhauser, K	2	0.37	27	3238
Kotsis, Kt	2	0.67	833	13
Macdonald, A	2	1.00	22	1738

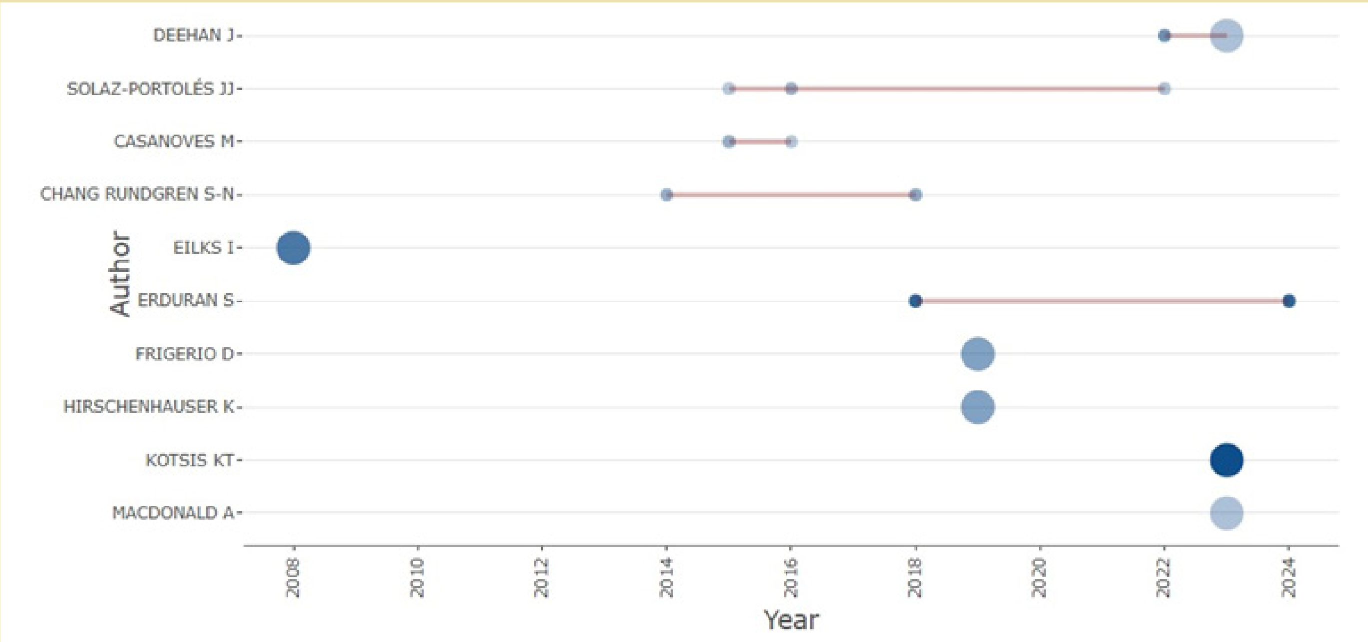

Figure 5 Top author production during the periods

b. Top sources

The list of research journals with the highest publicity and impact in scientific publications is shown in Table 4. The findings show that the *International Journal of Science Education* is the most prominent journal with the highest g-index (9) from 111 annual citations, indicating the journal's productivity and the influence of its articles on other researchers. However, the *Journal of Research in Science Teaching* (CS = 8.8) and *Research in Science Education* (CS = 7.3) maintain their reputation by limiting the number of publications annually. These differences reflect different journals' varied focus and appeal within this scientific literacy domain.

Most prominent literature

Regarding the most prominent literature, Table 5 lists the most cited articles in scientific literacy. Two articles have received the highest number of citations. Firstly, Rennie et al. [42] found that scientific literacy is a pivotal aspect for all members of society, as it fosters curiosity about the world, enhances understanding, promotes skepticsm, encourages questioning of scientific claims, supports the identification of research questions, facilitates investigations, enables evidence-based conclusions, and assists in making informed decisions regarding the environment and personal well-being. Secondly, McCaffrey and Buhr [43] explored climate-related science education in the context of national education standards, or science education curricula. It highlights the impact of their works in shaping scientific literacy. In addition, the article by Siegner and Stapert [44], published in the journal Environmental Education Research, is also considered influential due to its average of 11 citations per year. These articles focus on improving STEM learning and teaching using different methods.

Top countries and affiliations

Research publications are closely linked to contributing countries. Table 6 highlights the countries with the most published studies. The USA leads the standings with 11 publications, cited 50 times, and an average citation of 19.40 times per article. USA's excellence in scientific publications aligns with the country's policy of upholding STEM education. Australia has the highest average citations per article, though only 14 have 135 citations. In contrast, Indonesia has only published three articles, but those are frequently cited (17 times), compared to Turkey, which has four articles, but the frequency and average of citations are low. It indicates a limited scientific impact at the global level.

Table 4

Leading sources and their local influence

Source	Cite Score (2023)	N	h-index	g-index	m-index	TC	PY start
International Journal of Science Education	4.6	9	6	9	0.261	111	2002
Research in Science Education	7.3	4	4	4	0.167	149	2001
Journal of Research in Science Teaching	8.8	3	3	3	0.2	86	2010
Research in Science and Technological Education	5.1	3	3	3	0.3	57	2015
Asia-Pacific Forum on Science Learning and Teaching	1.0	2	2	2	0.125	25	2009
Education Sciences	4.8	5	2	5	0.25	71	2017
Eurasia Journal of Mathematics, Science and Technology Education	4.3	2	2	2	0.118	34	2008
European Journal of Science and Mathematics Education	1.6	2	2	2	0.667	9	2022
Frontiers in Psychology	5.3	2	2	2	0.2	53	2015
Journal of Biological Education	3.0	2	2	2	0.083	14	2001

The graph in Figure 6 illustrates the development of scientific literacy across leading countries. The finding is consistent with the results in Table 4, where the USA dominates with steady growth since the early 2000s. Afterward, the UK became the second-leading country, having shown stability in article publication since 2010, while Spain began to increase significantly in 2015.

Regarding affiliations, as shown in Figure 7, the *Universitat Rovira I Virgili* of Spain is the main contributor with 11 articles. Followingly, *Universidade Católica Portuguesa* (7 articles). The *University of Ioannina* and the *University of Missouri-Columbia* have six articles each, and the *Ludwig-Maximilians-University of Munich*, the *State University of Malang*, the *University of Turku*, and the *University of Vienna* each have five. In contrast, *Ghent University* and *Innovation Research and Training* has only four articles each. This finding shows that many countries collaborate to support the development of scientific literacy studies.

Keyword Trends

Identifying keyword trends has the potential to know the current and past popular research topics. Figure 8 highlights the top ten keywords in scientific literacy studies, displaying only those appearing more than twice. Notably, the term "scientific literacy" appeared 26 times in 2024, a significant increase in scientific literacy literature. The terms "science education" (10 times), "teacher education" (9), "education" (6), "primary education" (6), and "higher education" (6) show a strong connection between scientific literacy and various educational context. "Teacher education" is important in developing scientific literacy from primary to higher educational levels [45; 46]. This finding emphasized that scientific literacy is a well-known concept that includes several aspects of education.

Table 5

Top-cited research on scientific literacy

Rank	Total Citations	TC per Year	Author(s) (year)	DOI	Source
1	91	3.79	Rennie, Lj (2001)	10.1023/A:1013171905815	RES SCI EDUC
2	91	5.35	McCaffrey, Ms (2008)	10.2747/0272-3646.29.6.512	PHYS GEOGR
3	64	8.00	Wolff, L-A (2017)	10.3390/educsci7010032	EDUC SCI
4	60	4.00	Varelas, M (2010)	10.1002/tea.20336	J RES SCI TEACH
5	55	11.00	Siegner, A (2020)	10.1080/13504622.2019.1607258	ENVIRON EDUC RES
6	51	5.10	Ojanen, E (2015)	10.3389/fpsyg.2015.00671	FRONT PSYCHOL
7	50	5.56	Danielsson, K (2016)	10.1016/j.linged.2016.07.005	LINGUIST EDUC
8	40	2.35	Markic, S (2008)	10.1039/b801288c	CHEM EDUC RES PRACT
9	35	5.00	Martín-Gámez, C (2018)	10.1080/02635143.2018.1427568	RES SCI TECHNOL EDUC
10	34	2.62	Smith, Kv (2012)	10.1080/09500693.2011.565088	INT J SCI EDUC

Table 6

Countries with the highest number of publications and citations

Country	Frequency	Total Citation	Average Article Citations
USA	50	213	19.40
Spain	46	80	8.90
Germany	15	104	20.80
Australia	14	135	27.00
Sweden	10	96	19.20
UK	18	22	5.50
Greece	11	21	5.20
Turkey	9	13	3.20
Indonesia	17	15	5.00
Portugal	19	11	3.70

Knowledge structures analysis

This section explores the knowledge structure to gain insights into this field's conceptual, intellectual, and social landscape and research dynamics.

a. Conceptual structure

Figure 9 visualizes a co-occurrence network among terms within a set of publications. The term "scientific literacy" occupies a central position, indicating that this topic is a primary focus of related research. The terms "science education" and "teacher education" also form a prominent cluster that shows a strong connection to scientific literacy. The red cluster, which emphasizes aspects of "pre-service teachers" and "primary education," highlights the importance of incorporating scientific literacy from primary school onward and emphasizing a comprehensive approach for pre-service teachers through interactive learning methods. The blue cluster also highlights the domain of "teacher development" and "higher education," and the green cluster specifies certain areas. These clusters demonstrate a commitment to embedding scientific literacy in the science education curricula, with the teacher's role as a key element. It also suggests a broader academic focus on integrating scientific literacy into diverse educational settings and target groups.

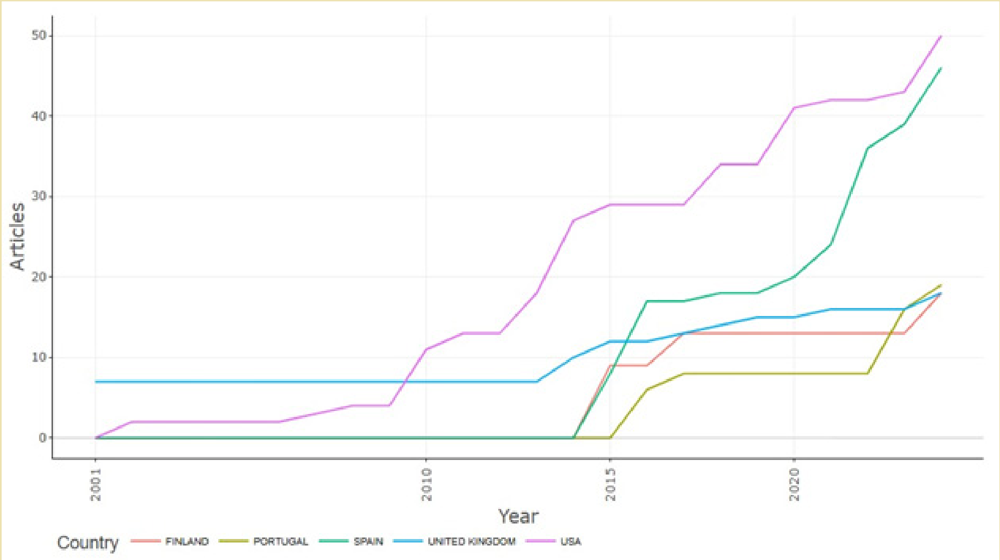

Figure 6 Document growth of scientific literacy by country

b. Intellectual structure

Co-citation networks and historiography are tools to assess the intellectual framework of the literature. As in Figure 10, the co-citation network identifies five clusters with significant group content. The purple cluster, "Osborne J," becomes the central node, which indicates that his works are often cited in science education research. The blue cluster, such as "Roberts DA" and "Driver R," contains work related to National Science Education Standards and other basis studies in science education. The orange clusters, including "Goodrum D" and "Glaser BG," likely focus on qualitative methods and their applications. The red cluster, such as "Dewey J" and "Roth WM," suggests a connection to practical aspects of education. The green clusters, such as "Kress G" and "Bryman A," deal with the social research method. These clusters highlight thematic or methodological links among the cited articles and showcase the conceptual framework of education and visual literacy.

c. Social structure

This structure can be examined thoroughly by analyzing co-author networks and international collaboration maps. Figure 11 presents the author collaboration network, highlighting the connections among authors within the scientific literacy domain. This network reveals eight significant clusters. For instance, the close collaborations of "Neuböck-Hubinger B" and "Hirschenhauser K" and "Solaz-Portolés JJ" and "Sanjosé V" reflect that the collaborations are more structured and limited to specific areas. These authors and their associated clusters indicate the potential for strengthening cross-cluster collaboration to expand the impact of research.

Regarding country collaboration, Figure 12 presents a map that visualizes the collaboration between countries in the publication of scientific literacy literature. These collaborative efforts are focused on leading countries (e.g., USA, Germany, England, Spain, and Australia). A thick brown line marks these countries. Darker blue shades represent countries that contribute more to scientific publications. The USA leads with the most significant output, followed by European countries like Germany and England. This map visualization highlights how scientific literacy studies are connected worldwide. It also emphasizes disparities in research funding, infrastructure, and access to academic networks on a global scale.

In this social structure, leading countries play an important role. They produce and share knowledge, even though they have limited connections. This structure shows that it is important to work together to create more inclusive and fair networks.

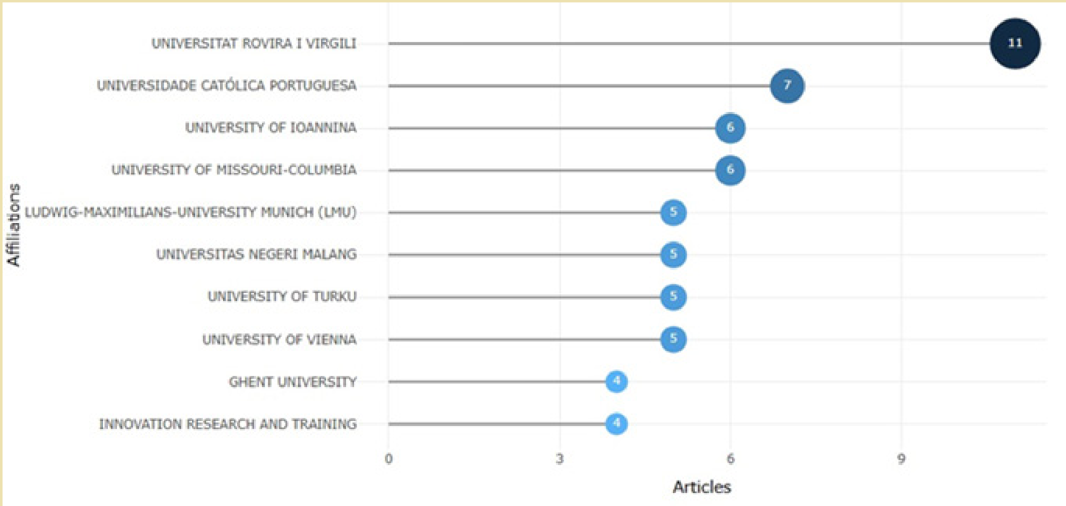

Figure 7 Top affiliations

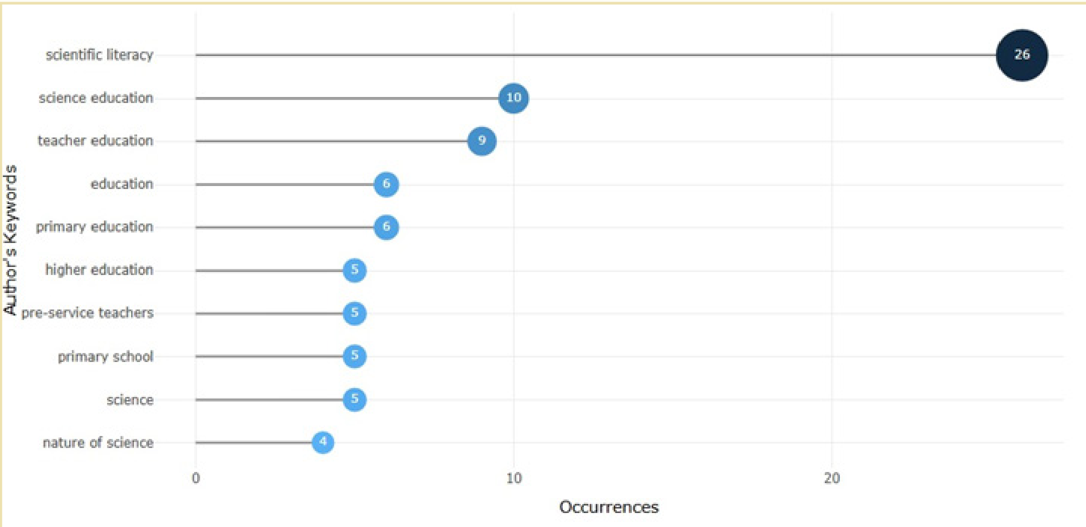

Figure 8 Most frequent words

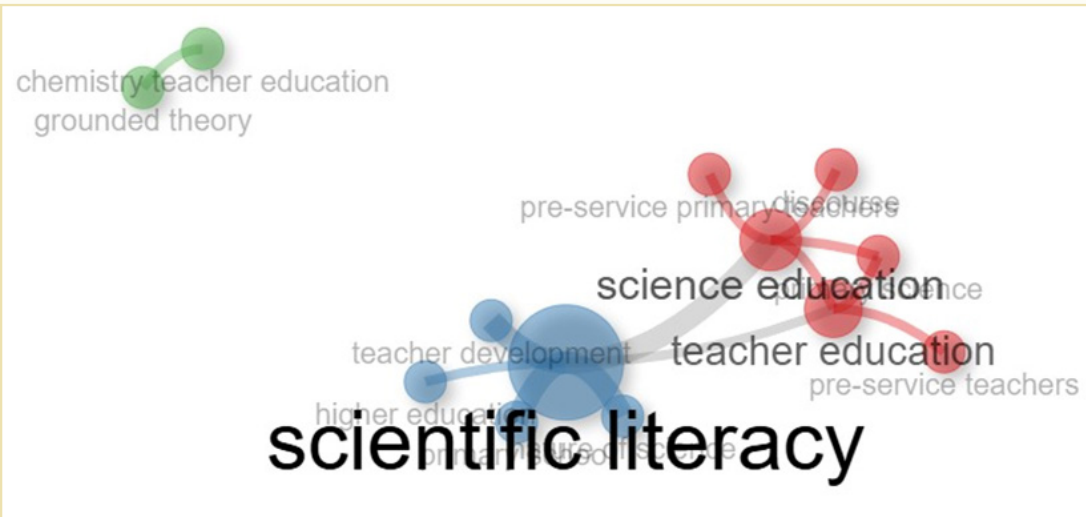

Figure 9 Co-occurence network

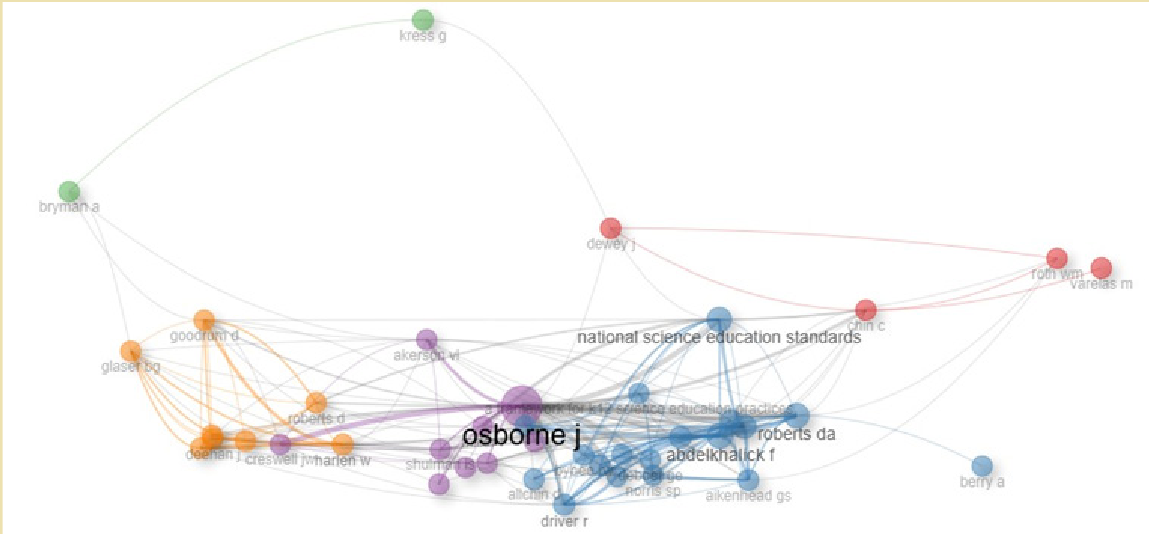

Figure 10 Co-citation network

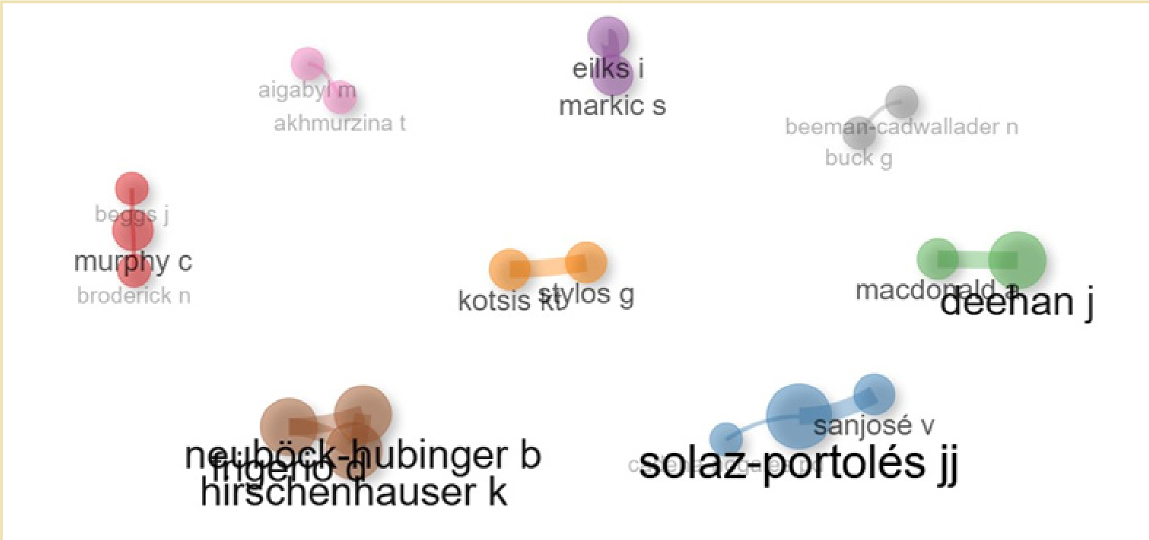

Figure 11 Collaboration network

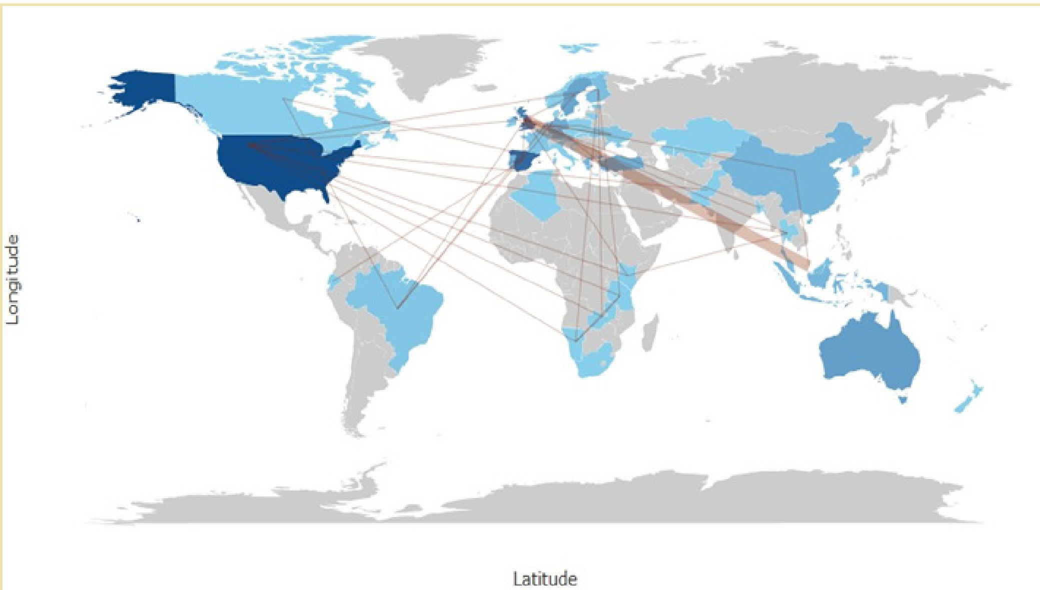

Figure 12 Country collaboration map

DISCUSSION

The findings of this bibliometric analysis, summarized in Table 6, show a significant rise in scientific literacy studies with an 8.10% growth rate over the last two decades. This increase indicates a growing focus on the topic and aligns with the demands of 21st-century education. Scientific literacy is crucial for developing 21st-century skills in primary school students [47] and supporting evidence-based decision-making in the future [48]. These findings align with global trends in scientific literacy, which show significant developments in primary education.

Most of the scientific publications come from developed countries. Those publications related to science education and improving teacher education, especially in primary schools. It is proved by the specific keywords related to these topics [37; 49]. Science and teacher education are important for enhancing primary and higher scientific literacy [8; 45]. An interdisciplinary approach can enhance science competence at the primary education level [50]. Programs should empower teachers to integrate scientific literacy effectively [6].

Research shows an anticipated escalation in scientific literacy throughout the year [12] caused by scientific literacy's role as a pivotal educational goal within society [51]. Moreover, scientific literacy helps people understand the scientific issues that affect local and national decisions. This understanding enables people to express opinions grounded in scientific and technological insights [52]. Further, technological advancements, like Artificial Intelligence (AI), have created intelligent devices capable of emulating human cognitive abilities in complex scientific interactions, which may facilitate the development of scientific literacy studies [49].

Table 7

Summary of the findings

Parameters	Information
Number of documents	105
Annual growth rate (%)	8.10%
Number of authors	311
Top author	Deehan, James (n = 3)
Number of sources	78
The most productive source	International Journal of Science Education
Top-cited article (DOI)	10.1023/A:1013171905815
The country with the most publications	USA
University with the highest number of documents	*Universitat Rovira I Virgili* (n = 11)
The most frequent keywords	Scientific literacy, science education, education, primary education
Emerging research directions	Science education, teacher education, pre-service teachers, nature of science, primary education, integrating technology in scientific literacy learning

The findings of collaboration networks among authors indicate a structured collaboration among specific groups. Highly reputable journals dominate publications, as evidenced by the number of citations per year (see Table 4). These findings indicate that scientific literacy is crucial for building a citizen science culture [16; 53]. The g-index and h-index measure the impact and influence of researchers' publications. The g-index ranks articles based on how many other researchers cite them [54]. The h-index considers both highly referenced articles and the number of citations in other publications [55]. Bradford's Law categorizes literature into three groups based on productivity. As innovation and educational development grow, the number of articles is expected to increase. Researchers need to be more selective, have high standards for sharing research on scientific literacy, and be inclusive to make the research in this domain more diverse.

CONCLUSION

This study highlights the importance of incorporating scientific literacy into primary and higher education curricula. Bibliometric mapping identifies key themes, influential contributors, and emerging research directions in scientific literacy. The findings emphasize the need to enhance and assess scientific literacy, explore effective pedagogical strategies, and investigate thinking skills relevant to this domain. Researchers suggest further studies to examine the correlation between scientific literacy and learning models in primary schools. Nonetheless, this study has notable limitations, as it relies exclusively on data from the Scopus database, encompassing 105 documents from 2000 to 2024, which may restrict the overall depth of the analysis. Future research should include data from other databases to broaden the scope and variety of sources. Additionally, while this study focuses on scientific literacy in primary education, incorporating other variables and subjects in future studies could enrich understanding and practical applications.

REFERENCES

1. UNESCO. (1993). Scientific and Technological Literacy for All. International Forum on Scientific and Technological Literacy for All.
2. ICASE. (2003). The way forward: A framework for STE for the 21st century. In *Increasing the Relevance of Science and Technology Education for All for the 21st century*.
3. Hurd, P. D. (1958). Science Literacy: Its Meaning for American Schools. *Journal of the Association for Supervision and Curriculum Development*, 13–52.
4. World Economic Forum. (2015). New Vision for Education: Unlocking the Potential of Technology. www.weforum.org
5. Millar, R. (2006). Twenty First Century Science: Insights from the Design and Implementation of a Scientific Literacy Approach in School Science. *International Journal of Science Education, 28*(13), 1499–1521. https://doi.org/10.1080/09500690600718344
6. Bybee, R. W. (2010). Advancing STEM Education: A 2020 Vision. *Technology and Engineering Teacher, 70*(1), 30–35.
7. Martín-Gámez, C., & Erduran, S. (2018). Understanding argumentation about socio-scientific issues on energy: a quantitative study with primary pre-service teachers in Spain. *Research in Science & Technological Education*, 1–21. https://doi.org/10.1080/02635143.2018.1427568
8. 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
9. PISA. (2023). PISA 2025 Science Framework. https://pisa-framework.oecd.org/science-2025/
10. Kutlu-Abu, N., Bozgün, K., & Uluçinar-Sağir, Ş. (2024). Studies on scientific literacy in primary education: A bibliometric and content analyses. *Hungarian Educational Research Journal, 14*(2), 158–183. https://doi.org/10.1556/063.2023.00220
11. Broderick, N. (2023). Exploring different visions of scientific literacy in Irish primary science education: core issues and future directions. *Irish Educational Studies*, 1–21. https://doi.org/10.1080/03323315.2023.2230191
12. Kähler, J., Hahn, I., & Köller, O. (2020). The development of early scientific literacy gaps in kindergarten children. *International Journal of Science Education, 42*(12), 1988–2007. https://doi.org/10.1080/09500693.2020.1808908
13. Demirel, M., & Caymaz, B. (2015). Prospective Science and Primary School Teachers' Self-efficacy Beliefs in Scientific Literacy. *Procedia - Social and Behavioral Sciences, 191*, 1903–1908. https://doi.org/10.1016/j.sbspro.2015.04.500
14. Yore, L., Bisanz, G. L., & Hand, B. M. (2003). Examining the literacy component of science literacy: 25 years of language arts and science research. *International Journal of Science Education, 25*(6), 689–725. https://doi.org/10.1080/09500690305018
15. Miller, A. (2024). Investigating the effects of lyrical and instrumental music on reducing stress. *Research Archive of Rising Scholars*, 1–8. https://doi.org/10.58445/rars.1083
16. Roberts, D. A. (2007). Scientific Literacy/Science Literacy. In *Handbook of Research on Science Education* (1st ed., pp. 743–794). Routledge.
17. Allum, N., Sturgis, P., Tabourazi, D., & Brunton-Smith, I. (2008). Science knowledge and attitudes across cultures: a meta-analysis. *Public Understanding of Science, 17*(1), 35–54. https://doi.org/10.1177/0963662506070159
18. Hérubel, J.-P. V. M. (1999). Review: Historical Bibliometrics: Its Purpose and Significance to the History of Disciplines. *Libraries & Culture, 34*(4), 380–388. https://www.jstor.org/stable/25548766
19. Pritchard, A. (1969). Statistical Bibliography or Bibliometrics. *Journal of Documentation, 25*, 348–349.
20. Narin, F., Olivastro, D., & Stevens, K. A. (1994). Bibliometrics/Theory, Practice and Problems. *Evaluation Review, 18*(1), 65–76. https://doi.org/10.1177/0193841X9401800107

21. Li, Y., & Guo, M. (2021). Scientific Literacy in Communicating Science and Socio-Scientific Issues: Prospects and Challenges. *Frontiers in Psychology, 12*(758000). https://doi.org/10.3389/fpsyg.2021.758000
22. Mao, G., Huang, N., Chen, L., & Wang, H. (2018). Research on biomass energy and environment from the past to the future: A bibliometric analysis. *Science of The Total Environment, 635*, 1081–1090. https://doi.org/10.1016/j.scitotenv.2018.04.173
23. Wang, Y., Lai, N., Zuo, J., Chen, G., & Du, H. (2016). Characteristics and trends of research on waste-to-energy incineration: A bibliometric analysis, 1999–2015. *Renewable and Sustainable Energy Reviews, 66*, 95–104. https://doi.org/10.1016/j.rser.2016.07.006
24. Effendi, D. N., Irwandani, Anggraini, W., Jatmiko, A., Rahmayanti, H., Ichsan, I. Z., & Mehadi Rahman, Md. (2021). Bibliometric analysis of scientific literacy using VOS viewer: Analysis of science education. *Journal of Physics: Conference Series, 1796*(1). https://doi.org/10.1088/1742-6596/1796/1/012096
25. Prahani, B. K., Amiruddin, M. Z. Bin, Jatmiko, B., Suprapto, N., & Amelia, T. (2022). Top 100 Cited Publications for The Last Thirty Years in Digital Learning and Mobile Learning. *International Journal of Interactive Mobile Technologies (IJIM), 16*(08), 18–33. https://doi.org/10.3991/ijim.v16i08.29803
26. Jatmiko, B., Prahani, B. K., Suprapto, N., Admoko, S., Deta, U. A., Lestari, N. A., Jauhariyah, M. N. R., Yantidewi, M., & Muliyati, D. (2021). Bibliometric Analysis on Online Physics Learning during COVID-19 Pandemic: Contribution to Physics Education Undergraduate Program. *Journal of Physics: Conference Series, 2110*(012018). https://doi.org/10.1088/1742-6596/2110/1/012018
27. Donthu, N., Kumar, S., Pattnaik, D., & Lim, W. M. (2021). A bibliometric retrospection of marketing from the lens of psychology: Insights from Psychology & Marketing. *Psychology & Marketing, 38*(5), 834–865. https://doi.org/10.1002/mar.21472
28. Mukherjee, D., Lim, W. M., Kumar, S., & Donthu, N. (2022). Guidelines for advancing theory and practice through bibliometric research. *Journal of Business Research, 148*, 101–115. https://doi.org/10.1016/j.jbusres.2022.04.042
29. Irwanto, I., Wahyudiati, D., Saputro, A. D., & Lukman, I. R. (2023). Massive Open Online Courses (MOOCs) in Higher Education: A Bibliometric Analysis (2012-2022). *International Journal of Information and Education Technology, 13*(2), 223–231. https://doi.org/10.18178/ijiet.2023.13.2.1799
30. Prahani, B. K., Rizki, I. A., Suprapto, N., Irwanto, I., & Kurtuluş, M. A. (2024). Mapping research on scientific creativity: A bibliometric review of the literature in the last 20 years. *Thinking Skills and Creativity, 52*(101495). https://doi.org/10.1016/j.tsc.2024.101495
31. Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ, 339*(7716), 332–336. https://doi.org/10.1136/bmj.b2535
32. Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics, 106*(1), 213–228. https://doi.org/10.1007/s11192-015-1765-5
33. Zupic, I., & Čater, T. (2015). Bibliometric Methods in Management and Organization. *Organizational Research Methods, 18*(3), 429–472. https://doi.org/10.1177/1094428114562629
34. Aria, M., & Cuccurullo, C. (2017). Bibliometrix: an R-tool for comprehensive science mapping analysis. *Journal of Informetrics, 11*(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007
35. Frigerio, D., Puehringer-Sturmayr, V., Neuböck-Hubinger, B., Gegendorfer, G., Kotrschal, K., & Hirschenhauser, K. (2019). Monitoring public awareness about the endangered northern bald ibis: a case study involving primary school children as citizen scientists. *PeerJ, 7*(9). https://doi.org/10.7717/peerj.7569
36. Deehan, J. (2022). Primary Science Education in Australian Universities: An Overview of Context and Practice. *Research in Science Education, 52*(6), 1735–1759. https://doi.org/10.1007/s11165-021-10026-6
37. Deehan, J., & MacDonald, A. (2023a). Relations Between Australian Primary Teachers' Reported Professional Development Engagement and Their Science Teaching Practices and Efficacy Beliefs. *Australian Journal of Teacher Education, 48*(8). https://doi.org/10.14221/1835-517X.6189
38. Deehan, J., & MacDonald, A. (2023b). "What's the Big Idea?": A qualitative analysis of the big ideas of primary science teachers. *International Journal of Educational Research, 119*(102189). https://doi.org/10.1016/j.ijer.2023.102189
39. Verdugo-Perona, J. J., Solaz-Portolés, J. J., & Sanjosé, V. (2018). Assessment of pre-service teachers' science knowledge: The case of Valencian community in Spain [Evaluación del Conocimiento Científico en Maestros en formación inicial: el caso de la Comunidad Valenciana]. *Revista de Educacion, 2018*(383), 129–157. https://doi.org/10.4438/1988-592X-RE-2019-383-404
40. Cadena-Nogales, P. D., Solaz-Portolés, J. J., Echegoyen-Sanz, Y., & Sanjosé-López, V. (2022). Level of Acceptance of Epistemically Unwarranted Beliefs in Pre-Service Primary School Teachers: Influence of Cognitive Style, Academic Level and Gender. *Journal of Baltic Science Education, 21*(3), 398–407. https://doi.org/10.33225/jbse/22.21.398
41. Markic, S., & Eilks, I. (2008). A case study on German first-year chemistry student teachers' beliefs about chemistry teaching and their comparison with student teachers from other science teaching domains. *Chemistry Education Research and Practice, 9*(1), 25–34. https://doi.org/10.1039/B801288C
42. Rennie, L. J., Goodrum, D., & Hackling, M. (2001). Science teaching and learning in Australian schools: Results of a national study. *Research in Science Education, 31*(4), 455–498. https://doi.org/10.1023/A:1013171905815
43. McCaffrey, M. S., & Buhr, S. M. (2008). Clarifying Climate Confusion: Addressing Systemic Holes, Cognitive Gaps, and Misconceptions Through Climate Literacy. *Physical Geography, 29*(6), 512–528. https://doi.org/10.2747/0272-3646.29.6.512
44. Siegner, A., & Stapert, N. (2020). Climate change education in the humanities classroom: a case study of the

Lowell school curriculum pilot. *Environmental Education Research, 26*(4), 511–531. https://doi.org/10.1080/13504622.2019.1607258
45. Azura, F., Jatmiko, B., Ibrahim, M., Hariyono, E., & Prahani, B. K. (2021). A Profile of Scientific Literacy of Senior High School Students on Physics Learning. *Journal of Physics: Conference Series, 2110*(1). https://doi.org/10.1088/1742-6596/2110/1/012029
46. Sholahuddin, A., Susilowati, E., Prahani, B. K., & Erman, E. (2021). Using a Cognitive Style-Based Learning Strategy to Improve Students' Environmental Knowledge and Scientific Literacy. *International Journal of Instruction, 14*(4), 791–808. https://doi.org/10.29333/iji.2021.14445a
47. Santos, F. C., & Oliveira, J. L. (2020). Scientific literacy and its role in primary education. *Journal of Science Education, 35*(2), 123–135.
48. Holbrook, J., & Rannikmae, M. (2009). The Meaning of Scientific Literacy. *International Journal of Environmental & Science Education, 4*(3), 275–288.
49. Tsoumanis, K., Stylos, G., & Kotsis, K. (2023). A Comparative Study between Greek Pre-service Teachers and Primary School Students' Scientific Literacy Levels. *Science Education International, 34*(2), 121–131. https://doi.org/10.33828/sei.v34.i2.6
50. Fitzgerald, A. (2012). Science in Primary Schools: Examining the practices of effective primary science teachers. SensePublishers. https://doi.org/10.1007/978-94-6091-858-2
51. Murphy, C., Beggs, J., Hickey, I., O'Meara, J., & Sweeney, J. (2001). National Curriculum: compulsory school science – is it improving scientific literacy? *Educational Research, 43*(2), 189–199. https://doi.org/10.1080/00131880010021294
52. Deta, U. A., Sasmi, R. R., Arisanti, A., Laila, L., Hudha, M. N., Mubarok, H., Prahani, B. K., & Suprapto, N. (2025). Earthquake scientific literacy profile of Indonesian first-year pre-service physics teacher. *Journal of Education and Learning (EduLearn), 19*(2), 890–899. https://doi.org/10.11591/edulearn.v19i2.21624
53. Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy. *BioScience, 59*(11), 977–984. https://doi.org/10.1525/bio.2009.59.11.9
54. Egghe, L. (2006). Theory and practise of the g-index. *Scientometrics, 69*, 131–152.
55. Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences, 102*(46), 16569–16572. https://doi.org/10.1073/pnas.0507655102

Authors

Ivo Yuliana
(Indonesia, Surabaya)
Candidate Doctor of Education
Department of Primary Education
State University of Surabaya
E-mail: ivoyuliana@unesa.ac.id
ORCID ID: 0000-0002-2599-3382

Wahono Widodo
(Indonesia, Surabaya)
Professor Doctor of Education
Department of Science Education
State University of Surabaya
E-mail: wahonowidodo@unesa.ac.id
ORCID ID: 0000-0003-3636-8571

Budi Jatmiko
(Indonesia, Surabaya)
Professor Doctor of Education
Study Program of Physics Education
State University of Surabaya
E-mail: Budijatmiko@unesa.ac.id
ORCID ID: 0000-0002-0713-9078

Suryanti
(Indonesia, Surabaya)
Professor Doctor of Education
Department of Primary Education
State University of Surabaya
E-mail: suryanti@unesa.ac.id
ORCID ID: 0000-0001-7243-2046

Author's contribution

Ivo Yuliana: Conceptualization, Visualization
Budi Jatmiko: Methodology, Formal Analysis
Wahono Widodo: Software, Validation
Suryanti: Writing - Review & Editing, Supervision

The author's declared no conficts of interest