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Review Article

How Important Does Chemistry and Literacy? Bibliometric Analysis from 1993–2023

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Abstract
Literacy is the ability to identify, understand, interpret, create, communicate and compute that involves a continuum of learning measured at different proficient levels. It become as important aspect in nation development since being functionally literate is fundamental to all forms of successes a student. Chemistry as a part of science education, also making the primary objective of education to be chemical literacy. The purpose of this study is to analyze the relationship between chemistry and literacy and see its trends to find the research opportunity for further research by conducting a comprehensive bibliometric analysis over the years. A total of 688 documents were collected using the VOSviewer software from 1973 indicating the beginning of the field until 2023, then analyzed 535 articles from the year 1993. There are 60 articles as the most published in the 2020 and the most cited papers from Timothy and Cynthia Shanahan in 2008 with 844 cited. Keyword such as "Students", "Chemistry", "Humans", and "Scientific Literacy" was the trending topic in this research. Sri Rahayu from Indonesia was the most productive authors and Journal of Chemical Education was the most active source with 81 documents. Universitas Negeri Malang with 22 papers as the most productive institution, followed by Universitas Negeri Yogyakarta, Universitas Pendidikan Indonesia and Universitas Negeri Jakarta with 10 papers. The most prolific country with the most research is the United States, followed by Indonesia and United Kingdom. This review provides summary of the research as well as potential future prospects for the area.

Keywords: Bibliometric analysis, chemistry, literacy, research trends, Scopus

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1. INTRODUCTION

A changing world has forced human society to be aware about production of scientific knowledge and the understanding of technology (Thummathong & Thathong, 2018). The advancements in science and technology in information and technology makes education faces significant challenge. One of them is that education needs to be able to generate human resources with talent and the capacity to overcome any obstacle in life (Rezkia Lukman et al., 2022). Education is the most important engine for nation-building. The expansion of academic institutions is crucial. Not only should a person be knowledgeable in a certain subject, but they should also be able to think critically, communicate effectively, work well in a team, solve problems, and possess other critical abilities to tackle the challenges of the twenty-first century (Alwathoni et al., 2020). Emphasizes globalization and internationalization in producing learners with innovative abilities, particularly in the use of information and technology to support their ability to work and make a livelihood (Cahyana et al., 2019). situation puts pressure on the government, academic institutions, and education stakeholders to generate professional, morally-responsible people resources in the future who can carry out the goal of character development set forth by the Indonesian Golden Generation (2045). This is due to the fact that Indonesia will receive a demographic dividend in 2045 in the shape of the greatest population of people in the working age range (15-64 years old) in history (Amran et al., 2019).

According to UNESCO (2004, 2017), literacy is the capacity to recognize, comprehend, interpret, create, communicate and compute, using written and printed materials associated with various contexts. It

is a continuum of learning that enables people to fulfill their potential, advance their knowledge and potential, and engage fully in their local and global communities (Montoya, 2018). People "must be able to adapt continually to developments in science, technology and to the pressures of social integration, participation and democratization," according to UNESCO (1997) on page 10. This is because science and technology are changing so quickly (Rintaningrum, 2009).

Here, science refers to the study of natural products, technology, and society. The idea of "scientific literacy" encapsulates the several scientific competences that were previously discussed. Creating a scientific literacy community is the aim of scientific literacy, particularly with regard to social issues. thinking abilities are also required, in addition to understanding scientific principles (Mellyzar et al., 2022). Recognizing scientific information and the relationship between science, technology, and society is really useful. A Teacher needs to provide the students with the necessary knowledge and skills to tackle challenges in the actual world, this is scientific literacy. Nowadays, scientific literacy is a significant problem that affects human decisions that demonstrated internationally in various science education angles (Shwartz et al., 2006b). In order to combat this, it is imperative that the future generation be equipped with the abilities necessary to handle change and address real-world issues. A person with scientific literacy will apply apply their knowledge to solve real-world issues and produce beneficial scientific products (Aiman et al., 2020).

The primary objective of teaching science in high school is to acquire scientific literacy for all students (Shwartz et al., 2006a). The PISA program, run by the global Organization for Economic Co-operation and Development (OECD), evaluates students' literacy levels in science and other subjects. "The ability to use scientific knowledge, to identify questions, and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity" is the PISA definition of scientific literacy (Witte & Beers, 2003). Chemical education as a part of science education, also making the primary objective of chemistry education to be chemical literacy (Muntholib et al., 2020).

Chemical literacy is a competence thatessential for students to have in the modern educational time (Fahmina et al., 2019). The ability of a learner to recognize, evaluate, and comprehend chemical concepts in order to solve problems in daily life and explain chemical phenomena in the world in a scientific manner is known as chemical literacy (Rezkia Lukman et al., 2022; Witte & Beers, 2003). It's important because allows pupils to use the science and technologies they have learned to appreciate nature (Imansari et al., 2018). A person who is chemically literate should comprehend basic scientific concepts, such as that chemistry is a branch of science and involves theories which help to explain the natural world, the knowledge acquired can be moved and utilized to another topics in science and technology. In response to the requirement that students comprehend chemistry and all of its applications to everyday life. A person who is chemically literate should value and be able to apply this information in daily activities (Celik, 2014).

In response to the need for students to comprehend chemistry and its many implications for daily life, the US National Research Council—NRC (2013) Framework for K–12 Science Education calls on educators worldwide to be aware of opportunities to supplement formal classroom instruction via informal communication channels. Students can benefit from talking with and interacting with science professionals in order to better grasp the role that science and chemistry play in everyday life (Kohen et al., 2020).

The Program for International Students Assessment (PISA) survey findings from 2000 to 2015 demonstrate that Indonesian students' scientific literacy achievement is still at a poor level, demonstrating the low level of scientific/chemical literacy skills of students (Imansari et al., 2018). This is confirmed by research that the PISA assessment results of Indonesian students over the last four years, namely 2006, 2009, 2012 and 2015, have a low average scientific literacy score in the score range of 382-403, then in 2018 it experienced another decline, producing a scientific literacy score of 396 (Yusmar & Fadilah, 2023). Chemistry learning contributes to chemical literacy in particular, and scientific literacy in general, so growing chemical literacy in Indonesian society is something that also needs to be done (Sulistina et al., 2021).

Based on the previous explanation, we know that the necessary of research in literacy and chemistry as a part of scientific literacy using bibliometric analysis. Quantitative analysis of academic and scientific publications is known as bibliometric analysis. In order to determine the impact, visibility, and influence of

research in a given field or discipline, it is necessary to analyze publication and citation patterns. This process can be used to spot research trends, gauge the significance of individual publications, assess the output of researchers and institutions, and locate possible partners or rivals (Dagli et al., 2023).

1.1 Research Objectives

This research reviews the literature on chemistry and literacy density using a bibliometric approach. In the discipline of chemistry and literacy, the goal is to find important themes, the most productive writers, the top journals and institutions, the top nations, and the co-occurrence of writers, organizations, and keywords between 1993 and 2023. The following research questions (RQ) served as the basis for the current investigation:

RQ1: From 1993 to 2023, what is the number of publications and citation trends?

RQ2: Which research papers do authors cite the most often?

RQ3: Which keywords are most frequently used in literacy and chemistry?

RQ4: Which writers in the fields of literacy and chemistry are the most prolific?

RQ5: Which sources are the most fruitful for literacy and chemistry research?

RQ6: Which institutions are the most prevalent?

RQ7: Which nation produces a large number of publications about literacy and chemistry?

2. METHODS

2.1 Study Design

This review attempts to investigate Chemistry Literacy by analyzing the trends of status publication, citation, author, institution, journal, country, and keyword factors from a global viewpoint using a bibliometric mapping method. A well-liked statistical technique for looking through and evaluating a lot of scientific data in a certain topic is bibliometric analysis (Irwanto, Wahyudiati, Saputro, & Lukman, 2023). A five-step process comprising research design, bibliometric data collecting, analysis, visualization, and interpretation was used to carry out scientific mapping research (Irwanto, Saputro, et al., 2023). In the last decades bibliometric has become a standar tool of science policy and research management (Glänzel, 2003). It become increasingly popular in research due to the development, accessibility, and availability of bibliometric software (e.g, Gephi, Leximancer, VOSviewer) and scientific databases such as Scopus and Web of Science (Donthu et al., 2021).

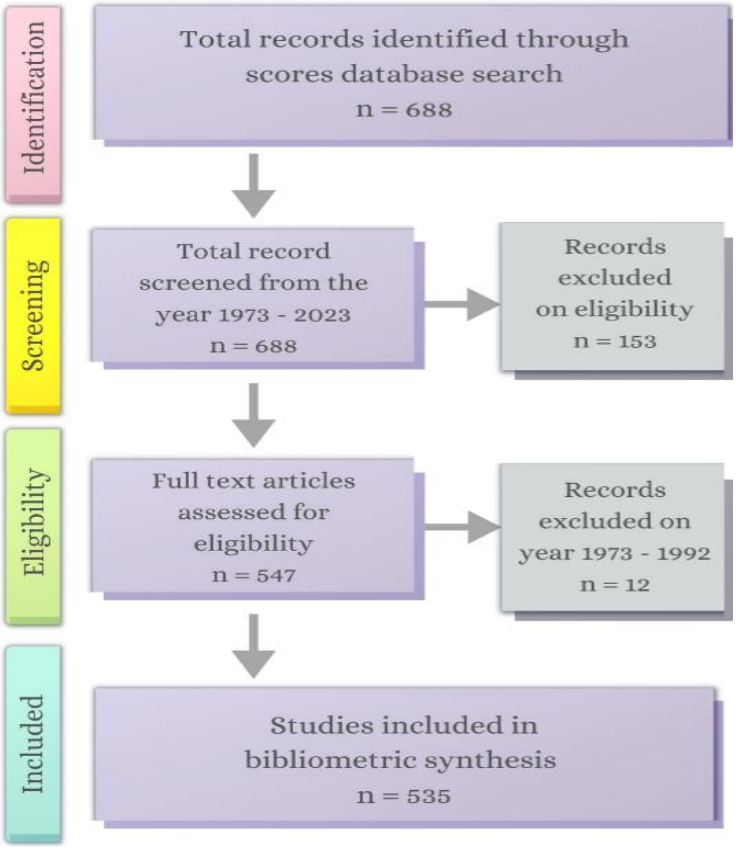

Figure 1. The Present Study using PRISMA Flow Diagram

2.2 Data Collection

On September 21, 2023, an electronic search and data retrieval were conducted. SCOPUS (https://www.scopus.com/), one of the most significant bibliographic databases, is where we first began our search for articles because it is a bibliometric online database that has a larger number of research papers on multidisciplinary topics (Irwanto, Saputro, et al., 2023). The search string includes a combination of compound terms and AND operators when using the advanced search tool. The directive is as follows: Title-ABS-Key (both "literacy" and "chemistry").

Articles meeting the inclusion requirements were those with at least one keyword appearing in the title, abstract, or body of the text. Publication language, year of publication, used keywords, cited documents, cited authors, active journals, productive journals, and prolific nations were the characteristics that were looked at. Next, in order to map trends in each variable, we extracted its frequency. The frequency of each variable was then extracted, and the index was quantitatively examined to map patterns in this domain.

A collection of 688 documents spanning all categories—books, newspapers, journal articles, conference proceedings, etc that were initially discovered between 1973 and 2023 were gathered via the Scopus database. After excluding non-English papers and other publishing types from the document collection using Scopus filters, we were only left with 535 publications to evaluate from 1993 to 2023 like in Figure 1 by using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta analysis (Moher et al., 2009).

2.3 Data Analysis

We obtained the data in research information systems (RIS) and comma-separated values (CSV) formats from the scopus database in order to do the analysis using bibliometric tools. The articles were downloaded in CSV format, and VOSviewer was used to process them. VOSviewer is a computer application designed especially for bibliometric network analysis. It may be used to view and explore maps as well as construct maps based on network data (van Eck & Waltman, 2013). This allowed for the visualization and analysis of patterns in the bibliometric form (Effendi et al., 2020), which included the ability to see co-occurring author keywords, author bibliographic coupling, and country bibliographic coupling. Additionally, we displayed tables and graphs regarding the number of yearly publications and cited texts using Microsoft Excel (Irwanto, Wahyudiati, Saputro, & Laksana, 2023).

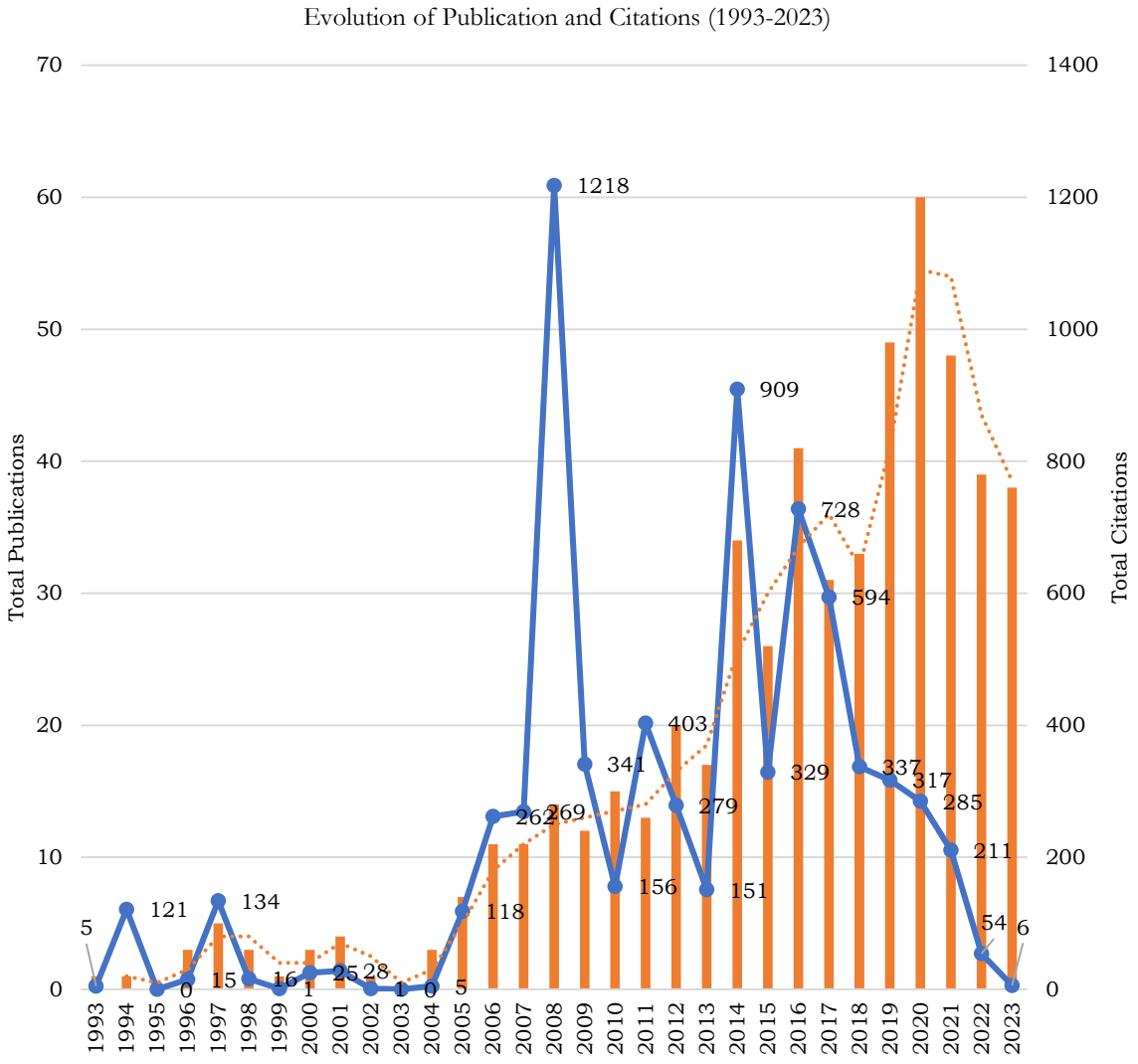

Figure 2. Evolution of Publication and Citations (1993-2023)

3. FINDINGS

3.1 Annual production Publication and Citation Trends

We visualize the annual scientific output in the field of Chemistry and Literacy by excel. The result indicated that the count of publications is different every year. From the graph, can be seen that the most publication has the big number of citations publications and publication each year.

In 2020, it was found that the most published articles were 60 articles and the most cited articles in 2008 were 1218 citations (16.64%) with fluctuating increases and decreases until this data was taken on September 21, 2023. In particular, there were 274 articles between 2014 and 2020, or 50.37% of all publications. 2020 had the greatest publishing to date, with 60 papers, or 10.45% of the entire volume, published. The amount of study evidence in this field is still growing at a robust rate, which is a good sign that the academic community is supporting the popularization of chemistry and literacy research.

3.2 The Most Widely Cited Papers

Table 1 lists and displays the documents that have received the most citations. Since 1993, the chemistry and literacy papers with the highest frequency of citations are displayed in this table.

Table 1. Top 10 Most Widely Cited Papers

No	Authors	Title	Year	Source title	Cited
1.	Shanahan & Shanahan (2008)	Teaching disciplinary literacy to adolescents: Rethinking content-area literacy	2008	Harvard Educational Review	844
2.	Blair & Raver (2014)	Closing the achievement gap through modification of neurocognitive and neuroendocrine function: Results from a cluster randomized controlled trial of an innovative approach to the education of children in kindergarten	2014	PLoS ONE	282
3.	Shanahan, Shanahan, & Misischia (2011)	Analysis of Expert Readers in Three Disciplines: History, Mathematics, and Chemistry	2011	Journal of Literacy Research	218
4.	Rigsby R.E.; Parker A.B (2016)	Using the PyMOL application to reinforce visual understanding of protein structure	2016	Biochemistry and Molecular Biology Education	194
5.	Abd-El-Khalick et al., (2008)	Representations of nature of science in high School chemistry textbooks over the past four decades	2008	Journal of Research in Science Teaching	190
6.	Gelcich S et al (2014)	Public awareness, concerns, and priorities about anthropogenic impacts on marine environments	2014	Proceedings of the National Academy of Sciences of the United States of America	161
7.	Lavonen & Laaksonen (Lavonen & Laaksonen, 2009)	Context of teaching and learning school science in Finland: Reflections on PISA 2006 results	2009	Journal of Research in Science Teaching	121
8.	Norris & Phillips, (1994)	Interpreting pragmatic meaning when reading popular reports of science	1994	Journal of Research in Science Teaching	121
9.	Al Mamun et al., (2018)	Intention and behavior towards green consumption among low-income households	2018	Journal of Environmental Management	116
10.	Shwartz et al., (2006b)	The use of scientific literacy taxonomy for assessing the development of chemical literacy among high-school students	2006	Chemistry Education Research and Practice	107

The top 10 works were selected in relation to the articles that had the most impact based on the number of cuts. As arranged in table 1, the first presents 844 citations", in which the authors are Timothy Shanahan and Cynthia Shanahan emphasize the importance of disciplinary literacy instruction in middle and secondary schools, discusses the challenges of teaching advanced literacy skills to adolescents and the need for more effective practices in integrating literacy instruction into content areas. The article presents findings from a study on disciplinary literacy, including the development of discipline-specific reading strategies. Chemical and literacy is noted in the text, states that in chemistry, different representations of an idea, including pictures, graphs, charts, text, or diagrams, are essential for a full understanding of concepts (T. Shanahan & Shanahan, 2008).

The next article "Closing the achievement gap through modification of neurocognitive and neuroendocrine function: Results from a cluster study on the experimental evaluation of an innovative approach to education that incorporates science, math, and literacy learning activities that support self-regulation (Blair & Raver, 2014), with a total 282 citations. Then the work entitled "Analysis of Expert Readers in Three Disciplines: History, Mathematics, and Chemistry" to describe educationally relevant differences in literacy use among three subject-matter disciplines history, chemistry, and mathematics (C. Shanahan et al., 2011), with 218 citations. As a result of the analysis, the total number of citations for 535 documents was found to be 7200. The highest number of citations was recorded in 2008 with 1218 citations. Among these publications, the average annual citations was 236.06. The number of paperes with at least have over 100 citations was 61.2%. In contrast, there are 124 articles which have not been cited to date equal with 23.17%.

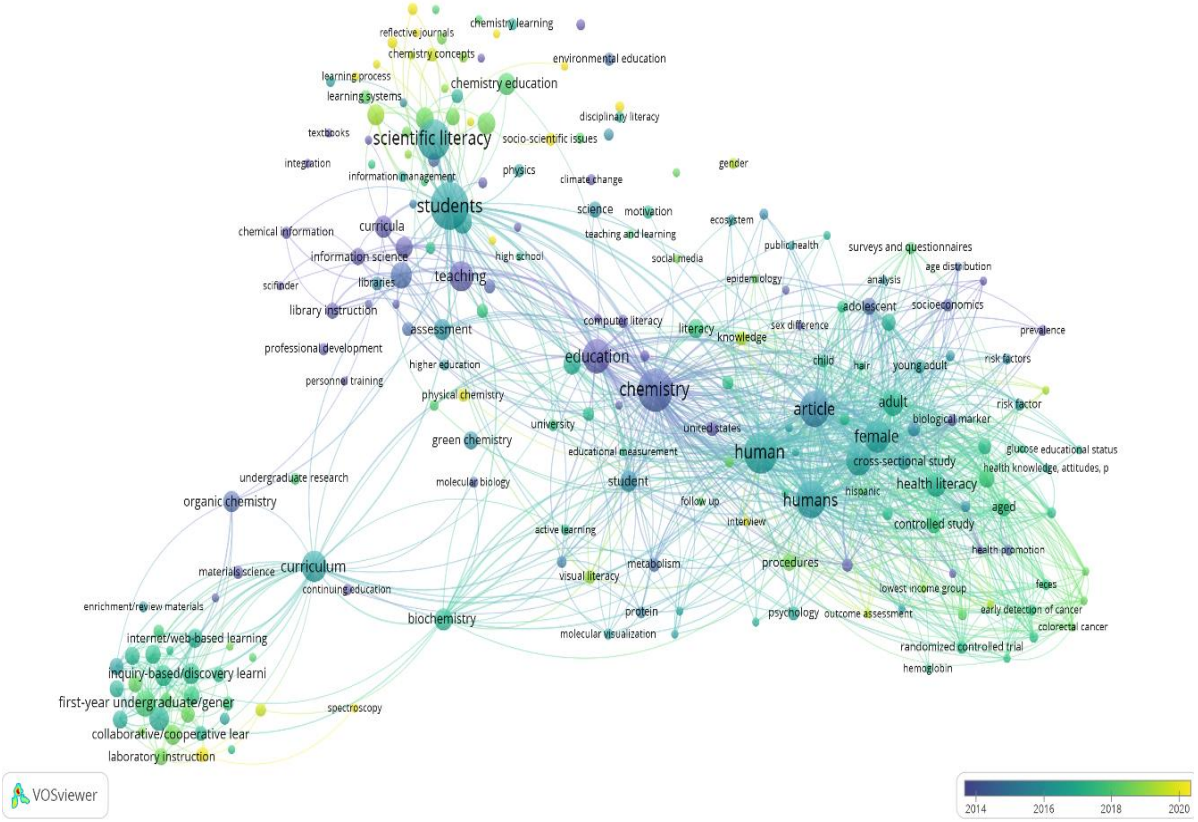

Figure 3. Bibliometric Map of Author Keyword Co-Occurrence

3.3 Most Used keywords

This analysis was determine which words were used frequently in the published article (Irwanto, Wahyudiati, Saputro, & Laksana, 2023). Figure 3, which displays the density representation of data, displays every issue related to chemistry and literacy in general. A keyword can only appear a minimum of four times per criterion and can be found in 214 out of the 3056 keywords that meet the criteria.

Figure 3 mean indicates that the various colors correspond to the dates of publication of the reviewed papers containing these keywords. The keywords that appear in yellow are those that have been published relatively recently in the subject and include scientific literacy, students, chemistry, education, humans, male, female, curriculum and article. This indicates that the relationship between chemistry and scientific literacy is tied to people, students, articles, education, and teaching strategies.

3.4 Most Prolific Authors

Table 2 lists the top 12 productive writers with the most publications in the fields of literacy and chemistry. An indicator of productivity is the number of publications, with the majority coming from Indonesia.

Table 2. Number of Publicitations in the top 12 authors

Author	Institution	Country	N	H-Index
Rahayu S.	Universitas Negeri Malang	Indonesia	14	9
Wiyarsi, A.	Universitas Negeri Yogyakarta	Indonesia	8	7
Rahmawati, Y.	Universitas Negeri Jakarta	Indonesia	7	10
Ferrer-Vinent, I.J.	University of Colorado Denver	United States	7	8
Eilks, I.	Universität Bremen	Germany	7	27
Mudzakir, A.	Universitas Pendidikan Indonesia	Indonesia	6	7
Geissinger, P.	Eastern Oregon University	United States	5	11
Farida, I.	UIN Sunan Gunung Djati Bandung	Indonesia	5	7
Dewi, C.A.	Universitas Pendidikan Mandalika	Indonesia	5	5
Blecking, A.	University of Wisconsin-Milwaukee	United States	4	5
Yamtinah, S.	Universitas Sebelas Maret	Indonesia	4	5
Prodjosantoso, A.K.	Universitas Negeri Yogyakarta	Indonesia	4	14

From the table above, the authors with the most publications were Sri Rahayu from Universitas Negeri Malang in Indonesia with 14 articles, followed by Antuni Wiyarsi, Yuli Rahmawati, Ahmad

Mudzakir, Ida Farida, Citra Ayu Dewi, Sri Yamtinah, Anti Kolonial Prodjosantoso which they are from Indonesia. This shows that the development of literacy, especially chemistry, is of great concern to academics because based on the PISA results, Indonesia still occupies a country with low PISA scores in the field of science.

As we can see from the list, Sri Rahayu is the most significant authors with 14 papers, with the first publications related with chemistry and literacy was in 2017 with the title "Environmental literacy with green chemistry oriented in 21st century learning" to evaluate how chemistry courses are designed with a focus on green chemistry in order to raise students' environmental literacy, which is a crucial component of learning in the twenty-first century (Mitarlis et al., 2017).

The authors from another country are Ignacio J. Ferrer-Vinent, Peter Geissinger, Anja Blecking from United states and Ingo Eilks from Universität Bremen in Germany with the highest H-Index =27 which introduced for the first time by Jorge E.Hirsch Professor of Physics at the University of California, San Diego, describing the h-index, which he called "a useful index to characterize the scientific output of the researcher" to describe the overall influence of particular scientists' research. It is the scientist's greatest number of articles that have received a "h" or more citation (Sangam & Mogali, 2009).

3.5 Most Productive Sources

In this study, there are 544 articles that published in 21 differents Journals since 1993-2023. The top 10 most productive sources regarding the number of total articles (n), H-index, scopus quartile (Q), SCImago Journal Rank (SJR), and the publisher accessed on www.scimagojr.com are presented in Table 3.

Table 3. Top 10 Most Productive Sources

Journal	n	H-Index	Q	SJR	Publisher
Journal of Chemical Education	81	95	Q2	0.555	American Chemical Society
Journal of Physics Conference Series	37	91	-	0.18	IOP Publishing Ltd
AIP Conference Proceedings	35	80	-	0.164	American Institute of Physics
Chemistry Education Research and Practice	23	53	Q1	0.711	Ioannina University School of Medicine
Science And Technology Libraries	15	23	Q2	0.277l	Routledge
ACS Symposium Series	11	71	Q4	0.172	American Chemical Society
International Journal of Science Education	10	121	Q1	1.003	Taylor and Francis Ltd.
Biochemistry And Molecular Biology Education	10	43	Q3	0.404	Wiley-Blackwell
Jurnal Pendidikan IPA Indonesia	8	23	Q3	0.356	Universitas Negeri Semarang (UNNES)
ASEE Annual Conference and Exposition Conference Proceedings	6	26	-	0	American Society for Engineering Education

Based on the table, *Journal of Chemical Education* published by American Social Society from United States was the most active source with 81 documents followed by *Journal of Physics Conference Series* (United Kingdom) and *AIP Conference Proceedings* also from United States that not yet assigned quartile.

3.6 Most Prolific Institutions

There are 25 institutions recorded in this bibliometric, but we took the 12 most influential in the earch for literacy and chemistry which are shown in the following table. Half of them from Indonesia with the total 74 papers then United Sates (41.7% with 31 papers) and the last from Universität Bremen in Germany (8 papers) where all of them come from public universities. Universitas Negeri Malang from Indonesia is the most productive organization in the top 12 with 22 papers, followed by Universitas Negeri Yogyakarta with 16 articles, and Universitas Pendidikan Indonesia same with Universitas Negeri Jakarta with 10 articles then Universitas Sebelas Maret with 9 papers and the last fom Indonesia is UIN Sunan Gunung Jati with 7 papers.

Table 4. Top 12 most prolific Institutions

Institutions	Country	Types	Documents
Universitas Negeri Malang	Indonesia	Public	22
Universitas Negeri Yogyakarta	Indonesia	Public	16
Universitas Pendidikan Indonesia	Indonesia	Public	10
Universitas Negeri Jakarta	Indonesia	Public	10
Universitas Sebelas Maret	Indonesia	Public	9
Iowa State University	United States	Public	8
Universität Bremen	Germany	Public	8
University of Colorado Denver	United States	Public	8
University of Illinois Urbana-Champaign	United States	Public	7
Purdue University	United States	Public	7
University of Wisconsin-Madison	United States	Public	7
UIN Sunan Gunung Djati	Indonesia	Public	7

3.7 Most Prolific Country

In studying this variable, countries were ranked from greater to lesser productivity on the basis of affiliation of authors to the institutions of the countries. This Figure shows that United states was the mos prolific country, with the total publication is 182 papers, the reason is the federal government devotes a significant amount of funding towards research (Hather et al., 2010). The next is Indonesia with 115 papers, then another country with the number of publications less than 5%, which are United Kingdom (n=24), Germany (n=22) and other countries.

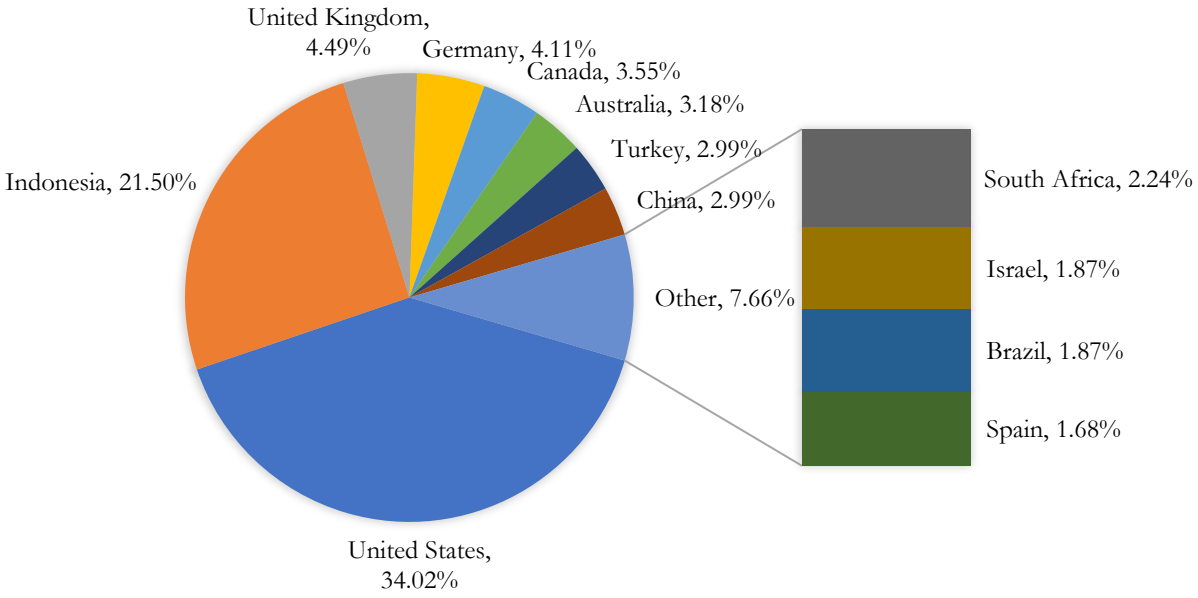

Figure 4. Top 12 Most Prolific Country

4. DISCUSSION

In this research, trends in articles examining literacy and chemistry from 1993 to 2023 were mapped using the Scopus database. This bibliometric evaluation offered a thorough comprehension of earlier research as well as some potential avenues for future investigation. Based on the data in Figure 1, it was discovered that there were 60 articles published in 2019 and that there were 1218 citations for the most cited article in 2008. This number is equal to the 844 citations for the most widely cited paper in 2008, which was written by Timothy and Cynthia Shanahan and titled "Teaching disciplinary literacy to adolescents: Rethinking content-area literacy" which chemical and literacy is noted in the text (T. Shanahan & Shanahan, 2008).

Based on VOSviewer's display of which words were used frequently in the published article, it was found that chemistry, education, students, humans and scientific literacy were the most dominant as shown in Figure 3 because it's made connection with other words in most papers. Chemistry and literacy are closely related in the development of science in the world of education in accordance with the demands of the times. This is because education must humanize students, to be aware of themselves, able to see environmental problems and be able to solve existing problems associated with the knowledge they have learned in accordance with the stage of literacy.

From table 2 regarding the 12 most productive writers' data, it was found that 8 peoples from Indonesia, where one of the most productive was Sri Rahayu from Universitas Negeri Malang. This shows the great attention of academics to research chemistry and literacy in order to improve PISA scores (Sulistina et al., 2021) so that Indonesia's scientific literacy scores increase from before. The government and educators in Indonesia are faced with a significant task due to the low PISA evaluation results, which have turned into homework for the institutions where teachers are trained. The most crucial issue is how to enhance teachers' comprehension and instructional abilities. Increased laboratory activities and the inclusion of a large number of scientific facts in the curriculum are insufficient, to improve students' scientific literacy. Still, in addition to hands-on exercises, students should be given mentally stimulating activities. Hearts-on learning must be incorporated into scientific literacy because the affective component

is crucial (Alwathoni et al., 2020). The next productive author Ignacio J. Ferrer-Vinent, Peter Geissinger, Anja Blecking from United states and Ingo Eilks from Universität Bremen in Germany.

This is in contrast to the 10 most productive journal data, which actually comes from the United States, namely the Journal of Chemical Education with a Q2 quartile value by publishing 81 articles in a span of 31 years, while the Indonesian journal is the Journal Pendidikan IPA Indonesia with a number of articles of 8 and a value of Q3 quartiles published by Universitas Negeri semarang. For journals that have a Q1 value, there are only 2 journals, namely Chemistry Education Research and Practice with a total of 23 papers and The International Journal of Science Education in position 7 (n=10) and the number of papers have not quartile is 3 with N =78. It means that the quality and credibility of the papers for chemistry and literacy still have to increased. A ranking of these journals is published by The Scimago Journal (Putri et al., 2023).

The United States (41.7%) with 31 papers, Universität Bremen in Germany (8 papers), and Indonesia (half) with 74 papers total, all from state universities make up the top 12 most prolific institutions in the table and the most productive institution among the top 12 is Universitas Negeri Malang in Indonesia, with 22 papers. This demonstrates that academics are quite concerned about the growth of literacy in Indonesia, particularly in chemistry, as seen by the PISA results (Mellyzar et al., 2022), which reveal that Indonesia continues to rank among nations with low science PISA scores. Most people in the United States agree that research is crucial to the nation's economic development and that the discoveries made by researchers have a huge positive impact on society (Hather et al., 2010). Because of this, a large portion of federal revenue is allocated to research. Therefore, the number of studies published is proportional to the amount of funding provided.

5. CONCLUSION AND IMPLICATIONS

The analysis provides valuable information on the total number of publications on chemistry and literature from 1993 to 2023. Research on chemistry and literacy was mostly concentrated between 2019 and 2021, and showed the highest peak in 2020 with 60 articles. The research trend on chemistry and literacy is still growing because as of the time this data was taken on September, 21 2023, there were already 38 articles, a difference of 1 article compared to 39 articles in 2022.

The most cited papers present 844 citations "Teaching disciplinary literacy to adolescents: Rethinking content-area literacy" in which the authors are Timothy Shanahan and Cynthia Shanahan emphasize the importance of disciplinary literacy instruction in middle and secondary schools. Our results also highlight that popular keywords in chemistry and literacy research are "students", "chemistry", "people", "scientific literacy", "education", "humans", and "articles'. This shows that the relationship between chemistry and literacy is very related. Sri Rahayu is the most significant author with 14 papers, followed by Antuni Wiyarsi, Yuli Rahmawati, and Ignacio J. Ferrer-Vinent. These authors dominated by researchers from Indonesia, showing great attention to research on Chemistry and Literacy.

The most productive journal is the Journal of Chemical Education, published by the American Chemical Society, with 81 articles. Other journals are the Journal of Physics Conference Series with publisher IOP Publishing Ltd. from the United Kingdom and AIP Conference Proceedings (American Institute of Physics, US). Regarding the number of publications by institution, Universitas Negeri Malang-Indonesia is the country's most productive with 22 papers, while Universitas Negeri Yogyakarta-Indonesia is ranked second most productive institution with 16 papers, and with same number of papers (n=10) are Universitas Pendidikan Indonesia and Universitas Negeri Jakarta-Indonesia. The last, most productive country with 182 papers is the United States, Indonesia with 115 papers, and the United Kingdom with 24 papers.

The limitation of our research is that it still uses one data source, namely Scopus and is limited to using English, so it is hoped that future research will use other sources and can compare between sources. This research is Lastly, the RQs' list of 7 variables is the exclusive focus of this bibliometric study. As a result, additional research is required to integrate it with content analysis, such as the study findings in the

examined articles, in order to enhance the conclusions. It follows that we think our research can serve as a guide for upcoming scholars and industry professionals to gain a deeper understanding of literacy and chemistry from a wider angle.

Conflict of Interest

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