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Analysis of Factors Causing Low Scientific Literacy Skills of Students and Ways to Improve Scientific Literacy

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Abstract

The low level of scientific literacy in various parts of the world is still a problem. The goal of scientific literacy is to understand scientific concepts and scientific facts. Scientific literacy skills are expected to detect and identify social problems and provide solutions to the issues faced. Scientific literacy skills can help students detect and identify problems faced by students. This study aims to identify and analyze publications of low scientific literacy and how to improve scientific literacy. Publication articles are used in the last five years, from 2020 to 2024. The method used is a systematic literature review using the PRISMA diagram. Data obtained from Scopus, Eric, and Science Direct articles. After going through the screening and eligibility process, 30 articles were obtained that met the criteria as samples. Our findings show that low scientific literacy is a problem in many countries. Various factors cause low scientific literacy, and scientific literacy can be improved in various ways.

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Introduction

Education is a teaching and learning process to develop a person's potential in terms of knowledge, attitude, or skills (Ilma et al., 2023). Science learning is a subject that can be a medium for students to learn about the natural environment in everyday life. So, it can be said that science is not just a collection of theories in the form of concepts and facts, but is also a process of discovery that is useful for life. In this case, it will require creative thinking and processing to learn many abstract concepts and scientific processes that require experimentation to support learning and to develop students' understanding. The goal of scientific literacy is to understand scientific concepts and scientific facts.

Chen and Yang (2019) argue that scientific literacy requires students to read, write, and speak scientific texts and be able to analyze, interpret, and reason in scientific discourse. Meanwhile, according to Bauer and Booth (2019), Scientific literacy skills are expected to detect and identify social problems and provide solutions to the issues faced. Scientific literacy skills can help students detect and identify problems faced by students (Adriyawati et al., 2020). The world of education is currently required to be able to provide opportunities for students to achieve core abilities and scientific literacy (Y. S. Park & Park, 2020). The literacy component supports students in facing certain challenges related to reading, writing, speaking, and listening, with informative, comprehensive, and critical reading strategies (J. C. Park, 2021). In line with 21st-century skills, literacy is an important skill that students must develop, navigate technology, and participate fully in the digital society (Aguayo et al., 2023).

The results of international scientific literacy measurement can be seen from the results of the PISA survey. International scientific literacy assessment surveys, namely Trends in Mathematics and Science Studies (TIMSS) and the Program for International Student Assessment (PISA) (OECD, 2019). The Achievement Association runs TIMSS for the Evaluation of Educational Achievement (IEA) (IEA, 2012). Scientific literacy is an important factor in helping make decisions based on effective knowledge and applying these concepts to solve problems. (National Research Council, 2012).

The low level of scientific literacy in various parts of the world is still a problem, one of which is in Indonesia. Based on the research results of Juwita Sari Rosdiana (2024) It was stated that the scientific literacy of students in a secondary school was still low, with students' attitudes still tending to be indifferent and lazy. In the research of Intan Rahmawati et al. (2024) science literacy skills in high schools obtained results that science literacy skills in the categories of aspects, processes, and contexts were still in the low category. Based on research from Azura et al. (2021) The scientific literacy skills of high school students in general are still in the very low category in various aspects.

In addition to Indonesia, low scientific literacy is also an educational problem in several other countries. The results of a study by Mohd Syafiq Aiman Mat Noor (2021), showed that the level of scientific literacy of students in schools in rural Malaysia was lower than that of students in the UK, based on three aspects of competence set by the OECD. According to research also conducted by Hatice Ceylan and Sabriye Seven (2023) in Turkey, the level of scientific literacy among secondary school students is still relatively low. Research by Pentin et al. (2018)

showed that scientific literacy among Russian students tends to be low, especially compared to international standards as measured by PISA. Overall, scientific literacy needs to be improved, especially in terms of applying scientific knowledge and skills in real contexts.

Low scientific literacy of students can have various impacts, including students tending to have difficulty in identifying and solving problems related to science in everyday life (Dewi et al., 2021; Winarni et al., 2020). In addition, low scientific literacy can result in difficulty in understanding complex scientific concepts (Suryanti et al., 2024; Yau et al., 2023). Low scientific literacy will also make it difficult for students to reason and make decisions in a scientific context (Istyadji & Sauqina, 2023; Shahzadi & Nasreen, 2020). Based on this, it is necessary to analyze the factors causing low scientific literacy skills and solutions to improve students' scientific literacy. so that students' scientific literacy can increase and be useful in their daily lives.

Method

This study used a systematic literature review and meta-analysis (PRISMA) (see Figure 1).

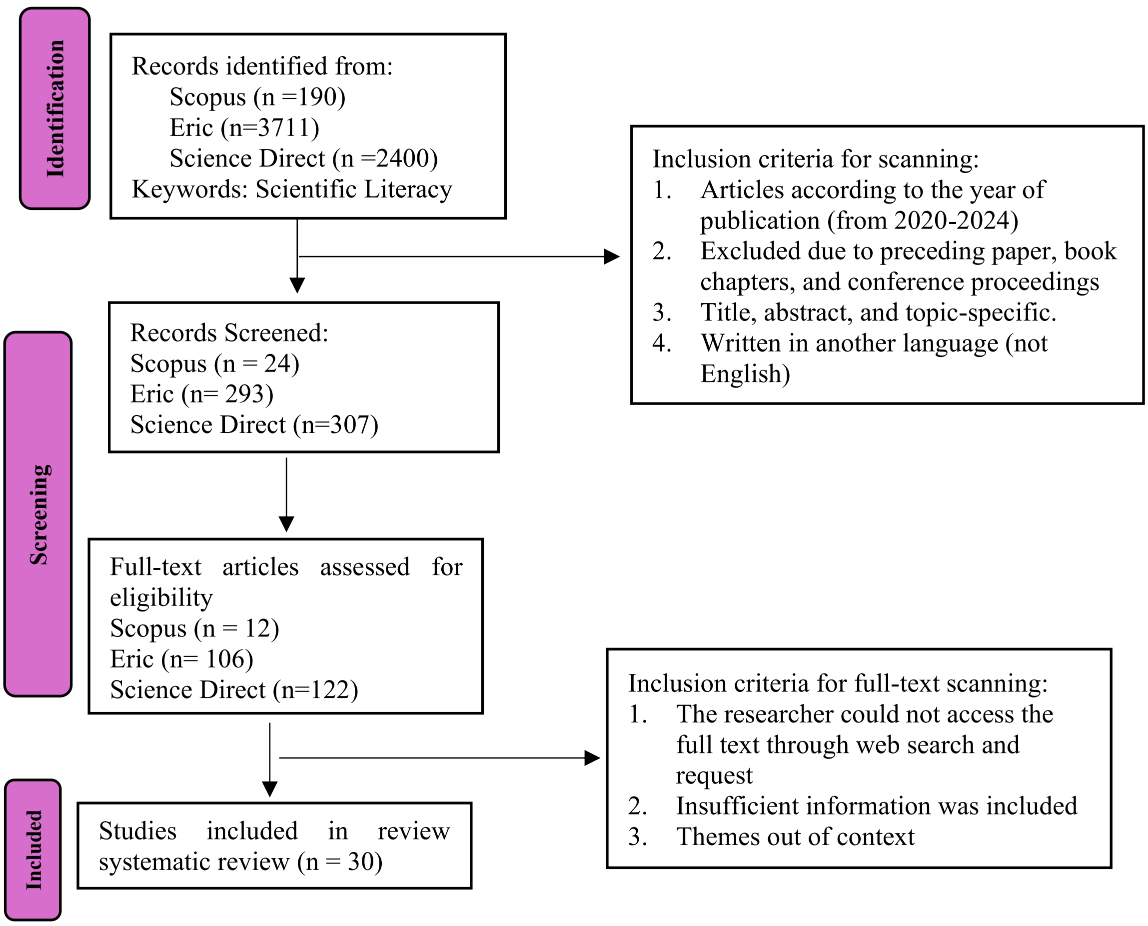

Figure 1. PRISMA Flow Diagram

A systematic literature review (SLR) is a literature review with a series of scientific methods that aim to limit systematic errors by trying to identify, assess, and synthesize all relevant research to answer certain questions. PRISMA is a procedure that has several stages, namely search, screening, initial inclusion, eligibility, and final inclusion. The main databases for the search procedure were Scopus, Eric, and Science Direct. The search time range is 2020 to 2024. Details of activities consist of strategies for searching data and information sources, study selection, quality assessment according to eligibility criteria, synthesis, and data extraction.

Identification

Identification is the process of identifying appropriate keywords to be used in the search process of articles/references for a Systematic Literature Review (SLR). The first stage in this research is looking for sources of information from various databases (Scopus, Eric, and Science Direct) by typing the keywords "Scientific" and "Literacy". Based on the keywords and databases, a total of 190 Scopus, 3711 Eric, and 2400 Science Direct were successfully obtained, and all of these articles will go through the second stage of screening.

Screening

Screening is the process of filtering according to the provisions of inclusion and exclusion criteria in selecting articles and references that are suitable for SLR. The criteria for screening are publication years in the last five years (2020 to 2024). SLR only selects journal articles published in English. Additionally, articles in the form of papers, book chapters, and conference proceedings are excluded. Other inclusion criteria are the focus of the title, abstract, and specific topic. After the screening process, 24 Scopus, 293 Eric, and 307 Science Direct records were obtained, and will proceed to the next step.

Eligibility

Eligibility is carried out to ensure that all selected articles are truly relevant and can be used in this SLR. In this process, articles were screened with the criteria of being fully accessible text, sufficient information included, and the theme of the article in context. In this process, 12 Scopus, 106 Eric, and 122 Science Direct articles were selected to go through the next process.

Articles Included

At the eligibility stage, 240 articles were obtained that met the criteria and continued to the inclusion stage. At the inclusion stage, the activities carried out are reviewing and analyzing the content of the article. At this stage, 30 articles are ready for analysis.

Results

This systematic literature review examines articles published from 2020-2024. Distribution of articles with journal identification according to inclusion criteria, namely international journals accredited by Scopus, Eric, and

Science Direct (see Table 1). Science literacy research is conducted using various research methods at various school levels (see Table 2).

Table 1. Distribution of Articles with Journal Identification

Pedagogical Approach and Journal Name	Quantity
Case study	1
Journal of Turkish Science Education	1
Causal-Comparative research design.	1
International Journal on Math, Science and Technology Education	1
Classroom action research	1
International Journal on Social and Education Sciences	1
Development research	3
JPBI (Jurnal Pendidikan Biologi Indonesia)	2
Jurnal Pendidikan Biologi Indonesia (JPBI)	1
Mixed-method study	1
Journal of Education in Science, Environment and Health	1
Pre-experimental	1
Journal Of Sciences Learning	1
Qualitative	3
Canadian Center of Science and Education	1
International Consortium for Research in Science & Mathematics Education	1
Journal of Technology and Science Education	1
Quantitative	9
Journal of Turkish Science Education	1
Anatolian Journal of Education	1
Bulletin Of Education and Research	1
International Journal of Educational Research	1
International Journal of Educational Research	1
International Journal of Instruction	3
JPBI (Jurnal Pendidikan Biologi Indonesia)	1
Quasi-experimental	10
JPBI (Jurnal Pendidikan Biologi Indonesia)	1
Eurasian Journal of Educational Research	1
European Journal of Educational Research	1
International Journal of Instruction	1
Journal of Education and E-Learning Research	1
Journal of Theoretical Educational Science	1
JPBI (Jurnal Pendidikan Biologi Indonesia)	1
Jurnal Pendidikan IPA Indonesia	1

Pedagogical Approach and Journal Name	Quantity
Pegem Journal of Education and Instruction	2
Grand Total	30

Table 2. Distribution of Articles by Research Country

School Level and Research Country	Quantity
Primary School	6
Indonesia	6
Primary School, Secondary School	1
England, German	1
Secondary School	23
Bangladesh	1
China	1
Finland	1
Indonesia	15
Pakistan	1
Philippines	1
Thailand	1
Turkiye	2
Grand Total	30

Table 3. Literature Review Results

No	**Author**	**Country**	**Causative Factor**	**Improvement methods**
1	(Adnan et al., 2021)	Indonesia	Ineffective teaching methods, lack of student engagement, and lack of resources and support.	Use of innovative learning strategies, increasing student engagement, training for teachers, monitoring and evaluation of curriculum, and support from parents and the community.
2	(Aiman et al., 2020)	Indonesia	Weak critical thinking skills, suboptimal use of media, lack of interactive learning approaches, and the state of education at the national level.	The implementation of the Process-Oriented Guided Inquiry Learning (Pogil) learning model supported by realia media has a positive influence on students' scientific literacy and critical thinking skills.
3	(Dewi et al., 2021)	Indonesia	Lack of context in learning, traditional teaching methods, minimal use of relevant learning resources, and	Implementation of contextual learning, collaborative learning, integration of ethnoscience, use of varied learning resources, and training for teachers.

No	Author	Country	Causative Factor	Improvement methods
			lack of engagement in collaborative learning.	
4	(Hindun et al., 2024)	Indonesia	Lack of attention to collaborative skills, the influence of gadgets and social media, and traditional learning methods.	The implementation of the Project-Based Learning (PJBL) model has a significant positive impact on students' scientific literacy and collaborative skills.
5	(Kristiantari et al., 2022)	Indonesia	Ineffective learning methods, lack of learning independence, minimal use of interesting learning media, and lack of support from the environment.	Implementation of the Pbl model, use of Prezi media, development of learning independence, practical activities and discussions, and increasing interest and motivation
6	(Liu & Sun, 2020)	China	Limited teacher knowledge, lack of professional training, focus on memorization, limited resources, and lack of humanistic integration.	Teacher professional development, implementation of active teaching methods, integration of social and environmental contexts, encouraging scientific attitudes, use of information technology, and evaluation and reflection
7	(Machado & Nahar, 2023)	Bangladesh	Teacher-centered teaching methods, lack of access to laboratories and resources, shortage of qualified science teachers, culture and attitudes towards science, and lack of practical experience.	Implementation of inquiry-based learning (ibl), professional training for teachers, use of adequate tools and resources, encouraging student engagement, building positive attitudes towards science, and curriculum evaluation and adaptation
8	(Mahlianurrahman et al., 2023)	Indonesia	Lack of implementation of sets learning, not by student characteristics and minimal innovation in learning.	Implementation of sets-based learning (science, environment, technology, and society) based on local wisdom.
9	(Palines & Cruz, 2021)	Filipina	Teacher quality, learning process, school curriculum, teaching materials, and administrative support.	Improving the quality of teaching, availability of teachers for consultation, development of learning modules, use of technology, practical and extracurricular activities, building

No	Author	Country	Causative Factor	Improvement methods
				research networks, and increasing awareness and reading habits
10	(Pratumsala & Nuangchalerm, 2023)	Thailand	Lack of understanding of the material, ineffective learning methods, and limited access to learning resources.	Implementation of the TPACK (technological pedagogical content knowledge) framework as a basis for designing learning activities, use of active learning methods, and design of interesting learning activities integrated with technology
11	(Pulkkinen & Rautopuro, 2022)	Finlandia	Gender differences, socioeconomic status (SES), inadequate scientific thinking skills, different assessment practices, and non-cognitive factors	Development of critical thinking and inquiry skills, improving the quality of teaching, integrating interdisciplinary learning, increasing access to educational resources, focusing on motivation and positive attitudes, and implementing fair and accurate assessments
12	(Y. Rahmawati et al., 2024)	Indonesia	The orientation of education is still focused on the content knowledge aspect, where the educational process places more emphasis on academic achievement than on developing student literacy.	Implementation of a steam-based project approach integrated with a dilemma story.
13	(Sahin & Ates, 2023)	Turki	Differences in cognitive style, logical thinking ability, mental capacity and mental rotation ability, and inequality of opportunities in learning	Holistic understanding, adaptation of teaching methods, development of teaching materials, and diverse learning activities
14	(Shahzadi & Nasreen, 2020)	Pakistan	Parental education level, parental skills, time dedicated to learning science, teaching methods and curriculum, and teaching materials.	Integration of science literacy concepts in the curriculum, increasing the duration of science learning time, teaching methods that encourage critical thinking, support from parents, improving the quality of parent education, and use of adequate

No	Author	Country	Causative Factor	Improvement methods
				resources
15	(Sholahuddin et al., 2021)	Indonesia	The ineffective learning process, limited teacher knowledge, and skills, learning orientation that is too focused on content, lack of innovative learning strategies, and limitations in identifying problems.	Implementation of cognitive style-based learning strategy (CSBLS), use of active learning methods, scaffolding for complex tasks, integration of science content with daily life, development of social and character skills, evaluation and adjustment of learning methods
16	(Simsek & Hamzaoglu, 2023)	Turki	Traditional teaching methods, lack of practical engagement, lack of context in learning, and motivational factors.	Implementation of context-based stem activities, use of react (relating, experiencing, applying, cooperating, and transferring) strategy, increasing practical engagement, building a constructive learning environment, and focusing on student motivation and interest.
17	(Wahyu et al., 2020)	Indonesia	Suboptimal learning approaches, less effective use of instructional media, low student engagement, and varied quality of education.	Use of virtual labs and augmented reality technology, interactive learning approaches, improving the quality of learning media, and training for teachers
18	(Yuliana et al., 2021)	Indonesia	Traditional teaching methods, quality of learning resources, lack of cultural context, and minimal inquiry activities.	The use of ethnoscience-themed picture books integrated into context-based learning (Ethcbl), evidence-based argumentation, and inquiry activities
19	(Arieska Putri et al., 2021)	Indonesia	Lack of student engagement, limitations in practical learning, and deficiencies in teaching science concepts	Use of virtual laboratories, inquiry-based learning, development of teachers' pedagogical skills, increased access to learning resources, and focus on 21st-century concepts and skills
20	(Arizen & Suhartini, 2020)	Indonesia	Lack of understanding of the importance of science, less relevant learning approaches, and lack of innovative learning tools.	Use of mobile-based student worksheets, implementation of innovative learning approaches, improvement of students' ICT skills, and training for teachers.

No	Author	Country	Causative Factor	Improvement methods
21	(Marpaung et al., 2021)	Indonesia	Lack of active and innovative learning approaches, as well as a lack of student understanding of the application of science concepts in everyday life, uninteresting teaching methods, and a lack of student engagement.	The SETS (science, environment, technology, and society) learning approach combined with the vee diagram has a significant influence in improving students' scientific literacy skills on environmental pollution material.
22	(Muench & Wieczorek, 2022)	England, German	Socioeconomic background, differences in education systems, and quality of teaching and resources	Focus on teaching quality, relevant curriculum development, support for students from low socio-economic backgrounds, and ongoing monitoring and evaluation
23	(Munawaroh et al., 2023)	Indonesia	Selection of learning resources, learning quality, lack of use of local context, and limited access to quality learning materials.	Development of contextual learning modules, implementation of active learning methods, integration of technology in learning, training for teachers, increasing access to quality learning resources, and evaluation and feedback.
24	(Murniati et al., 2023)	Indonesia	Low concept mastery, inadequate development of scientific literacy, and lack of understanding of science.	Implementation of innovative learning models, development of investigative skills, integration of science content in daily life, training and professional development for teachers, and increasing access to learning resources.
25	(Hidayah et al., 2021)	Indonesia	Poor understanding of basic concepts, inaccuracy in observing data, and difficulty in reading phenomenal statements	Implementation of guided inquiry learning model, use of techno-ecopreneurship-based worksheets, focus on science literacy competencies, increasing student engagement and positive response to learning
26	(Parno et al., 2020)	Indonesia	Traditional learning methods, lack of practical experience, limitations in	Implementation of PBL-STEM, use of practical projects, collaboration and teamwork, improvement of problem-

No	Author	Country	Causative Factor	Improvement methods
			problem-based learning, and environmental and resource factors	solving skills and feedback and reflection
27	(Pertiwi et al., 2024)	Indonesia	Difficulty in addressing environmental problems, lack of motivation, and low level of environmental awareness.	Implementation of stem project-based learning (stem-pjbl) model, development of critical thinking skills, provision of adequate resources, involvement in environmental issues, training for teachers, and evaluation and feedback.
28	(Sulisetijono et al., 2023)	Indonesia	Traditional learning methods, lack of interesting learning resources, limitations in concept visualization, lack of critical thinking skills, and environmental and support factors.	Development of e-module based on augmented reality (AR), implementation of active learning methods, provision of diverse learning resources, independent learning and customization, constructive evaluation and feedback, and integration of science concepts in daily life
29	(Safrizal et al., 2022)	Indonesia	Lack of consistency in teaching, limited facilities and infrastructure, lack of stakeholder engagement and decontextualized education.	Use of adequate facilities and infrastructure, implementation of strong academic culture, use of interactive learning methods, provision of awards and sanctions, cleanliness and health programs, and involvement of all stakeholders
30	(Winarni et al., 2020)	Indonesia	Inadequate learning process, lack of language skills development, high international standards, and lack of engagement in learning.	Discovery learning model, use of information and communication technology (ICT) based learning media, language skills development, active and participatory learning, and application of science concepts in daily life.

From the final screening process, a total of 30 studies were included in the synthesis. Interestingly, a majority of these studies originated from Indonesia, even though the literature search was conducted globally through leading international databases such as Scopus, ERIC, and ScienceDirect. This dominance occurred not due to geographical restrictions in the search strategy, but because Indonesian studies were more aligned with the inclusion criteria, particularly regarding the analysis of factors contributing to low scientific literacy skills and strategies to improve scientific literacy. This suggests that research on this topic has been more extensively developed in the Indonesian context during the selected publication timeframe.

The dominance of Indonesian studies is also substantively linked to the theme of this review, which focuses on factors contributing to low scientific literacy and approaches to improve it. Indonesia has consistently shown below-average performance in scientific literacy in international assessments such as PISA. This situation has encouraged Indonesian researchers to actively investigate various underlying factors, including instructional quality, teacher competence, availability of learning resources, and characteristics of the national curriculum. Consequently, the prevalence of Indonesian research in this review is not merely a technical outcome of the selection process, but also reflects the high urgency and scholarly interest in scientific literacy within the Indonesian educational context. This provides added value by offering an in-depth understanding of the challenges faced by countries with similar educational conditions.

Discussion

Factors Causing Low Scientific Literacy Skills of Students

Based on Table 3, low scientific literacy is caused by various aspects, including student characteristics, teaching methods, teacher knowledge and skills, student involvement in learning, learning facilities and resources, parental and environmental backgrounds, socio-economic backgrounds, and differences in education systems and curricula.

Differences in Student Characteristics

Learning that does not follow characteristics will make it difficult for students to identify scientific problems (Mahlianurrahman et al., 2023). Research shows that differences in cognitive styles in students, such as thinking styles, can affect students' understanding and application of scientific concepts (Sahin & Ates, 2023). Cognitive styles that do not follow the teaching methods used can cause difficulties in improving scientific literacy. Differences in students' levels of understanding of basic concepts of the material affect the interpretation of data and phenomena of scientific literacy (Hidayah et al., 2021; Marpaung et al., 2021; Murniati et al., 2023). In addition, low motivation in students to learn science is also a factor that affects scientific literacy (Simsek & Hamzaoglu, 2023; Pertiwi et al., 2024).

Ineffective Teaching Methods

Research results show that teaching methods applied in schools are often ineffective in improving student understanding (Adnan et al., 2021; Dewi et al., 2021). The use of conventional learning methods is less interactive and does not encourage active student involvement in the learning process (Hindun et al., 2024). The use of learning methods that are not interactive and do not involve students can hinder their understanding of science concepts (Kristiantari et al., 2022). Learning that does not actively involve students or does not use an appropriate approach can result in a lack of interest and motivation in students to learn science (Pratumsala & Nuangchalerm, 2023).

Limited Teacher Knowledge and Skills

Many teachers have limited knowledge of science education and are less able to apply appropriate learning strategies (Sholahuddin et al., 2021). Without proper guidance from teachers, it will make it difficult for students to understand science material effectively (Machado & Nahar, 2023). Lack of training and professional development for teachers can cause them to be unskilled in using innovative and effective teaching methods, making it difficult to integrate science literacy into teaching (Liu & Sun, 2020).

Lack of Student Involvement in Learning

Students often do not play an active role in the learning process (Arieska Putri et al., 2021). Students who are not actively involved in the learning process can hinder their understanding of science material and its application in everyday life (Winarni et al., 2020). Lack of student involvement in the learning process will also contribute to low science literacy (Wahyu et al., 2020).

Limited Facilities and Learning Resources

Limitations in facilities and learning resources that support science learning are also factors that influence low science literacy (Safrizal et al., 2022; Yuliana et al., 2021). More innovative learning tools integrated with information technology will increase student involvement in science learning (Arizen & Suhartini, 2020). Students who do not have adequate access to quality learning materials will be affected by their science literacy (Munawaroh et al., 2023).

Parental Background and Environment

Parental background and environment influence students' scientific literacy levels. Research shows that there are differences in students' scientific literacy scores related to their fathers' education. Students who have fathers with higher levels of education tend to have better scientific literacy scores (Shahzadi & Nasreen, 2020). A learning environment with parental support contributes to students' scientific literacy (Sulisetijono et al., 2023). An unsupportive learning environment can lead to low scientific literacy in students (Parno et al., 2020).

Socioeconomic Background

Research shows that students' socioeconomic background has a significant influence on educational achievement, including scientific literacy. Students from disadvantaged backgrounds tend to have lower access to quality educational resources (Muench & Wieczorek, 2022). In addition, there is a positive relationship between socioeconomic status and academic achievement. Students from higher socioeconomic status backgrounds tend to get better grades (Pulkkinen & Rautopuro, 2022). This suggests that students with lower socioeconomic status may face more challenges in achieving high science literacy, such as a lack of access to quality educational resources.

Differences in Education Systems and Curriculum

Different education systems in a region or country will affect the level of science literacy. Indonesia has a different education system from other countries (Aiman et al., 2020). Likewise, with England and Germany, for example, differences in the level of focus on competence and mastery of material in their education systems will affect science literacy outcomes (Muench & Wieczorek, 2022). Differences in the curriculum applied in a region or country will also affect science literacy (Palines & Cruz, 2021). Low science literacy is also influenced by the orientation of education that still focuses on aspects of content knowledge, where the education process emphasizes academic achievement rather than developing student literacy (Y. Rahmawati et al., 2024).

How to Improve Students' Scientific Literacy

Based on Table 3, scientific literacy can be improved in various ways, including by selecting effective learning approaches and models, using innovative learning media, involving students in learning, teacher training, developing education systems and curriculum, having support programs from schools, increasing access and educational resources, and evaluation and feedback.

Selection of Effective Learning Approaches and Models

Effective selection of learning approaches and models can improve students' scientific literacy. Some learning approaches and methods that can be used include the TPACK learning approach (Pratumsala & Nuangchalerm, 2023), the context-based STEM approach (Simsek & Hamzaoglu, 2023), the SETS learning approach combined with Vee Diagram (Marpaung et al., 2021), the SETS learning approach based on local wisdom (Mahlianurrahman et al., 2023), the STEAM-based project approach integrated with dilemma stories (Y. Rahmawati et al., 2024), the cognitive style-based learning approach (Sholahuddin et al., 2021), the constructivist learning method (Adnan et al., 2021) and the ethnoscience-based contextual collaborative learning method (Dewi et al., 2021).

Some learning models that can be used include the POGIL learning model supported by realia media (Aiman et al., 2020), project-based learning model (Hindun et al., 2024), problem-based learning model with the help of prezi media (Kristiantari et al., 2022), inquiry-based learning model (Machado & Nahar, 2023), brain-based learning model (Murniati et al., 2023), problem-based learning model with STEM integration (Parno et al., 2020), STEM project-based learning model (Pertiwi et al., 2024), discovery learning model with ICT based learning media (Winarni et al., 2020).

Use of Innovative Learning Media

Learning media used in the teaching and learning process must also be innovative and relevant to support students' understanding of science concepts, such as mobile augmented reality (Wahyu et al., 2020), context-based ethnoscience picture books (Yuliana et al., 2021), virtual laboratory media for inquiry-based learning (Arieska Putri et al., 2021), mobile-based student worksheet media in the integration of socio-scientific issues (Arizen &

Suhartini, 2020), contextual learning modules with local contexts (Munawaroh et al., 2023), techno-ecopreneurship-based worksheet media (Hidayah et al., 2021) and AR e-module media (Sulisetijono et al., 2023).

Increasing Student Engagement in the Learning Process

Encouraging students to be actively involved in the learning process can develop a better understanding of science and its applications in everyday life (Winarni et al., 2020).

Science Literacy Teaching Training for Teachers

Training and professional development of teachers with knowledge and skills are needed to teach science concepts effectively (Liu & Sun, 2020). Improving teacher personality traits and teaching styles, including communication, empathy, and emotional stability, to create a more supportive learning environment (Palines & Cruz, 2021).

Development of Education Systems and Curricula

The development of education systems and curricula is specifically designed to improve science literacy or integrate science literacy concepts and activities into the learning process (Shahzadi & Nasreen, 2020).

The Existence of Support Programs from Schools

Implementing targeted support programs for students from low socioeconomic backgrounds, including tutoring, access to educational resources, and mentoring programs (Muench & Wieczorek, 2022).

Improving Access and Educational Resources

Providing better access and educational resources can help students support effective science learning (Pulkkinen & Rautopuro, 2022).

Evaluation and Feedback

Evaluating student progress and providing constructive feedback will help students understand areas where they need to improve their skills, thereby supporting the overall development of scientific literacy (Sahin & Ates, 2023).

Conclusion

Based on the results of a systematic review of several published studies, it can be concluded that low scientific literacy in various countries is caused by various factors. Among them are the characteristics of students, teaching methods, teacher knowledge and skills, student involvement in learning, learning facilities and resources, parental and environmental backgrounds, socio-economic backgrounds, and differences in education systems and curricula.

Based on the results of a systematic review of several published studies, scientific literacy can be improved in various ways, including by selecting effective learning strategies and models, student involvement in learning, teacher training, developing education systems and curricula, support from families and communities, increasing access and learning resources, using supportive learning media, and evaluation and feedback.

Recommendations

Based on the synthesis of the 30 selected studies, several recommendations can be proposed for researchers, educators, and policymakers. First, future research is encouraged to broaden the geographical scope of studies on scientific literacy by including more diverse educational contexts. Although the dominance of Indonesian studies in this review reflects a strong scholarly response to the country's persistent low performance in international assessments such as PISA, expanding the representation of studies from other regions will enable a more comprehensive understanding of global scientific literacy challenges. Cross-country comparisons, harmonization of scientific literacy indicators, and evaluation of contextual differences in educational systems would further strengthen the generalizability of future findings.

Second, teachers and educational practitioners should be supported through sustained professional development aimed at strengthening their pedagogical content knowledge, inquiry-based teaching practices, and ability to integrate scientific reasoning into daily instruction. Given that ineffective learning methods, limited teacher competencies, and low student engagement are consistently identified as major contributors to low scientific literacy, targeted interventions such as training in STEM-based approaches, technology-enhanced learning, and contextualized science instruction are essential. Increasing teacher competence will directly influence students' opportunities to explore, analyze, and apply scientific concepts in meaningful ways.

Third, improving students' scientific literacy requires systemic support from schools and educational authorities. Schools are recommended to provide adequate learning facilities, including laboratories, digital resources, and context-rich learning materials that can facilitate experimentation, modeling, and authentic scientific inquiry. Support programs for students from low socioeconomic backgrounds should also be strengthened to reduce disparities in access to quality learning resources. At the policy level, curriculum development should focus on balancing content mastery with the cultivation of scientific skills such as critical thinking, problem-solving, data interpretation, and evidence-based reasoning, ensuring that scientific literacy becomes an integral component of science education rather than an additional emphasis.

Finally, evaluation and feedback mechanisms should be systematically integrated into science instruction. Regular formative assessments that measure students' conceptual understanding, reasoning skills, and ability to apply scientific knowledge in real-life contexts will help teachers identify learning barriers more accurately and adjust their instructional strategies accordingly. Strengthening feedback practices will not only support students' metacognitive development but also contribute to the continuous improvement of scientific literacy outcomes.

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