Bibliometric analysis of scientific literacy using VOS viewer: Analysis of science education

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Abstract. Scientific literacy is a person's ability to use scientific knowledge and processes to understand scientific phenomena in solving problems or making decisions. The purpose of this study is to analyze scientific literacy research in the field of physics education and see its trends to find the research opportunity for further research. The results of the bibliometric analysis were used in this study. The search results from the Scopus database was extracted using the VOSviewer software. A total of 644 articles related to scientific literacy were analyzed and mapped. Based on the mapping results, 44 scientific literacy articles in education and 3 scientific literacy articles in physics were obtained. Based on these findings, it can be concluded that scientific literacy related to physics education has been rarely studied. Thus, it can be an opportunity for further researchers to conduct research related to the trends.

Keywords: Bibliometric analysis, scientific literacy, physics education, VOSviewer

1. Introduction
Scientific literacy is a term that has been introduced since the late 1950s [1]. Scientific literacy was first used by De Paul Hard Hurd, McCurry, and Rockefeller Brothers Pund in 1958 [2]. This term has been used to express a wide variety of purposes ranging from a broad knowledge of science to specific goals of science education [3,4]. Paul De Hard Hurd, in 1958, used scientific literacy as the goal of science education [5]. A clear perspective emerges when Hurd illustrated that scientific literacy is an understanding of science and applied it to the experience of each individual as a citizen. The curriculum connection and the selection of appropriate teaching materials will provide students with opportunities to use scientific methods and apply them to personal, political, economic, and social problems as well as to develop an appreciation of science as a human effort in intellectual achievement [3]. Scientific literacy is the ability to use scientific knowledge, identify questions, and draw conclusions based on existing evidence to understand and make decisions about nature and changes caused by human activities [6–8]. Scientific literacy is referred to as the achievement of science education. However, this goal is not accepted by some people [1]. Scientific literacy in recent decades has been measured using various assessment tools [5].

In scientific literacy literature, many similar definitions have been used. All definitions focus on the skills of each individual to use scientific knowledge in life. Scientific literacy describes a person's ability to understand laws, theories, phenomena, and scientific matters which means that scientific literacy is required in every life [9,10]. Scientific literacy is classified into four categories. Three
categories were introduced by Shen in 1975 and the fourth category was introduced in 2008 by Trefil [9]. The level of scientific literacy in various OECD countries has been incorporated into international studies, namely the Program for International Student Assessment (PISA) [3]. The Organization for Economic Cooperation and Development (OECD) is an organization based in Paris. In this organization, an assessment of the scientific literacy of international students is carried out through the PISA program [11]. Scientific literacy is an educational concept that has been widely recognized as the main goal of education [12]. To achieve scientific literacy at the K-12 level, the emphasis on science learning has been carried out for nearly 5 decades [13]. Scientific literacy is one of the most important competencies for every individual to master because it can increase the country's competitiveness in terms of knowledge [14,15]. If a country wants to develop its human resource, then it needs to make its children scientifically literate. Scientific literacy will help a generation to lead a better life as it ensures quality education for all.

Indonesia is one of the countries participating in PISA. The results of the TIMSS scientific literacy survey (2000-2012) stated that Indonesian students, in each period, always get the lowest rank [16–18]. Also, the PISA data produced several findings, namely 1) the achievement of scientific literacy of students was low with an average of 32% for all aspects, consisting of 29% for content, 34% for the process, and 32% for context; 2) the diversity of students' scientific literacy between provinces in Indonesia is relatively low; 3) the problem-solving skills of Indonesian students are low and far behind countries such as Malaysia, Thailand, or the Philippines [19]. The importance of scientific literacy in education has been described; therefore, scientific literacy has become a benchmark for the level of quality of education and has been internationally recognized [20].

Efforts to improve scientific knowledge and skills have become a necessity that requires policy changes in the education system. One of the skills that students must possess is scientific literacy skills. The scientific literacy approach has become an option in developing the scientific knowledge and skills of students around the world [21]. In this case, various efforts had been made to improve the quality of education in various countries, including research. Research related to scientific literacy in various fields has been carried out, such as health [22], geography [23,24] and biology [25]. However, scientific literacy research in education is still very limited. As far as the researchers' knowledge, there has been no bibliometric analysis research with the topic area of scientific literacy in education or physics. For this reason, this study focuses on mapping related keywords and looking at trends in scientific literacy research topics in the field of physics education to become research opportunities in the future. Comprehensive studies are needed to assist other researchers in planning steps to improve the quality of education.

This article aimed to provide a bibliometric analysis of the literature related to scientific literacy research as well as research or publication trends indexed by the Scopus database. This analysis can reveal the topic areas that are the subject of most publications and research opportunities for scientific literacy in education, especially in the field of physics.

2. Research Method

The analyzed articles were retrieved from the Scopus Database. Scopus contains a wider range of publications [26]. Besides, Scopus is one of the most comprehensive databases of peer-reviewed journals. A literature search was conducted online in July 2020 with 3 keywords, namely scientific literacy, scientific literacy in education, and scientific literacy in physics. Specific literature for journals, conference proceedings, title words, and years had been searched. In the initial search, 1082 scientific literacy articles had been found which consisted of 87 scientific literacy articles in education and 3 scientific literacy articles in physics. The matching articles indexed by the Scopus database were filtered. Newspapers, books, book references, and book chapters are not included in this data. Of the mentioned 1082 articles, 87 articles, and 3 articles, only 644 articles, 44 articles, and 3 articles were taken.

The article had been downloaded in CSV format to be processed using VOSviewer to visualize and analyze the trends in the bibliometric form. VOSviewer can create publication maps, country maps,
journal maps based on a network (co-citation); build a keyword map based on shared networks; and create maps with a large number of items [27]. The number of keywords to be used can be adjusted as desired and less relevant keywords can be removed. Data mining, mapping, and grouping of articles retrieved from the database can be done using the VOSviewer software.

3. Result and Discussion

3.1 The Visualization of the Topic Area "Scientific Literacy" Using VOSviewer

In bibliometric research, topic mapping is important [27]. All the topic areas regarding the keywords of scientific literacy, in general, can be seen in picture 1. In the bibliometric analysis, VOSviewer can display 3 different mapping visualizations, namely Figure 1 (network visualization), Figure 2 (overlay visualization), and Figure 3 (density visualization). The minimum number of relationships between topics is limited to 2 events/conditions.

![Figure 1. The Network Visualization of Literacy Topic Area](image)

After being analyzed by the VOSviewer software, 15 clusters had been obtained in the mapping of all topics (red, dark green, blue, dark yellow, dark purple, Tosca, orange, brown, light purple, pink, green, light grey, cream, violet, and light Tosca). The clusters showed that there was a relationship between one topic to another. The thickness of the connecting line showed the strength of pairs of topic areas or keywords. Apart from clusters and lines, the size of the nodes indicated the frequency with which the keyword or topic appears. From Figure 1, it can be seen that the dominant topics or keywords were scientific literacy, information literacy, human, and female. This means that these topics in the 1951-2020 period were the most discussed by researchers. Also, nodes or keywords that did not have a network with other keywords, have the potential to become new research topics in the future.
Figure 2. The Overlay Visualization of the Scientific Literacy Topic Areas

Figure 2 shows the year to year trends related to the research topic area or keyword. The colors in the keywords indicate the period of research.

Figure 3. The Density Visualization of the Scientific Literacy Topic Areas
The depth of research related to the topic area can be seen in Figure 3. The more concentrated the colours, the more researchers are conducting research related to the topic area. Scientific literacy, science literacy, information literacy, human, and female are topics that are widely discussed.

3.2 The Visualization of the "Scientific literacy in Education" topic area

![Figure 4. The Overlay Visualization of Scientific Literacy In Education](image)

Based on the extracted results, 44 articles related to scientific literacy in education had been found. The articles were published in 1984-2020. Figure 4 shows a visualization of the overlay of scientific literacy in education. It can be seen that the keywords scientific literacy, science education, and information literacy are the most dominant (frequent) and mostly discussed by researchers.

The findings of this analysis show that scientific literacy research in education is limited judging from the articles found related to the topic area or keywords. But, scientific literacy is one of the most important competences in preparing a generation and use of this knowledge and information of science helps to deal with the challenges of life [28]. So, considering the importance of scientific literacy, the number of research on it should be increased. This is a research opportunity for future researchers to research related keywords. Keywords that do not have a network with other keywords can be a new research topic opportunity. Figure 4 also shows that the latest research trends in scientific literacy in education can be related to gender and digital explanations. This can also be a research opportunity because research related to this topic area is still very recent.
3.3 Visualization of the topic area “Scientific Literacy in Physics” using VOSviewer

The results were extracted from 3 different published articles, namely journals (1) and conference proceedings (2). After being analyzed using VOSviewer, 4 clusters were obtained in the related keywords. The clusters showed the relationship between topic areas. Apart from clusters, line thickness and colour in mapping are important points. The more concentrated the line, the stronger the topic areas.

Figure 5 shows the overlay visualization related to scientific literacy in physics. Mapping results show that scientific literacy research in physics is still lacking. Also, the lines that appear on the map show that the relationship between scientific literacy in physics is not that strong. This means that scientific literacy research in physics is low in number.

The findings in this analysis are that there are many research opportunities related to the keyword scientific literacy in physics. Given that research related to keywords is still very minimal. This analysis also uncovers recent topic trends in physics research. Keywords that do not have a network or relationship with other keywords can become a trend for further research topics. Physics, reflection and refraction, content knowledge, and science assessments are the recent trends. It can be seen from the colour of the nodes. This can be a research opportunity in the coming period to create the latest research in physics.
The frequency of research can be seen in Figure 6. It can be seen that scientific literacy research has increased and decreased. Most research was conducted in 2018 (67 research) and the least conducted research was in 1951, 1976, 1980, 1985, 1989, and 1995 with 1 research each.
Not only the topics, but bibliometric can also analyze authors, journals, research countries, and language used. Figure 7 shows specifically for countries related to scientific literacy research. The results show that the United States is the country with the most scientific literacy research studies, followed by Canada, Australia, and Turkey. Meanwhile, the study of scientific literacy in Indonesia is considered recent as can be seen from the mapping results using VOSviewer.

Figures 1 - 7 are mapping extraction based on the title, keywords, and abstract as well as a year of publication. It appears that scientific literacy in general can be linked in various fields. However, scientific literacy research in education is still lacking in number. This can be seen from the search for keyword literature and visualization mapping using VOSviewer. According to [25] student’s scientific literacy skills are low on competence and attitude toward science dimension. Due to the low level of reading, the student also didn’t understand about scientific literacy well. In this circumstance, research on scientific literacy is very necessary, especially in Physics. Because this study found that scientific literacy research in physics is still very minimum. Overall, the findings of this study recommend scientific literacy trends. Various trending topics related to scientific literacy in education and physics can be developed in further research. After seeing various opportunities in the topic area, it is possible to develop research-based on these keywords. Science and the environment play an important role in forming a good understanding of students in supporting sustainable development programs [29-34]. Therefore, it is necessary to carry out various innovations related to educational innovations to support students’ understanding of science and the environment [35-42].

4. Conclusion
This study reviewed all journal articles related to scientific literacy, scientific literacy in education, and scientific literacy in physics. All data were collected in the Scopus database. Out of 1082 articles, 644 articles were searched with the keywords of scientific literacy, 44 articles from 87 articles on the keywords of scientific literacy in education, and 3 articles with the keywords of scientific literacy in physics were extracted. There have been many studies on scientific literacy in various fields. However, scientific literacy research in education and especially in the field of physics is still lacking. This can be seen from the results of the analysis using VOSviewer software. This article employed bibliometric analysis to identify the main topic areas in any research that has been carried out over a certain period and to identify trending topic areas related to the research to provide renewal opportunities for conducting further research in the future.

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