

RESEARCH TRENDS AND LITERATURE REVIEW OF SCIENCE TECHNOLOGY SOCIETY IN SCIENCE LEARNING

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Abstract :

This study aims to analyze research trends and developments in the implementation of the Science Technology Society (STS) approach in science education. The study uses bibliometric analysis and systematic review, with data collected from Scopus, Web of Science, and other databases. Tools include VOSviewer for keyword network analysis and the PRISMA method for data selection. The STS approach significantly enhances critical thinking, collaboration, and problem-solving skills. Key topics include digital technology integration and the role of STS during the COVID-19 pandemic. Gaps exist in applying STS across educational levels and its impact on scientific attitudes. This study provides a comprehensive understanding of STS research trends, emphasizing the integration of digital tools in education and identifying unexplored areas. It advances the knowledge by suggesting future research directions to improve STS implementation.

Keywords: Literature Review, Science Learning, Science Technology Society

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INTRODUCTION

Science learning continues to develop along with advances in science and technology. One approach that is widely used in science education is Science Technology Society (STS), which emphasizes the relationship between science, technology, and society (Çınar & Çepni, 2021; Kamizi & Iksan, 2021). This approach aims to improve students' understanding of how science and technology affect everyday life and how they can play a role in solving social and environmental problems (Mulyanti et al., 2021a; Noga et al., 2021). With the increasing complexity of global challenges today, the STS approach is becoming increasingly relevant in forming individuals who are critical, creative, and concerned about science and technology issues in society (Yoon & Olsen, 2023).

Previous research conducted by Acut & Antonio (Acut & Antonio, 2023) focused on evaluating the effectiveness of the STS approach on student learning outcomes through quantitative data analysis from various studies. The focus was on measuring the extent to which this approach improves conceptual understanding, critical thinking skills, and attitudes toward science. In contrast, the current study focuses more on research trends and literature reviews to identify patterns, challenges, and under-explored research areas in STS implementation. The main gap between the two studies lies in their approaches and objectives; the previous study focused on empirical evidence of the effectiveness of STS, while the

current study explores the research landscape more broadly to provide theoretical insights and future research directions.

The STS approach focuses not only on the transfer of scientific knowledge, but also on the integration of technology and its impact on society. In the context of learning, this approach helps students understand how science is applied in the real world and how technological innovation can provide benefits and challenges for society (Bauphitak et al., 2024; Net et al., 2025; S. & D., 2023). In addition, the STS approach also plays a role in improving 21st century skills, such as critical thinking, problem solving, communication, and collaboration (Arabloo et al., 2022; Bauphitak et al., 2024; Eiamkosakun et al., 2024). Therefore, research on the implementation of STS in science learning is becoming increasingly important to ensure its effectiveness in facing the challenges of modern education.

Along with the development of digital technology and the industrial revolution 4.0, the STS approach in science learning has also undergone a transformation. The use of digital technology in education has opened up new opportunities in the implementation of STS, such as the use of simulations, project-based learning, and data-driven approaches (Cujba & Pifarré, 2024; Tedre et al., 2021). This leads to the need to review the related literature to understand how the integration of modern technology can strengthen the STS approach in the context of science learning (Jumini et al., 2022; Mulyanti et al., 2021b; Rachmadtullah et al., 2022). In addition, research trend analysis can provide insight into how this approach has evolved in the face of developments in the era (Cui et al., 2023; Elmatsani et al., 2024).

In conducting this literature review, the methods used include bibliometric analysis and systematic reviews of various studies that have been published in academic journals. This approach allows the identification of major trends in STS research, including the most widely studied themes, the methodologies used, and the implications of research results for science learning (N. Ellili et al., 2023; N. O. D. Ellili, 2022; Passas, 2024). By understanding research patterns and trends, it is hoped that new opportunities can be found for the development of a more effective STS approach that is in accordance with current educational needs.

This study has novelty and urgency because it combines bibliometric analysis and systematic review to explore research trends in the implementation of the Science Technology Society (STS) approach in science learning. Previously, many studies have focused on the effectiveness of the STS approach on learning outcomes, but not many have explored the development patterns, dominant themes, and research gaps in this field. By understanding the research landscape comprehensively, this study not only provides insight into the theoretical and practical contributions of STS but also helps identify areas that need further attention. The urgency of this study lies in its role in providing strategic guidance for academics and practitioners to develop more relevant and innovative STS studies and applications in the future. This study aims to analyze research trends and developments in the implementation of the Science Technology Society (STS) approach in science education.

RESEARCH METHOD

Research Design

This study uses a literature review approach with systematic review and bibliometric analysis methods to analyze the trend of Science Technology Society (STS) research in science learning (Gupta et al., 2025; Rojas-Sánchez et al., 2023; Zheng et al., 2022). The systematic review method is used to critically evaluate and synthesize existing studies, with the aim of gaining a comprehensive understanding of the research landscape (Mahran & Elamer, 2024; Mancin et al., 2024; Sánchez et al., 2024). On the other hand, bibliometric analysis is used to identify patterns, trends, and key contributors in the field, including the most cited articles, influential authors, and dominant research themes (Ghorbani et al., 2022; Kumar et al., 2024; Tanwar et al., 2022). By integrating these two methods, this study aims to provide an in-depth and objective overview of the development and current state of STS research in science learning.

Research Target/Subject

The subject of this study includes scientific articles that discuss the application of the Science Technology Society (STS) approach in science learning. The articles analyzed were selected from journals indexed in Scopus with a focus on publications in the period 2015-2025 to identify the development of trends and research contributions in this field. Inclusion criteria include empirical research, conceptual studies, and articles that connect the STS approach to science learning at various levels of education (Cheung & Erduran, 2023; Patiño et al., 2023).

Research Procedure

The research procedure was carried out through a series of systematic stages designed to ensure the accuracy and relevance of the research results. The first stage is the identification and selection of literature, where researchers collect relevant scientific articles from indexed databases such as Scopus, using keywords that are tailored to the focus of the research. After the articles are found, the next stage is article screening using inclusion and exclusion criteria, which include the range of publication years (2015-2025), relevance to the topic of science learning, and availability of full text. Articles that do not meet these criteria will be excluded from the analysis. This process will be illustrated using the PRISMA flowchart to show the selection steps and the reasons why certain articles were not included in the analysis.

After articles that meet the criteria are selected, the next stage is data extraction, where important information from the selected articles, such as title, author, year of publication, methodology, main results, and themes discussed, will be systematically recorded. The collected data will then be analyzed using two main approaches: bibliometric analysis and systematic analysis. Bibliometric analysis was conducted to identify patterns, trends, and key contributions in the field of STS through the creation of network maps using software such as VOSviewer, as well as the measurement of bibliometric indicators such as the number of citations and H-index. Meanwhile, systematic analysis was conducted to evaluate in depth the content of the selected articles, identify key emerging themes, and explore their contributions to science learning. The results of these two approaches were then combined to provide a comprehensive picture of the development of STS research in science learning. The results of the analysis will be compiled in a report that provides a comprehensive picture of the trends, contributions, and directions of research development in this field.

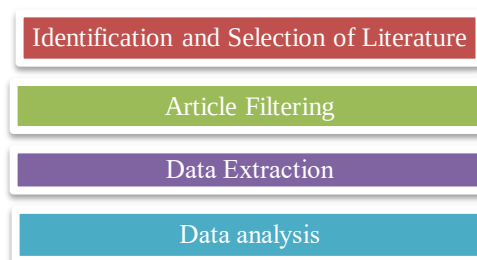


Figure 1. Research Procedure

Instruments, and Data Collection Techniques

The data collection technique in this study was carried out through several stages. The first stage is the identification and selection of articles from relevant data sources, namely scientific articles published in journals indexed in Scopus with a focus on the topic of the application of Science Technology Society (STS) in science learning (Marcos-Zambrano et al., 2021). Literature searches were conducted using keywords such as "Science Technology Society in Science", which were adjusted to various research perspectives and contexts (Chigbu et al., 2023).

Furthermore, the articles found will be filtered based on inclusion and exclusion criteria including the range of publication years, relevance to science learning, and availability of full text (Ullah

et al., 2023). Articles that do not meet these criteria will be excluded from the analysis. Important information from the selected articles will be systematically extracted, including the title of the article, author name, year of publication, journal, research methodology, results, and themes and topics discussed (Imran & Almusharraf, 2023). The PRISMA flowchart will be used to illustrate the article screening process, from identifying relevant articles to articles that meet the inclusion and exclusion criteria (Rethlefsen & Page, 2022; Sohrabi et al., 2021).

Data analysis technique

Data analysis in this study was conducted through two main approaches, namely bibliometric analysis and systematic analysis. Bibliometric analysis aims to identify patterns and trends in Science Technology Society (STS) research in science learning (Ogutu et al., 2023). To do this, bibliographic data from selected articles will be analyzed using software such as VOSviewer, which allows the creation of network maps depicting the relationships between authors, journals, keywords, and the most influential institutions in the field (Ejaz et al., 2022; Nurdin et al., 2021). Several bibliometric indicators, such as the number of publications, the number of citations, and the H-index, will be used to identify significant research contributions and explore temporal trends in publications in the field of STS (Zyoud et al., 2024).

Meanwhile, systematic analysis is conducted to assess and synthesize the contents of the articles in depth (Chiang et al., 2022). In this approach, the selected articles will be analyzed based on the research objectives, the methodology used, the main results, and their contributions to science learning. This process involves coding the data manually or using software to identify key themes and thematic patterns that emerge in STS research. The results of these two approaches, namely bibliometric analysis and systematic analysis, will be combined to provide a more comprehensive picture of the trends, contributions, and developments of STS research in science learning. This integrated approach is expected to produce a more complete and objective understanding of the current state and direction of research in this field.

RESULTS AND DISCUSSION

Literature Search and Selection

The search process begins by collecting scientific articles from indexed databases such as Scopus. The search was conducted using keywords such as “Science Technology Society in Science” which were adjusted to various research perspectives and contexts. From the initial search, 24 articles were obtained that were relevant to the research topic. The search results for these articles can be seen in the following table:

Table 1. Articles Search Results

	Year	Number of Articles
1.	2025	1
2.	2023	3
3.	2022	1
4.	2021	1
5.	2020	3
6.	2019	3
7.	2018	4
8.	2015	1
9.	2014	1
10.	2010	1
11.	2009	1
12.	1998	1
13.	1996	2
14.	1995	1

These articles then went through an initial elimination stage based on inclusion and exclusion criteria, such as publication year range (2015–2025), topic relevance to science learning, and full-text
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availability. Articles that did not meet these criteria were eliminated, leaving 17 articles for further screening. The results can be seen in the table below:

Table 2. Article Search Results from 2015-2025

No.	Year	Number of Articles
1.	2025	1
2.	2023	3
3.	2022	1
4.	2021	1
5.	2020	3
6.	2019	3
7.	2018	4
8.	2015	1

Screening Process

In the screening stage, the inclusion criteria used included empirical and conceptual research that linked the Science Technology Society (STS) approach to science learning at various levels of education. In addition, only articles published in indexed journals and with full-text access were included. Articles that did not include clear methodological data or results were excluded from the analysis. This process was carried out systematically to ensure that only relevant and high-quality articles were selected for the final analysis. From the screening process, 10 articles were obtained that met the criteria, the results of which can be seen in the table below:

Table 3. Results of screening articles that connect the Science Technology Society (STS) approach to science learning at various levels of education.

No.	Author	Year of Publication	Title
1.	Ayong, R.M	2025	Instructional Modules for Constructivist Environmental Learning in Science, Technology and Society (STS) Subject
2.	Acut, D., Antonio, R.	2023	Effectiveness of Science-Technology-Society (STS) Approach on Students' Learning Outcomes in Science Education: Evidence from a Meta-Analysis
3.	da Silva, W.A., do Nascimento Firme, R.	2023	An Integrative Review of Publications that Articulate Liberating Education and Science-Technology-Society (STS) Education in Science Teaching in the Brazilian Context
4.	Yoon, J., Olsen, A.	2023	Promoting Science Affinities through a Video Project in a Science, Technology, and Society (STS) Learning Approach
5.	Havu-Nuutinen, S., Kärkkäinen, S., Keinonen, T.	2018	Changes in primary school pupils' conceptions of water in the context of Science, Technology, and Society (STS) instruction
6.	Correa, B.F., Silveira, R.M.C.F., Maciel, N.A.P.	2015	Environmental education: Awareness of solid waste in the context science, technology and society - STS

Filtering and Analysis Results

Of the total 24 articles screened, 6 articles met all inclusion criteria and were further analyzed. In the bibliometric analysis, data from the selected articles were analyzed using VOSviewer to create a network map depicting the relationships between keywords, authors, and institutions. The results of this analysis indicate that keywords such as “STS approach,” “science education,” and “21st-century skills” are the main focus of research in this field. In addition, certain authors from leading institutions in

countries such as the United States and Australia dominate the contributions in these publications. The results of the analysis using VOSviewer can be seen in the image below:

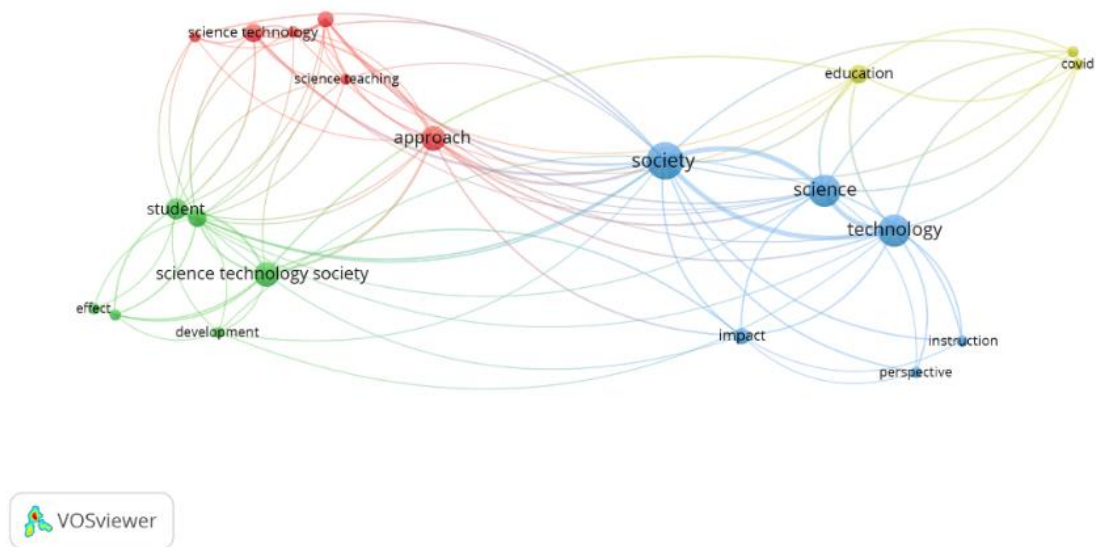


Figure 2. Network Visualization

The image above is a visualization of a keyword network map created using VOSviewer software. This map shows the relationships and strength of associations between key concepts related to the field of "science, technology, and society." Different colors reflect clusters or groups of keywords that are closely connected to each other based on the frequency of their co-occurrence in the analyzed documents. For example, keywords such as "science technology society" and "student" are in a green cluster, indicating a focus on the relationship between technology and society in the context of education.

In the red cluster, concepts such as "approach," "science teaching," and "science technology" dominate. This reflects the approach or method used in learning science and technology. This cluster shows that there is significant attention to how science teaching is implemented, especially in integrating technology as a learning tool. The interconnectedness of these words with other clusters indicates that this learning approach is relevant to improving the relationship between technology, society, and education.

On the other hand, the blue cluster that focuses on keywords such as "society," "science," and "technology" highlights the impact of technology on society in general. This connection indicates that the role of technology in science is not only limited to education, but also its impact on social structures. In addition, the yellow cluster with keywords such as "education" and "covid" indicates a more specific topic, namely the role of technology in education during the COVID-19 pandemic. Overall, this visualization reveals the dynamic interaction between technology, education, and society.

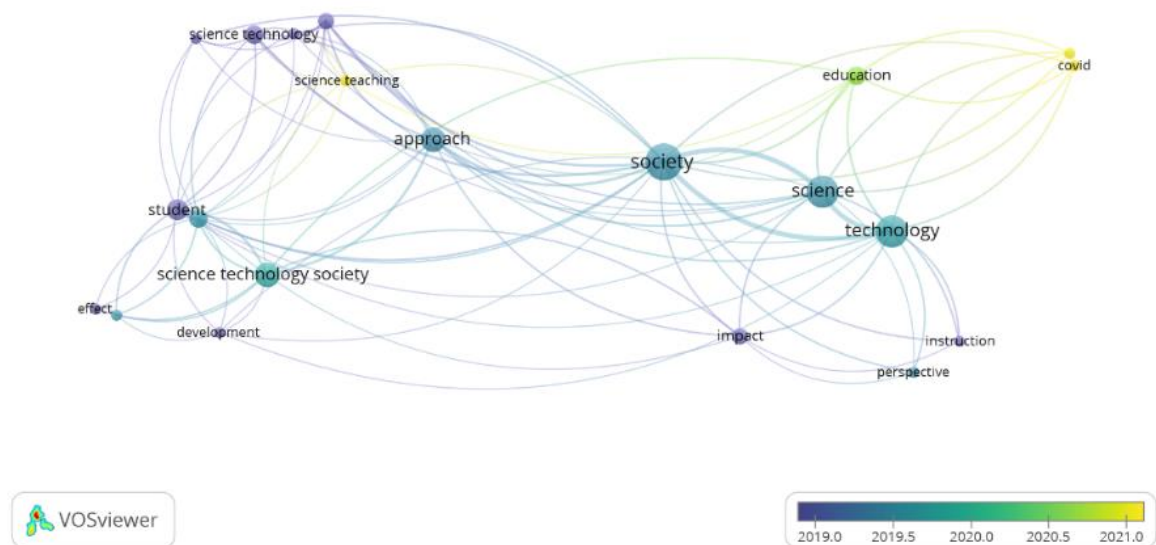


Figure 3. Overlay Visualization

This second image is a visualization of the keyword network with a time dimension displayed in the form of a color gradient, showing the development or trend of a particular topic from 2019 to 2021. Darker colors (blue) indicate keywords that appeared more frequently in the early years of the analysis (2019), while lighter colors (yellow) indicate keywords that became more relevant or popular in the following years, especially approaching 2021.

Keywords such as "science technology society" and "student" which are in blue or bluish green indicate that this topic began to receive attention from the beginning of the analysis period. This indicates an early focus on the relationship between technology, science, and society in the context of education, and how student engagement in this dynamic has been a significant issue since the beginning.

On the other hand, keywords such as "covid" and "education" which are marked in yellow indicate that this topic only emerged or received greater attention in 2020 and 2021. This is very relevant to the context of the COVID-19 pandemic, which has driven the transformation of education through technology. The connection between these words suggests a significant shift in how technology is being used to support education amidst global challenges.

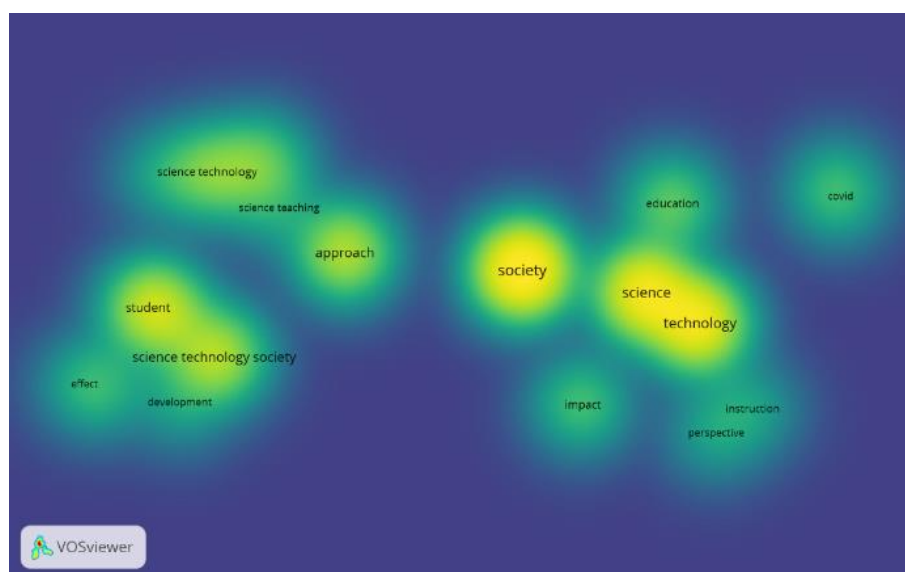


Figure 4. Density Visualization

This third figure is a visualization of keyword network density, which shows the concentration or density of the frequency of occurrence of keywords in related research. Yellow indicates areas with higher keyword density, while blue indicates lower density. Keywords such as "society", "science", and "technology" have high densities, indicated by the bright yellow color. This indicates that the topic of the relationship between society, science, and technology is the center of attention in this analysis. This area reflects the main focus of research that seeks to understand how technology and science affect society.

On the other hand, keywords such as "student" and "science technology society" also have significant densities, although not as high as the previous group. This indicates attention to the role of students and the relevance of science and technology in the social context. Meanwhile, keywords such as "covid" have isolated densities on the right side, indicating this topic is a specific focus but not as broad as other topics, possibly related to the impact of the pandemic on education and technology use.

Implementation of the Science Technology Society (STS) Approach in Science Learning

Based on the literature study that has been conducted, 6 articles have been selected from the Scopus database that discuss the science technology society (STS) approach in science learning. The results of the literature study are presented in Table 4 below.

Table 4. Matrix of Implementation of the Science Technology Society (STS) Approach in Science Learning

No.	Author	Year	Research methods	Research result
1.	Ayong, R.M.	2025	Research and Development with ADDIE Model	The findings revealed that both students and experts had rated the instructional module positively, indicating its effectiveness in facilitating learning and completing lessons. Key aspects such as the style of illustrations and written expressions, the usefulness of learning activities, and the guidance provided by illustrations and captions were especially well-received. The module was praised for its clear objectives, understandable instructions, and engaging tasks like trivia and puzzles. Expert evaluations highlighted relevance, simplicity, and balanced emphasis on topics in the module content. Furthermore, students in test group demonstrated significant improvement in performance, with post-test scores notably higher than pre-test scores, confirming the module's effectiveness in enhancing learning outcomes.
2.	Acut, D., Antonio, R.	2023	Quantitative	Results showed that the STS approach significantly and positively impacts students' learning outcomes ($g = 1.882$), particularly psychomotor skills, affective domain, and cognitive skills. Moderator analysis showed that STS is an effective teaching strategy that yields similar positive results regardless of the assessed learning outcomes. The findings demonstrated that the STS approach facilitates students' development of scientific knowledge, skills, and mindset to innovate for real-world problems.

3.	da Silva, W.A., do Nascimento Firme, R.	2023	Integrative Literature Review	The integrative review shows that the articulation between Liberation Education and STS Education: has different objectives, among them, the political redirection in Science teaching; is carried out in different ways, such as, for example, through Thematic Investigations; promotes possibilities, such as the reconfiguration of the curriculum based on critical perspectives and social contexts; and contains limitations such as the gap between Freire's assumptions and scientific literacy. Pre- and post-survey data showed that the video project using the STS approach did not have a statistically significant impact on participants' high achievement in STEM. However, their interviews showed that the study helped maintain and enhance their interest and learning in science even during the Pandemic by engaging them in the learning process, understanding Science and Technology in our society, and making decisions for the future of society.
4.	Yoon, J., Olsen, A.	2023	Quantitative	Students (N = 41) studied water over a four-week period and considered water-related concepts and phenomena in scientific, social, and technological contexts. Before and after STS instruction, students wrote essays and based on the analysis of the essays, 10 students were selected to be interviewed. Before STS instruction, students' conceptions of water were descriptive and situated in their daily lives, and students considered their water use subjectively. Students were rarely able to explain the relationships between concepts or phenomena. After STS instruction, scientific explanations increased, and water was understood more globally, and issues such as water status and water circulation were interrelated. In this study, the process of students' conceptual change occurred primarily as a reorganization of the conceptual hierarchy but also included some insights for higher-level changes. In addition, the learning context appeared to play an important role in such changes. The learning context supported students to consider water as a broad and interrelated phenomenon. STS instruction challenged students to consider water phenomena as a global issue.
5.	Havu- Nuutinen, S., Kärkkäinen, S., Keinonen, T.	2018	Mixed-Method Approach	The results of the study show that the Science, Technology, and Society (STS) approach contributes significantly to improving Environmental Education by increasing scientific and technological literacy,
6.	Correa, B.F., Silveira, R.M.C.F., Maciel, N.A.P.	2015	Literature Research	

strengthening environmental awareness, and encouraging sustainability-oriented citizen action. CTS helps students critically understand environmental issues by linking scientific, social, and technological concepts. This approach also empowers social groups to take real action in waste management and other environmental issues. In addition, the integration of CTS with interdisciplinary education provides a holistic perspective, making CTS a promising strategy for strengthening environmental literacy and awareness.

Analysis of the six articles reviewed shows that the Science Technology Society (STS) approach has a broad and flexible scope of application in science learning. This approach not only focuses on improving learning outcomes quantitatively, but also contributes to more qualitative aspects, such as strengthening learning interests, forming critical thinking patterns, and awareness of social and environmental issues.

Several studies have shown that STS is able to bridge the gap between formal science and students' real-life contexts. This can be seen from the transformation in the way students understand scientific concepts—from being initially local and descriptive, to being more global and conceptual. This transformation shows that STS is not just a learning method, but also a framework for building a complete and meaningful understanding.

From a pedagogical perspective, the STS approach supports interactive, relevant, and contextual learning strategies. By integrating social and technological elements into the learning process, STS provides a more realistic and applicable learning experience. This is in line with the needs of 21st-century education which requires students to not only understand theory, but also be able to apply it in real and complex situations.

In addition, the STS approach also shows its potential in building social and environmental awareness. Several findings suggest that STS can encourage students to think critically about issues such as sustainability and social justice, as well as stimulate active participation in facing global challenges. This approach plays a role in forming students who are not only academically intelligent, but also empathetic and socially responsible. Thus, the STS approach has great potential to be developed as a primary strategy in science education, because it is able to integrate cognitive, affective, and psychomotor aspects while strengthening the relationship between science and social reality.

Analysis of the gap between previous and current research on the Science Technology Society (STS) approach in science learning shows a significant shift in the focus of the study. Research conducted by Çınar and Çepni (Çınar & Çepni, 2021) and Mulyanti et al. (Mulyanti et al., 2021b) focuses more on the direct effects of the STS approach on students, such as improving learning outcomes and critical thinking skills. These studies used an experimental approach to quantitatively test the effect of STS on students at elementary to secondary levels, with results showing that STS can significantly improve students' cognitive abilities and conceptual understanding. Meanwhile, recent research examining research trends and literature reviews on STS in science learning shows a broader and more reflective approach. This research is no longer limited to the influence of the STS approach on student learning outcomes directly, but rather highlights how STS is implemented in various contexts, the variety of research methods used, and the relationship between STS and global issues such as sustainability, critical education, and socio-technological integration in the curriculum. This approach is more oriented towards mapping discourse and scientific trends, thus contributing in the form of knowledge synthesis and future development directions.

Thus, the main gap that is seen is the difference in the scope and objectives of the study. Previous research was applied and oriented towards individual student learning outcomes, while the current research is conceptual and strategic, with the aim of comprehensively understanding the development of STS research and examining how this approach can continue to be utilized within a broader and more

sustainable educational framework. This gap shows the need for integration between practical and reflective approaches in STS research so that its implementation in the field remains relevant to the dynamics of current educational needs.

Recent research focusing on research trends and literature reviews on the Science Technology Society (STS) approach in science learning has a positive impact in the form of a more holistic understanding of the development and implementation of STS in various educational contexts. This study is able to identify patterns, strengths, and potential for integrating STS with contemporary issues such as critical education, the environment, and technology. However, the limitations of this study lie in its nature as a literature review, so it does not directly test the effectiveness of the STS approach through empirical data in the field. In addition, reliance on articles available in one database (Scopus) can also limit the diversity of perspectives and geographical contexts included in the analysis.

CONCLUSION

Based on the results of the research that has been conducted, it can be concluded that the Science Technology Society (STS) approach in science learning has experienced significant development, both in terms of themes, methods, and context of its application. Through a combination of bibliometric analysis and systematic review, this study has succeeded in providing a comprehensive picture of the trends, contributions, and directions of the development of STS studies in the last decade. This study shows that the STS approach plays an important role in improving 21st century skills, including critical thinking, collaboration, and problem solving. In addition, the integration of digital technology and responses to global issues such as the COVID-19 pandemic are the main focus of recent publications. However, there are still research gaps that need to be explored further, such as the application of STS at various levels of education and its influence on students' scientific attitudes. Therefore, this study provides a strong foundation for researchers and education practitioners to design STS-based science learning innovations that are more contextual and relevant to the challenges of the times. Therefore, this study recommends further exploration of the STS approach to support the needs of modern education.

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