

Implementation of Science, Technology, and Society Approach in Science Learning to Develop Science Literacy: Evidence-Based Literature Review

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Abstract. The low level of students' science literacy in Indonesia, as reflected in international assessments such as PISA, indicates that many students still struggle to understand and apply scientific concepts in real life contexts. This problem is often linked to the limited use of contextual and integrative learning approaches in science education. Therefore, this study aims to analyze the implementation of the STS approach to improve students' scientific literacy. The research method used is a SLR with a PRISMA design. Articles were collected from the google scholar database covering the years 2020 to 2025, and 20 studies met the inclusion and exclusion criteria. The results of the review indicate that the STS approach is effective in improving science literacy by strengthening students' conceptual understanding, critical thinking, and environmental awareness through active learning methods and the integration of digital media. However, challenges such as limited teacher competence, lack of training, and insufficient learning resources hinder optimal implementation. Therefore, efforts to improve teacher professional development and develop contextual learning media are essential to maximize the success of STS based science learning.

Keywords: Scientific literacy, STS approach, systematic literature review

Introduction

In the era of globalization and the rapid development of science and technology, scientific literacy is one of the essential skills that students must have, especially in the 21st century (Rohmaya, 2022). Science literacy is an ability to understand scientific concepts and scientific processes to solve problems and make decisions based on existing scientific evidence (Banila et al., 2021). Based on the results of the Program for International Student Assessment (PISA) research in 2022, it shows that Indonesia is ranked 68 out of 81 countries (Kade et al., 2023). This shows that the ability of Indonesian students to understand and apply science concepts is still lacking. There are factors that cause the low science literacy of students in Indonesia, namely: low understanding of the nature of science; low ability of students to read and interpret data in the form of images; low ability to think critically, creatively, and solve a problem; and students have not been able to apply science concepts in everyday life (Utami & Setyaningsih, 2022).

The results of research in the form of a test of students' scientific literacy skills in science learning in Surabaya showed that the indicator of explaining scientific phenomena

obtained a percentage of 34.4%, the indicator of evaluating and designing scientific investigations showed a percentage of 36.6%, and the indicator of interpreting data and scientific evidence was 33.3% (Tillah, 2025). These results show that the science literacy of students is still relatively low so that efforts are needed to improve science literacy through appropriate learning approaches. Therefore, a contextual and experience-based learning approach is needed, one of which is the STS approach (Kauano & Marandino, 2022).

The STS approach is an approach that integrates science, technology, and society in the context of learning which aims to increase students' understanding of science concepts and awareness of implementing science in everyday life (Afifah & Bani, 2021). The stages of the STS approach include: initiation/starting; concept formation; concept application; concept stabilization and finally assessment. The main goal of the STS approach is that students can understand science concepts related to life, increase curiosity, be critical, responsible, independent and have an interest in recognizing and studying environmental events (Rachmadtullah et al., 2022).

Various primary studies have been conducted to analyze the effect of the STS approach on science literacy skills. Research by Irmitya (2023) showed that the STS Model learning device showed high feasibility with Aiken's for RPP of 0.697 and for LKS of 0.644. According to research by Amaliana et al. (2022) showed that the STM approach implemented on energy material in living systems showed that science literacy results increased in the medium category. Research by Jumini et al. (2022) shows science learning with the STS approach has a significant effect on science literacy on environmental awareness. Research by Afifah & Bani (2020) showed an increase in the science literacy skills of students taught using the STS learning model. Research by Pertiwi et al. (2020) showed a significant increase in science literacy after implementing SETS approach learning. Research by Setyowati (2018) shows that integrating contextual science literacy (local wisdom) strengthens junior high school students' science literacy skills. Finally, research by Muhajir & Rohaeti (2015) shows that the STS learning model is better than the CTL learning model in improving students' science literacy and science learning achievement.

From the various relevant studies above, there is currently no research using the SLR method that specifically focuses on the application of the STS approach to science literacy skills in science learning. In addition, topics related to the integration of the STS approach and science literacy are still difficult to find. Therefore, the purpose of this study is to identify and analyze the influence of the STS approach to science learning in developing science literacy skills.

The results of this study are expected to provide comprehensive information on the implementation and development of the STS approach to science learning in schools. The purpose of this research is to analyze the STS approach to develop students' science literacy in science learning.

Methods

This research method is SLR a research method by collecting, evaluating, integrating, and presenting findings from several research studies on related topics (Sari et al., 2023). The SLR method in this study aims to map previous research on the STS approach in science learning.

The research data was obtained from the google scholar database. Utilization of the database as the main source of information due to its broad coverage. This research procedure uses the PRISMA design. The research procedure consists of four stages, namely identification, screening, eligibility, and inclusion.

In the identification step, the search keywords were "STS and science literacy". These keywords were written in the google scholar search box with a limit of 2020-2025. The number of articles from the search results was based on each topic of STS, science literacy, and both. The articles were identified in terms of title, keywords and abstract related to the purpose of the article.

At the screening stage, articles are read with a quick method to harmonize the content and purpose of the article. Articles that are not relevant to the research topic are excluded at this stage. This process aims to reduce the number of articles that must be fully evaluated and ensure that only potentially relevant articles will be analyzed further. In the eligibility stage, the articles will be selected in the eligibility category if each component of the article such as identity, title, objectives, methods, results, and conclusions are related to the study objectives. Finally, the inclusion stage is where articles in the feasible category will be analyzed and the results of the analysis will be interpreted in tabular form. Inclusion criteria in this study include: (1) the article is the result of research published in accredited international and national journals; (2) the article explicitly discusses the application of the STS approach in science learning; (3) the focus of the research is on students' science literacy skills; (4) the article is available in open access; and (5) the article is not a conference or seminar proceedings. The research procedure can be seen in Figure 1.

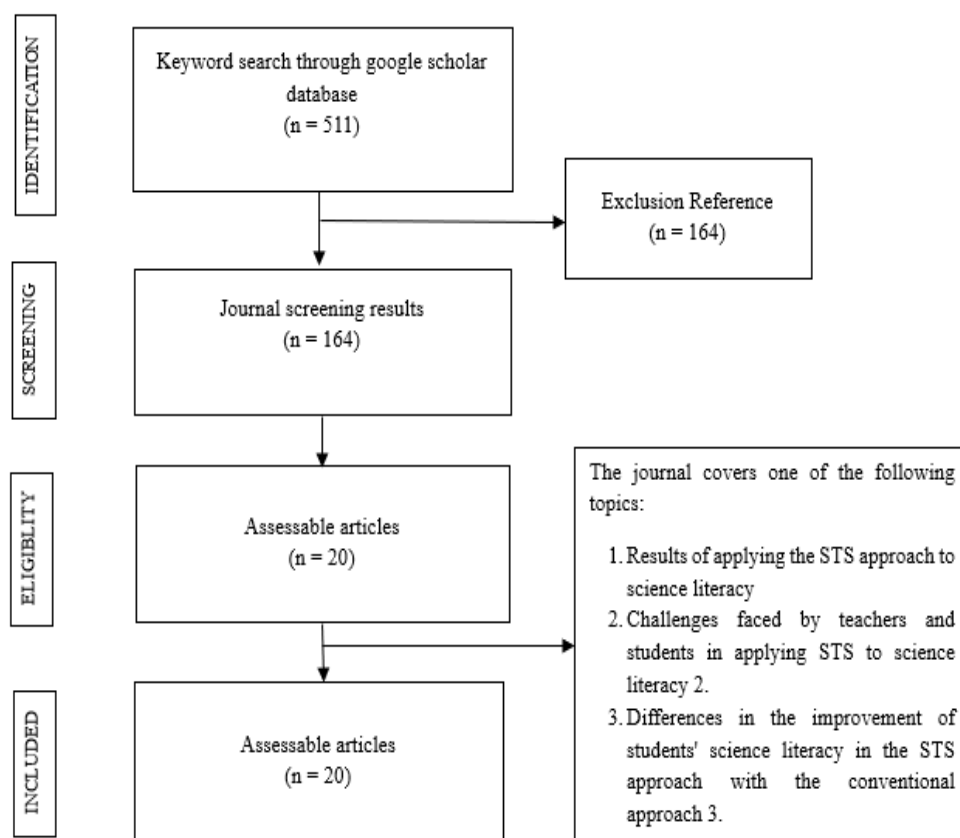


Figure 1. Research procedure

The distribution of STS theme article publications and science literacy in science learning can be shown in Table 1.

Table 1. Distribution of STS and science literacy theme article publications in science learning

No	Procedure Steps	Total Articles (N)
1	Identification	511
2	Screening	164
3	Feasibility	23
4	Included	20

Next is to determine the research question or research question (RQ) of this research, namely:

RQ1: What are the results of the application of the STS approach in developing students' science literacy in science learning?

RQ2: What are the challenges faced by teachers and students in applying the STS approach to develop science literacy in science learning?

Results and Discussion

Articles with the theme of STS and science literacy in science learning on the google scholar database with a publication range of 2020-2025. The initial search displayed the results of 511 article publications. However, not all articles can be identified properly, because there is no availability of the full text of the article. Based on the final results of the analysis, 20 articles were obtained that met the selection criteria based on the inclusion and exclusion criteria of the study. The following articles will be analyzed and examined further in the systematic review, as shown in Table 2.

Table 2. List of relevant articles

No	Researcher and Year	Title	Journal
1	(Santoso et al., 2021)	Penerapan model STS melalui eksperimen lapangan dan eksperimen laboratorium ditinjau dari sikap peduli lingkungan dan literasi sains siswa	Inkuiri: Jurnal Pendidikan IPA
2	(Intan et al., 2024)	Pengaruh pendekatan STM terhadap literasi sains siswa pada materi fluida dinamis	Relativitas: Jurnal Riset Inovasi Pembelajaran Fisika
3	(Marwah et al., 2021)	Efektivitas penerapan model pembelajaran sts terhadap peningkatan kemampuan berpikir tingkat tinggi	Edutechnologia
4	(Jumini et al., 2022)	STS learning through the utilization of potato skin waste on students' science literacy	Radiasi : Jurnal Berkala Pendidikan Fisika
5	(Zuliana & Refelita, 2022)	Desain media pembelajaran weblog kimia berbasis STM untuk mendukung literasi sains siswa	Konfigurasi: Jurnal Pendidikan Kimia dan Terapan
6	(Amaliana et al., 2022)	Pengaruh pendekatan STM terhadap literasi sains peserta didik kelas 7 mts ympi rappang mutiah	Celebes Science Education
7	(Lorencia & Jatmiko, 2021)	Online learning pbl model with the sts approach to improve high school students' science literacy ability	Pendipa: Journal of Science Education
8	(Jailani et al., 2022)	Implementasi pendekatan STS pada materi pokok lingkungan hidup untuk melatihkan literasi sains siswa	Jurnal Serambi Ilmu

9	(Pertwi & Poluakan, 2022)	Pengaruh model pembelajaran STS berbasis multiple representation-semiotic resources materi pencemaran lingkungan di smp untuk meningkatkan literasi sains	Sciencing : Science Learning Journal
10	(Da Silva & Capossoli, 2021)	Teaching physics within STS approach: contributions between sciences and act 10.639/2003	arXiv preprint
11	(Irmita, 2023)	Pengembangan perangkat pembelajaran menggunakan model pembelajaran STS untuk meningkatkan literasi sains	Orbital : Jurnal Pendidikan Kimia
12	(Wati et al., 2021)	Pengaruh penerapan model pembelajaran STM terhadap literasi sains siswa kelas x sma negeri 3 boyolali	Jurnal Bioedukasi
13	(Hadianty et al., 2025)	Evaluasi hasil belajar siswa pada materi bioteknologi berorientasi STS dalam meningkatkan kemampuan literasi sains	Jurnal Ilmiah Pendidikan Biologi
14	(Suliono et al., 2022)	Studi korelasi pengetahuan sains dan sikap terhadap sains di sma santo paulus pontianak pada pendekatan STS	Pendipa Journal of Science Education
15	(Mazidah et al., 2024)	Implementasi model pembelajaran STS terhadap kemampuan literasi sains pada mata pelajaran fisika	Jurnal Senassdra
16	(Junanto & Rody, 2023)	Pengembangan model pembelajaran STS berorientasi literasi sains bagi mahasiswa calon guru kimia	Jurnal Kependidikan Kimia (Hydrogen)
17	(Nisa et al., 2021)	Literasi sains dan SETS	Jurnal Edusains
18	(Muhajir & Rohaeti, 2021)	Perbedaan penerapan model pembelajaran STS dan CTL terhadap literasi sains dan prestasi belajar ipa	Jurnal Pendidikan Matematika dan Sains Tahun III
19	(Afifah & Bani, 2021)	Pengaruh model pembelajaran SETS dan STS terhadap peningkatan literasi sains siswa	Jurnal Pendidikan Sains
20	(Destini et al., 2022)	Implementasi pendekatan SETS terhadap kemampuan berpikir kritis peserta didik sekolah dasar	Jurnal Basicedu

Based on the review of a number of research articles, it can be concluded that the STS approach has a strategic role in improving the quality of science learning in schools, especially in developing students' science literacy. This approach has proven to be effective in linking science concepts with real problems in society, such as the utilization of organic waste, biotechnology issues, and environmental problems. The implementation of STS encourages students to understand science not only as a collection of facts, but as knowledge that is applicable, relevant to life, and has a social impact.

Thus, the STS approach can be effectively implemented in science learning as a means to train students' science literacy holistically, including cognitive, affective, and contextual aspects. These findings provide a strong foundation for the importance of research and development of STS-based learning in schools as an effort to bridge science and science with the needs and challenges of today's society.

RQ1: What are the results of applying the STS approach in developing students' science literacy in science learning?

The application of the STS approach in science learning has proven effective in developing the science literacy of students at various levels of education. This approach places science in the context of real life through the integration of relevant technological and social issues, so that learning becomes more meaningful and applicable (Kade et al., 2023).

In general, science literacy emphasizes not only understanding of science concepts, but also critical thinking, scientific data-based decision-making, and awareness of the social and environmental impacts of science and technology (Digal et al., 2024). The STS approach addresses this need by emphasizing the connection between science, technological development, and social issues. The following is a table of research results

from journal articles on the implementation of the STS approach to the development of students' science literacy skills in science learning.

Table 3. Research results of journal articles

No	Researcher and Year	Learning Model	Research Results
1	(Santoso et al., 2021)	STS model through field experiments and laboratory experiments	The use of field experiments and laboratory experiments has an effect on students' science literacy skills.
2	(Intan et al., 2024)	STS approach with quasi-experimentation	The STM approach is proven to be effective in improving science literacy, enabling students to link dynamic fluid concepts with real applications, and making a positive contribution to science learning in schools.
3	(Marwah et al., 2021)	STS learning model with quasi experiment	The application of the STS learning model is effective in improving students' higher order thinking skills in the science subject of Environmental Pollution.
4	(Jumini et al., 2022)	STS learning model with quasi-experimentation	Science learning with the STS approach has a significant effect on science literacy in the realm of awareness and concern for the environment.
5	(Zuliana & Refelita, 2022)	Design of STS based chemistry weblog learning media to support students' science literacy	Weblog media is declared feasible and implementation in learning shows effective results in improving students' science literacy.
6	(Amaliana et al., 2022)	STS approach with quasi-experimentation	The STM approach has an effect on improving the science literacy skills of seventh grade students at MTs YMPI Rappang on the material of Energy in Living Systems.
7	(Lorencia & Jatmiko, 2021)	Pbl model with stm approach	Online learning PBL model with STM approach was found to improve the science literacy skills of high school students.
8	(Jailani et al., 2022)	STS approach with instruments in the form of observation sheets, questionnaires and interviews.	The implementation of the STS approach improved the quality of students' science and technology literacy well.
9	(Pertiwi & Poluakan, 2022)	STS learning based on multiple representation-semiotic resources (mr-sr)	The effect of the MR-SR-based STS learning model on students' science literacy on environmental pollution material at SMP Negeri 1 Dumoga in the covid-19 era
10	(Da Silva & Capossoli, 2021)	STS based learning with quasi-experiment	Learning with the STS approach is proven to improve students' science literacy skills
11	(Irmitya, 2023)	STS learning model with the application of lesson plans and learning worksheets	STS-based learning tools proven feasible to improve students' science literacy

Table 3 shows the first article on the application of the STS model through field and laboratory experimentation methods. The results of related research show that this combination of methods has a positive impact on improving students' science literacy skills. This approach allows learners to understand scientific concepts with real context and direct experience, thus strengthening the link between theory and practice.

The second article of the research study applied the STM approach with a quasi-experimental design. The results show that this approach is not only effective in improving science literacy, but also encourages students to relate dynamic fluid concepts to real phenomena in everyday life. This approach makes an important contribution in strengthening contextual-based science learning in schools.

The third article evaluates the effectiveness of the STS model with a quasi-experimental method in science learning, especially on the topic of environmental pollution. As a result, this model is proven to improve students' higher order thinking skills. This shows that STS not only enriches knowledge content, but also trains critical and analytical thinking skills.

The fourth article examined the effect of the STS approach on students' science literacy, particularly in the aspects of awareness and concern for the environment. The findings show a significant increase in both aspects. In other words, STS-based learning not only conveys knowledge, but also forms a strong attitude of environmental care.

The fifth article focuses on the development of chemistry weblog-based learning media integrated with the STM approach. The results show that this media is feasible to use and effective in improving students' science literacy. This weblog-based digital media provides easy access to information and encourages more independent and interactive learning.

The sixth article examines the application of the STM approach at the MTs level on energy material in living systems. Using a quasi-experimental design, they found that this approach was able to significantly improve learners' science literacy. This shows that the STM approach is relevant to be applied at various levels of education, including the junior secondary level.

The seventh article developed online learning using problem based learning (PBL) model combined with STM approach. The results showed a real improvement in the science literacy of high school students. The combination of PBL and STM in online learning proves its effectiveness in stimulating the ability to think and solve scientific problems.

The eighth article studies the implementation of the STS approach using observation sheets, questionnaires, and interviews as data collection instruments. The implementation results showed an increase in the quality of students' science and technology literacy. This shows that the STS approach is able to create holistic learning and center on students' learning experiences.

The ninth article examines STS learning based on multiple representation-semiotic resources (MR-SR) on environmental pollution material. The study, conducted during the covid-19 pandemic at SMP Negeri 1 Dumoga, showed that the approach was effective in improving science literacy, especially through the use of various forms of representation (pictures, graphs, symbols, etc.) in learning.

The tenth article conducted a study with the STS approach through a quasi-experiment. They found that this approach was consistently able to improve students' science literacy, strengthening the validity of the STS approach as a global method in science learning. Finally, they conducted a study by developing STS learning tools in the form of lesson plans and worksheets. The results of the study show that these tools are not only feasible to use in learning, but also able to improve students' science literacy. This reinforces the importance of developing learning tools based on contextual approaches such as STS to support meaningful learning processes.

Based on the results of a literature review of eleven research articles, it can be concluded that STS and STM learning approaches and models are consistently effective in improving the science literacy of students at various levels of education. This approach not only improves the understanding of scientific concepts, but also develops higher-order thinking skills, concern for the environment, and skills in linking science knowledge with real-life contexts. The application of STS/STM through various methods such as experiments, digital media, problem-based learning, and semiotic representation has been proven to create contextual, interactive and meaningful learning experiences for students.

Based on a review of the reviewed research articles, it can be concluded that the STS approach and its variations, such as STM have proven to be effective and consistent in improving the science literacy of students at various levels of education. This approach not only strengthens the understanding of scientific concepts, but also clearly encourages the development of critical thinking skills, environmental awareness, and skills to contextualize scientific knowledge in everyday life.

The combination of the STS approach with field and laboratory experimentation methods, as shown in the research by Sari et al. (2023) successfully connects the concept of dynamic fluid with real phenomena, making learning more contextual and meaningful. Research by Irmitya (2023) also reinforces that the STS approach on the topic of environmental pollution improves students' higher order thinking skills, especially in analysis and evaluation skills. Meanwhile, a study by Kade et al. (2023) showed that the integration of the STM approach with digital media such as chemistry weblogs is very effective in improving science literacy, while fostering learning independence and interactivity.

Thus, the application of the STS/STM model, either independently or in combination with modern learning methods and media, can provide relevant, reflective, and problem-solving-oriented learning experiences, which ultimately strengthen science literacy as a 21st century competency.

RQ2: What are the challenges faced by teachers and learners in applying the STS approach to develop science literacy in science learning?

In an effort to improve science literacy, the STS approach has been widely adopted as a learning strategy that emphasizes the connection between scientific concepts, technological developments, and their impact on society. This approach is believed to foster critical thinking, environmental awareness and decision-making skills based on contextual issues.

However, behind this great potential, the implementation of STS in science classrooms faces various challenges, both from the side of teachers and students. Teachers often face limitations in designing real issue-based learning, time constraints, and lack of training in the STS approach. On the other hand, learners face difficulties in connecting scientific concepts with complex social and technological contexts, especially if their basic science literacy skills are still low. The following is a table of the results of the analysis of articles on the challenges of STS implementation on students' science literacy skills in science learning.

Table 4. Analysis of STS challenges in science learning

No	Author and Year	Article Title	Challenges revealed
1	(Acut & Antonio, 2023)	Effectiveness of STS approach on students' learning outcomes in science education: evidence from a meta-analysis	Variation in results between studies; lack of teacher training; limited resources
2	(Humairah et al., 2024)	Development of STS based physics student worksheet to improve students science literacy	Limited contextual learning resources; need for validation and media trials
3	(Santosa & Gede, 2021)	Effective strategies to improve science literacy in the digital era	The digital divide and teachers' lack of digital skills
4	(Suparya et al., 2022)	Low scientific literacy: causes and alternative solutions	Inappropriate use of textbooks, student misconceptions, decontextualized learning, low reading ability, learning environment and climate, school infrastructure, human resources, school management

5	(Autieri et al., 2021)	The STS framework for achieving scientific literacy: an overview of the existing literature	lack of teacher training in the STS approach, limited resources, and resistance to changing traditional teaching methods.
6	(Husniyyah & Erman, 2022)	Implementation of science process skills during the covid-19 pandemic	Decreased science process skills such as hypothesis formulation and experimentation in online learning
7	(Aslam et al., 2023)	Challenges in implementing stem education: insights from novice stem teachers in developing countries	Lack of teacher training and adequate infrastructure for interdisciplinary approaches
8	(Yatin & Abidin, 2020)	Literature review: development of STM learning in indonesia based on variations in subjects, teaching materials, and assessment aspects in 2019-2022	Lack of teacher training in interdisciplinary approaches and rigid school structures
9	(Ummah, 2020)	Development of STS based learning modules with mind maps	Decreased science process skills such as hypothesis formulation and experimentation in online learning

The STS approach has been widely recognized as an effective learning strategy to improve students' science literacy. However, an analysis of a number of studies shows that the implementation of this approach still faces various complex and interrelated challenges. One of the main challenges is the lack of teacher training in implementing the STS approach effectively (Acut & Antonio, 2023; Autieri et al., 2021; Aslam et al., 2023; Yatin & Abidin, 2020). Teachers tend not to be familiar with the interdisciplinary and contextual characteristics of STS, and have not received adequate assistance in designing STS-based learning.

In addition, there are limited educational resources and infrastructure, especially in the provision of contextualized teaching materials and appropriate learning media (Humairah et al., 2024; Autieri et al., 2021). These obstacles are further exacerbated by rigid school structures and school management systems that have not supported STS-based learning innovations (Yatin & Abidin, 2020; Suparya et al., 2022). However, the use of inappropriate textbooks, scientific misconceptions, and low reading and critical thinking skills of students are major obstacles in achieving optimal science literacy (Suparya et al., 2022).

Another challenge arises from the pedagogical aspect, particularly in the decline of science process skills such as formulating hypotheses and conducting experiments, which has become increasingly visible during the online learning period due to the covid-19 pandemic (Husniyyah & Erman, 2022; Ummah, 2020). Digital inequality and the lack of technology skills in teachers also exacerbate this condition, especially in the era of digital-based learning (Santoso et al., 2021). Equally important, some studies show resistance to change in traditional learning methods, both from teachers and from educational institutions themselves (Autieri et al., 2021). This hinders the implementation of innovative approaches such as STS as a whole. Thus, the success of developing science literacy through the STS approach is not only determined by the quality of teaching tools, but also highly dependent on teacher readiness, infrastructure support, school policies, and learning designs that are able to integrate science with social and technological contexts in a meaningful way.

To overcome various challenges in implementing the STS approach in science learning, the main solution suggested is to improve teacher competence through continuous training and mentoring. This training not only equips teachers theoretically, but also practically, especially in developing science literacy-based teaching tools and utilizing learning technology effectively (Sukinaswati et al., 2021). Teacher mentoring such as in the science literacy program at SDN Jelambar Baru showed an increase in the ability to

design contextual learning that trains critical thinking (Hafizah & Nurhaliza, 2021). Active and contextual learning strategies such as PBL have also proven effective in improving science literacy, especially when combined with relevant and interactive media (Varelasiwi, 2022). In addition, culturally responsive teaching can make learning more meaningful by linking science to the context of students' lives (Hardiansyah et al., 2022).

The development of contextualized learning media, especially based on local and global issues, is also key. This kind of media encourages students to think critically and understand the linkages between science, technology and society (Awalina et al., 2024). In addition, the curriculum needs to be directed to explicitly support science literacy-based learning, including by providing varied and applicable learning resources. Another solution that supports the success of the STS approach is the implementation of differentiated learning. This strategy allows teachers to adapt learning methods to students' learning needs, thus improving motivation and learning outcomes, including in terms of science literacy. By applying these various solutions synergistically, STS-based science learning can be more optimal in forming students who are science literate and able to think critically about real issues in society.

Conclusion

The results of this study show that the STS approach is effective in improving students' scientific literacy in science learning. The STS approach helps students connect scientific concepts with real-life issues, thereby strengthening conceptual understanding, critical thinking, and environmental awareness. However, the implementation of this approach still faces several challenges, including limited teacher competence, lack of contextual learning media, and insufficient support for science process skills. Therefore, improving teacher training and developing contextual, locally relevant learning media are essential steps to optimize the application of the STS approach in enhancing students' science literacy.

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