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Analysis of Scientific Literacy in Science Learning: A Systematic Literature Review

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Abstract

The purpose of this study is to analyze the trend of scientific literacy research in science learning. The research method used is PRISMA with Bibliometric analysis using the VOS Viewer application. Articles analyzed through the Scopus database by searching using the keywords "scientific literacy" AND "science learning". The object of this study is 882 articles from internationally reputable Scopus journals published over the past 6 years (2019-2024). The articles are selected based on the year of publication, document type, language, source type, open access and are selected by adjusting the title, abstract, scientific field, research objectives, and research samples, research methods and countries where the research is conducted. The results of the study indicate that scientific literacy research is widely conducted in Indonesia in science learning for junior high school and high school students. The type of research that is widely used in conducting research related to scientific literacy is qualitative research.

Keywords: *Scientific Literacy, Science Learning, Systematic Review*

Introduction

The development of technology in the 21st century has brought significant changes in various areas of life, including education. Education serves as a means to help individuals develop their quality of life, so that they are able to face changes and solve problems that arise, and equip themselves with knowledge, insight, skills, and expertise to develop their talents and interests (Aprizanti, 2023). Along with the current era, education is not only required to teach basic skills, but also abilities that are in accordance with the demands of the times. With the advancement of technology, 21st century learning requires students to have independent learning skills, ethics and responsibility, communication skills, critical thinking, problem solving, creativity, originality, strategy, teamwork, flexibility, and digital skills and literacy (Lestari, 2020). Therefore, the ability to adapt and interact with technology effectively is crucial to facing future challenges.

In this context, science learning plays an important role in preparing students to face the development of science and technology in the 21st century (Kristyowati & Purwanto, 2019). Science learning is expected to not only equip students with scientific knowledge and concepts, but also be able to accommodate the skills needed to face the challenges of the development of the times (Latip, 2022). One of the main skills that must be developed in science learning is scientific literacy, which is the key to

preparing students to face the challenges of science and technology that continue to develop. Thus, the integration of scientific literacy in science learning is an important part of efforts to meet the demands of 21st century education and prepare students to face the challenges of life in the future.

Scientific literacy in the context of science learning was first introduced by James Bryant Conant in 1952, and expanded by Hurd in 1958. Scientific literacy is defined as an understanding of science and the ability to apply it in one's life (Wang et al., 2024). According to PISA (2010), scientific literacy is the ability to use scientific knowledge, identify relevant questions, and provide explanations based on scientific evidence to understand and make decisions related to the natural environment and its impact on human activities (Sakti et al., 2021). Scientific literacy is not only an individual process, but is also influenced by the social context, students are invited to understand scientific knowledge personally and together criticize and discuss ideas collectively (Eymur & Çetin, 2024). Scientific literacy focuses on four interrelated aspects: knowledge, context, competence, and attitude (Aprizanti, 2023; Fuadi et al., 2020). Scientific literacy also includes the ability to identify questions, build knowledge, provide evidence-based explanations, and make decisions related to natural phenomena and changes caused by human activities. With scientific literacy, students can develop reflective thinking patterns so that they are able to participate in scientific and social issues related to science (Kristyowati & Purwanto, 2019; Lestari, 2020; Sakti et al., 2021).

Scientific literacy skills prepare the skills that students must have in the 21st century from elementary school to college, namely critical thinking, creativity, collaboration and communication skills (Lestari, 2020; Thoriq, 2024). Scientific literacy also includes the ability to identify questions, build knowledge, provide evidence-based explanations, and make decisions related to natural phenomena and changes caused by human activities. With scientific literacy, students can develop a reflective mindset so that they are able to participate in scientific and social issues related to science (Kristyowati & Purwanto, 2019; Lestari, 2020; Sakti et al., 2021). Through scientific literacy, students are prepared with various essential skills in the modern era, such as critical thinking, creativity, collaboration, and communication (Lestari, 2020; Sakti et al., 2021). With scientific literacy, students can develop a reflective mindset so that they are able to participate in scientific and social issues related to science.

The importance of scientific literacy in solving real scientific problems makes this skill must be taught early on at various levels of education, from elementary school to college (Humairah & Wahyuni, 2024; Situmorang, 2016). So that many studies have been conducted at various levels to examine students' scientific literacy skills. The future science education curriculum should be designed to improve scientific literacy, so that students are able to provide critical views on social and ethical issues. PISA also emphasizes that scientific literacy is an important competency that allows students to participate as reflective citizens, with the skills to explain scientific phenomena, evaluate and design scientific investigations, and interpret scientific data and evidence (Chen et al., 2022).

Therefore, scientific literacy plays an important role in developing students' ability to understand and apply science in real life, along with the growing needs of 21st century skills. This study aims to examine the trend of scientific literacy research in science education in various countries, and the focus of scientific literacy research at various levels.

Method

This study uses Systematic Literature Review (SLR) with the help of VOS Viewer to map the findings. This study presents a description, review and analysis of the trend of scientific literacy research in science learning. This study uses the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) method. This method is used to identify, filter, test eligibility, enter and analyze data according to research needs and interpret the results of the analysis into narrative form. Items for Systematic Review and Meta-Analysis (PRISMA).

Identification

Identification of literature articles in this study was carried out using the Scopus database in August 2024. The search was carried out using the keywords "scientific literacy" AND "science learning" so that 882 documents were obtained.

Screening

The identified documents were then filtered. Filtering was done based on the year of publication, namely the last 6 years (2019-2024), document type "article", language used in the article "english", search type "journal" and all open access. The filtering results obtained were 156 documents. The results of the extraction were exported into CSV format for further filtering.

Eligibility

Data obtained through the Scopus database, manually filtered in Excel by filtering based on title and abstract. This aims to identify and select documents that are relevant to the topic of this study. The results found 78 documents that will be analyzed further.

Included

Furthermore, relevant articles that discuss scientific literacy in science learning are examined further by conducting an analysis based on research needs by reviewing more specifically the research objectives, types of research, samples used in the research, distribution of research locations, and research results. The results of the analysis obtained 32 articles that were worthy of further review in this study. Figure 1 shows the stages carried out in this study.

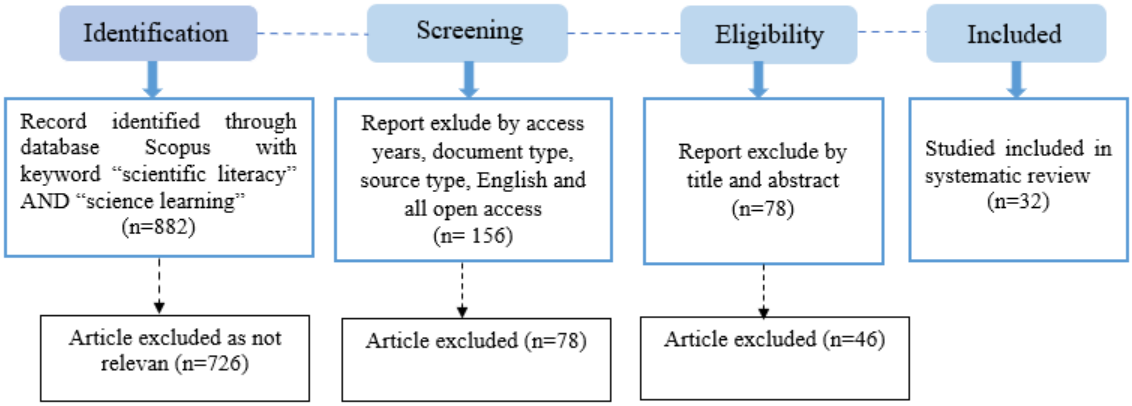

Fig 1. *Research Flow Based on the PRISMA Method*

A total of 32 articles were further analyzed using the VOSviewer application to see the relationship between scientific literacy in science learning.

Results and Discussion

Publication Year

This study reviews and analyzes the trend of scientific literacy research in science learning in various countries. A total of 32 articles that have been analyzed using the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) method were further reviewed in this study. The initial review was conducted based on the year of publication of the article. Figure 2 shows the distribution of scientific literacy research in science learning reviewed from the year of publication of the article.

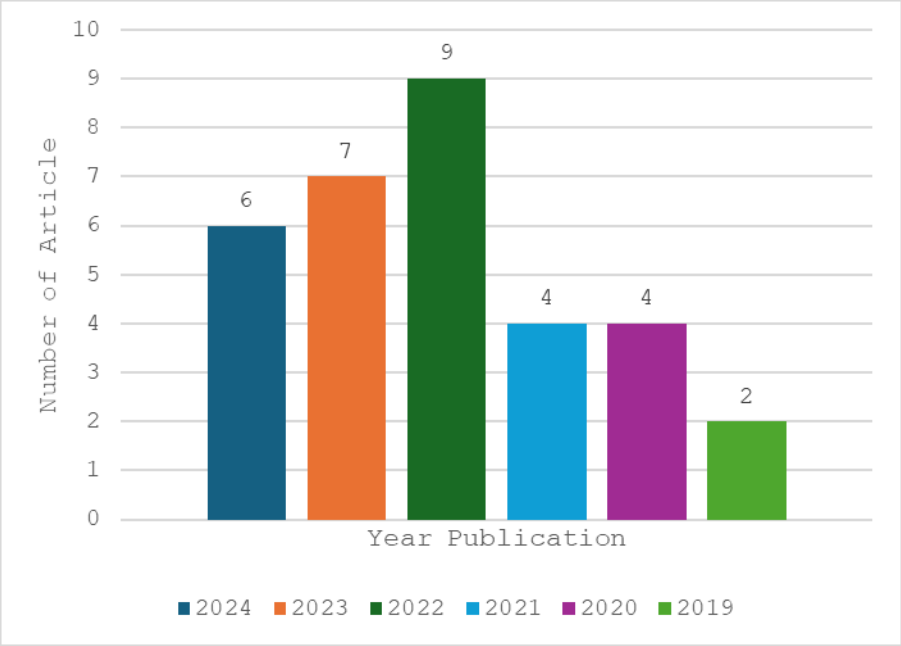

Fig 2. *Article Distribution by Year Publication (2019-2024)*

Based on the review of publication years over the past 6 years, it can be seen that in the analysis results of Figure 2, research on scientific literacy in science learning was most widely published in 2022 (n = 9 articles), and the least published in 2019 (n- = 2 articles). While in 2023 (n = 7 articles), 2024 (n = 6 articles), 2021 and 2020 (n = 4 articles).

The results of the distribution of research publications related to scientific literacy were further reviewed based on the country where the research was conducted. The results of the analysis can be seen in Figure 3.

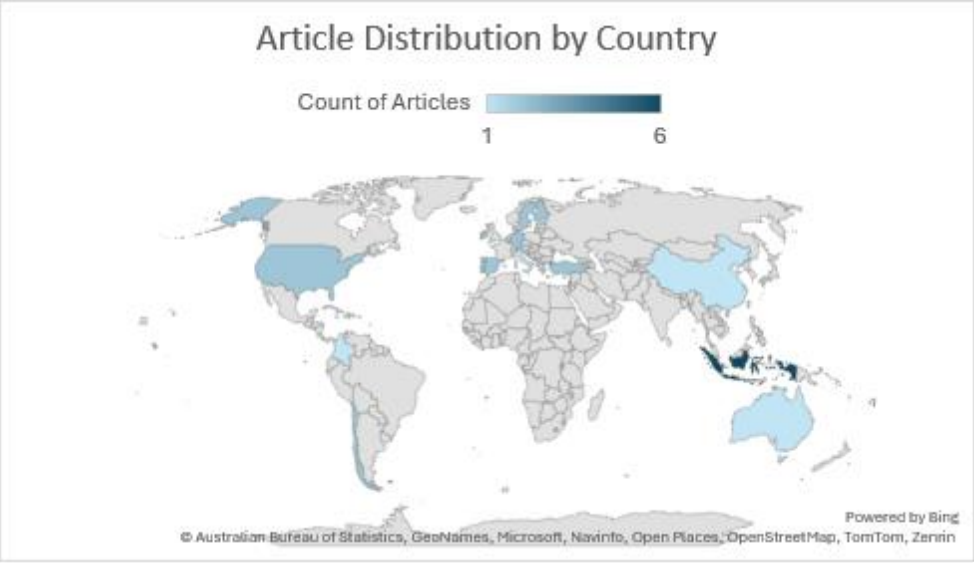

Fig 3. *Distribution Country Number of Documents Relevant to The Topic of Scientific Literacy Every Year for a Period of 6 years (2019-2024)*

Based on the analysis in Figure 3, it shows that there are 18 countries that conduct scientific literacy research in science learning. The country that has conducted the most research related to scientific literacy is Indonesia, which is 6 articles. The research generally examines the development of scientific literacy, the use of appropriate learning models to improve scientific literacy, assessing students' scientific literacy is very important for science education policy, accountability, and the design and implementation of physics learning curriculum, improving students' scientific literacy skills through contextual collaborative learning based on ethnoscience. This research was conducted on junior high school students, high school students and science education students (El Islami & Nuangchalerm, 2020; Fitria et al., 2023a; Safrizal et al., 2022; Zhang et al., 2023a). In addition to Indonesia, scientific literacy research has also been conducted in various countries such as Turkey, Finland, Ireland, Spain, Germany, Portugal, Sweden, Chile, Greece, Australia, Italy, Austria, Estonia and China. Research in various countries shows that scientific literacy is a global issue that is considered important and has an impact on the education systems of various countries in the world.

Types of research

There are many types of research that can be chosen in conducting research in the field of education, especially science education. The types of research used in scientific literacy research in science learning are presented in Figure 4.

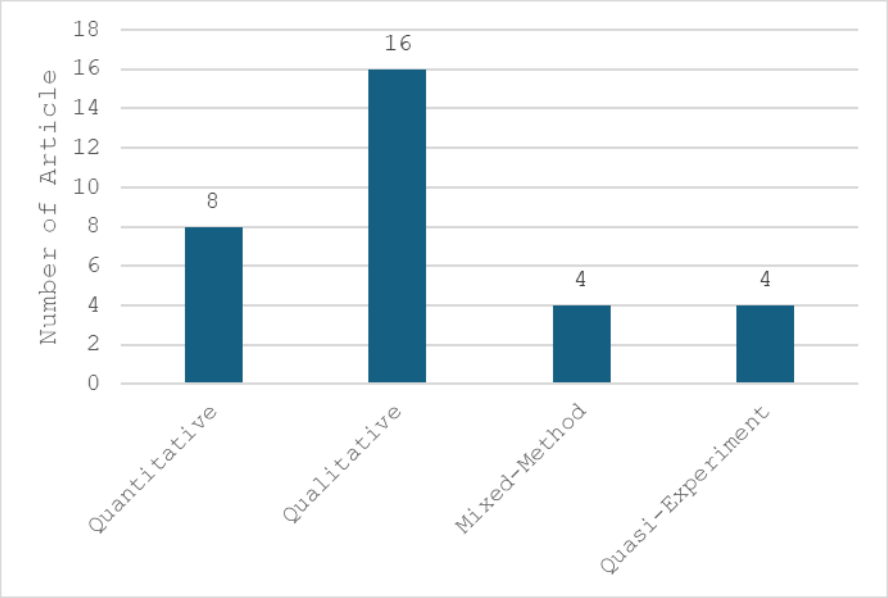

Fig 4. *Types of Research Methodologies in Article*

The graph above shows that in an effort to improve scientific literacy skills in science learning, researchers often use qualitative research. There are 16 articles found in this study that examine scientific literacy qualitatively. Among them are studies that examine the development of scientific literacy in students in one of the schools in Indonesia (Safrizal et al., 2022; Zhang et al., 2023a), research that compares scientific literacy competencies that include components of knowledge, attitudes, and context in the science learning curriculum in high schools in Finland and several other studies conducted in various countries to explore scientific literacy of students at various level(Bossér, 2024; Galamba & Matthews, 2021; Murphy et al., 2021). In addition, 8 articles were found that conducted scientific literacy research in science learning with quantitative research types (Bórquez-Sánchez, 2024; Coppi et al., 2023; Mierdel & Bogner, 2019; Rofieq & Fauzi, 2022; Schiffl, 2020; Tsoumanis et al., 2023; Vogelzang et al., 2020; Zhang et al., 2023). Other types of research that were also used were mixed methods (Mierdel & Bogner, 2019b; Silva et al., 2024; Väljataga & Mettis, 2022; Wang et al., 2024) and quasi-experiments (Eymur & Çetin,

2024; Fitria et al., 2023b; Roth et al., 2022). Some of these types of research can certainly be a reference for conducting scientific literacy research in science learning.

Research Sample

The results of the analysis of 32 articles that examine scientific literacy in science learning as the object of this study, apparently used research samples dominated by students in junior high schools, namely 8 studies, 7 studies using samples of high school students, 5 studies using research samples are teachers who teach science education, 3 studies using students as samples and 11 studies using samples of elementary school students. In addition, there are 3 studies using combined samples, namely junior high school students and high school students, 3 studies using samples of science education teachers and students, 2 studies using samples of parents. Figure 5 shows the distribution of samples used in the study in the 32 articles reviewed.

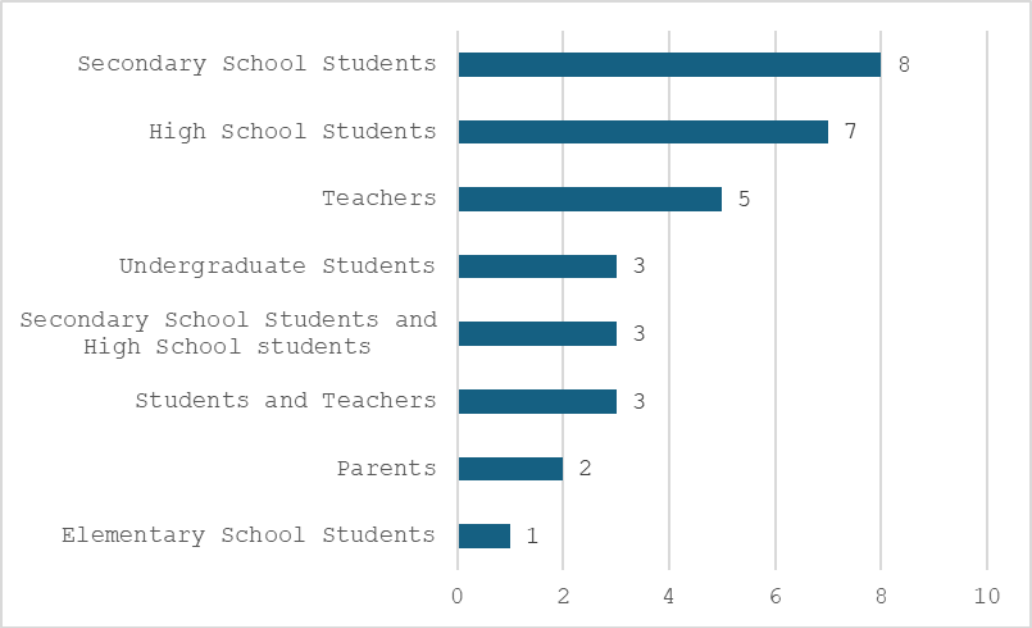

Fig 5. *Research Sample List of Article*

The selection of samples distributed across various age groups shows that scientific literacy research trends can be carried out on different samples according to research needs.

Network Visualization (Frequently Used Keywords)

The analyzed keyword is scientific literacy in science education, as presented in Figure 6. The analysis was conducted using VOSViewer to see the relationship between the two keywords used in this study. Scientific literacy is closely related to the green color group and is closely related to science education. This cluster relationship provides an explanation that scientific literacy research is often conducted in science education.

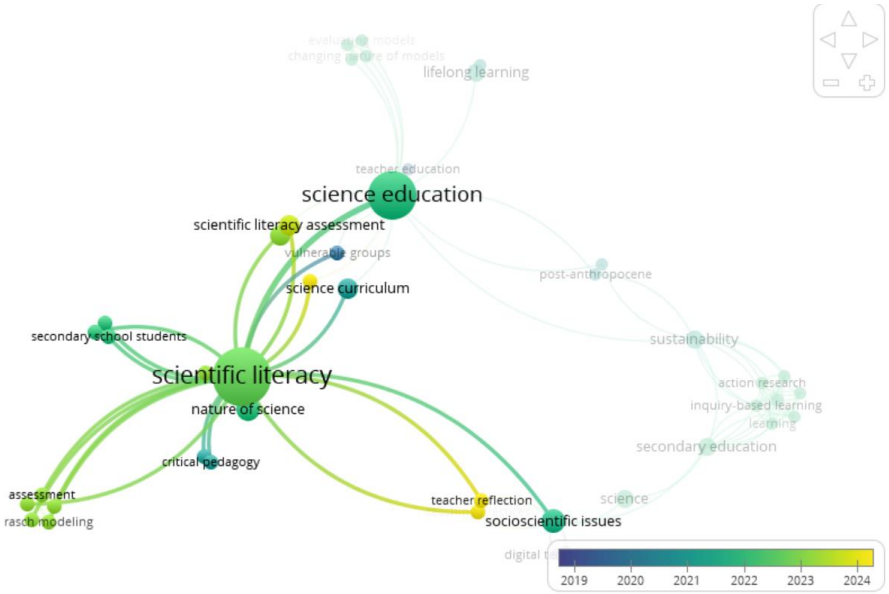

Fig 5. *Overlay Visualization*

Figure 6 shows the network density based on the keywords used. The keywords scientific literacy and science education are frequently discussed topics and have many connections in the 32 articles reviewed and are an important focus in the analyzed literature. The large number of studies discussing or connecting these two keywords indicates significant interest and relevance in between scientific literacy and science education.

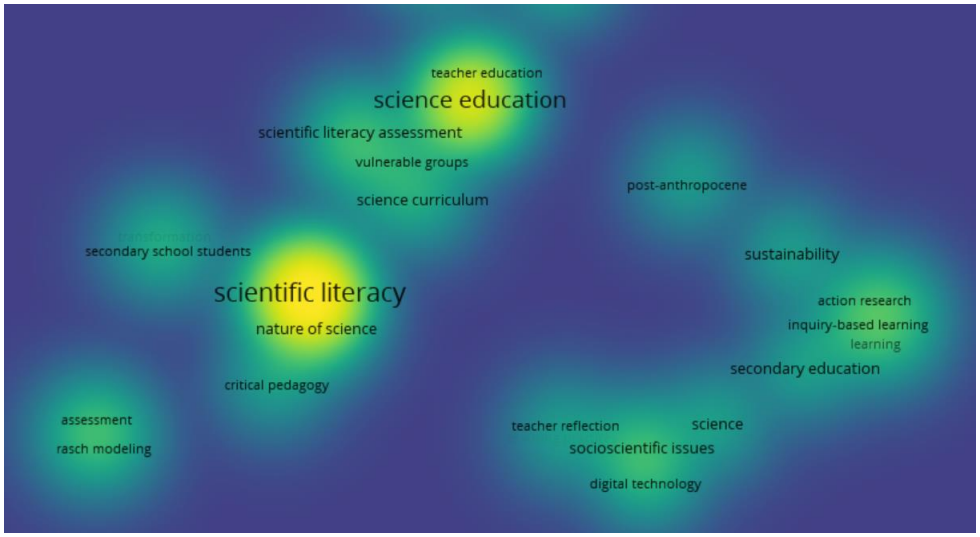

Fig. 6 *Density Visualization*

The use of scientific literacy in science education

Research on scientific literacy in science learning has been widely conducted at various levels of education, from elementary school, secondary school, college and also the general public. In science learning in elementary schools, research on scientific literacy generally aims to investigate and compare the level of scientific literacy of prospective teachers and elementary school students (Tsoumanis et al., 2023). At the high school level, research on scientific literacy aims to describe the development of scientific literacy in students and promote new forms of scientific literacy as a skill to empower students

as agents of change (Norambuena-Meléndez et al., 2023; Safrizal et al., 2022; Tasquier et al., 2022; Zhang et al., 2023). In addition, it also aims to analyze the level of scientific literacy of students based on a comparison of gender, age, socio-economic status and evaluate the relationship between scientific literacy and attitudes towards science (Bórquez-Sánchez, 2024; Väljataga & Mettis, 2022). In addition, other studies also aim to examine the influence of the argument driven inquiry (ADI) learning model, the effect of using socio-scientific issues (SSI) in science teaching on students' scientific literacy (Badeo & Duque, 2022; Eymur & Çetin, 2024). In addition to students, scientific literacy is also important for prospective teachers who take science education in college. Several findings indicate that research related to scientific literacy among students studying science in college aims to improve prospective teachers' understanding of scientific literacy (Rofieq & Fauzi, 2022; Sengul, 2023). Scientific literacy is important for students to understand the environment, health, economy, modern society, and technology. Technological advances have an impact on a person's behavior and habits, especially in how to access and obtain information. The ease of accessing information in an increasingly sophisticated technological era must be balanced with the provision of knowledge, attitudes, and individual skills (Sakti et al., 2021).

Scientific literacy research has also been shown to be important for teachers who teach science to students at various levels of education. Several findings explore how teaching by teachers involving socio-scientific issues can help students develop scientific literacy skills that are useful in real-life contexts and science-based decision-making (Bossér, 2024; Kang et al., 2024). Scientific literacy research has also been conducted on the general public with various educational backgrounds, with the aim of analyzing and improving scientific literacy among citizens, as well as understanding the factors that influence scientific literacy (Bossér, 2024; Kang et al., 2024).

Therefore, based on the results of this study, the development of scientific literacy in science learning is very important at all levels of education, to ensure that individuals can understand and apply their knowledge in everyday life. Specific research in science learning is needed to identify innovative learning models or effective teaching materials to improve students' scientific literacy skills. This also includes an analysis of differences in scientific literacy based on factors such as gender, age, and socioeconomic status. With in-depth research, a better approach to science learning can be produced, which helps students, prospective teachers, teachers, and even the general public to improve their scientific literacy skills so that they are able to overcome scientific and technological challenges with the knowledge and skills they have.

Conclusion

The results of this systematic review indicate that research on scientific literacy in science learning is quite a trend in various countries. From 2019 to 2024, 32 studies (n=32) were found that conducted research on scientific literacy in science learning at various levels. The research samples studied in identifying and improving scientific literacy skills were students at elementary school level, students at secondary school and science education students at universities, teachers who teach science to the community in various educational backgrounds. These findings can be a reference for future research to conduct further research related to scientific literacy by reviewing appropriate learning models and strategies, as well as being a reference for curriculum development in science learning.

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