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The Research Landscape of Socioscientific Issues in Science Learning

A Bibliometric Review

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ABSTRACT

Socio-scientific Issues (SSI) are scientific issues that enable students to view science realistically by integrating attitudes and ethics into the assessment of scientific information, in accordance with the demands of today's society. This research aims to thematically synthesize research articles on SSI published between 2019 and 2024 in the Scopus database and to evaluate author distribution, inter-country networks, citations, affiliation distribution, sources, conceptual structure, intellectual structure, and social structure. The method used was bibliometric analysis assisted by VOSviewer and Biblioshiny. An initial search of the Scopus database identified 711 records. After applying the publication year (2019–2024), document type (journal article), language (English), and thematic relevance to socioscientific issues in science learning criteria, 129 articles were retained as the final dataset for bibliometric analysis. The results show an increasing research trend during the 2019–2024 period. Frequently occurring and highly connected keywords, including knowledge, strategy, problem, and reasoning, represent well-established themes in SSI research. In contrast, moral sensitivity, scaffolding set, and local wisdom are less frequently represented in the bibliometric network, suggesting that these topics may constitute potentially underexplored directions for future research. The conclusion is that bibliometric analysis provides insights into rising research trends in the 2019-2024 period, with research topics that might be addressed, including moral sensitivity, scaffolding sets, and local wisdom.

Keywords
Bibliometric Analysis
Biblioshiny
Science Learning
Socio-scientific Issues
VOSviewer

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Introduction

All students should be able to access science education in schools and institutions, regardless of gender, and it should be humanistic, multicultural, and value-driven [1], [2]. Put another way, scientific education needs to be integrated into community life and take place in a variety of contexts where students and community members can participate in activities that will improve their own lives [3]. One possible learning option for advancing scientific literacy is to apply knowledge that incorporates elements of both society and science. A key component of achieving this is using creative classroom teaching practices that address the content, process, and context elements of scientific literacy. Through the introduction of evidence-based frameworks that support the explicit integration of socio-scientific issues (SSI) to highlight the significance of scientific literacy, research has shown new trends in science education [4], [5].

Although SSI is a scientific problem, it affects society and causes debate and moral quandaries. By incorporating attitudes and ethics into the evaluation of scientific data, SSI enables students to interpret science realistically. This is done in compliance with European science curricula, societal needs, and popular science learning trends [6], [7], [8]. Though SSI is a contentious topic, not all contentious topics fall under this category. To help students use information in relevant and personal situations, the SSI framework makes use of formal debate, informal discussion, and argumentative reasoning [9], [10]. Because of this, a growing number of educators are incorporating socio-scientific issues (SSI) into science curricula in an effort to foster the growth of scientific thinking skills and social awareness [7], [11]. The SSI that manifests is typically associated with societal issues like genetically modified food and environmental degradation. Though still in small amounts, SSI content has begun to be integrated in Indonesia, from classroom use to the creation of resources to support its implementation.

According to related research, science courses and instruction do not inspire students to "do science" or "study science." [12], [13]. Most students believe that science and science education are "irrelevant" to society and themselves. Therefore, to pique students' interest in science courses, educators need to make learning "more relevant" [14]. The science education model has been highlighted in light of the aforementioned issues to ensure its relevance. Furthermore, SSI can be used to enhance the relevance of science education, according to preliminary research on model relevance.

SSI addresses contentious issues (open, complex, unstructured problems) that are difficult to solve using basic algorithms or by recollecting previously learned material [15]. As a result, involving students in SSI and science practices fosters scientific literacy while also helping them to relate 21st-century skills and science to societal challenges. As a result, SSI-based learning requires students to develop their critical thinking abilities through informed or informal reasoning, going beyond conceptual comprehension.

The multifaceted and multidisciplinary approach of SSI-based learning encompasses several areas, including biology, chemistry, physics, earth science, environmental science, and so forth [16], [17]. As a result, this study sees science as SSI's primary focus. All things considered, the goal of SSI and its relevance-focused science instruction is to boost students' enthusiasm for science, as well as their drive to learn and attitudes towards it [18]. From the teacher's perspective, impressions and attitudes toward SSI-based teaching are gathered through SSI-based learning questionnaires, interviews, and course assignments. Teachers perceive themselves as having sufficient knowledge of SSI pedagogy, as evidenced by quantitative results and qualitative analysis, and they have a strong awareness of numerous essential features of SSI-based teaching. Instructors also showed favorable attitudes toward teaching, as indicated by the SSI. Teachers are still aware of the difficulties in applying SSI teaching for learning in Indonesia, nevertheless [19].

A systematic review of research articles focused on SSI is needed to evaluate their relevance to the science education model. This research aims to thematically synthesize research articles on SSI from 2019 to 2024 in the Scopus database and to evaluate author distribution, inter-country networks, citations, affiliation distribution, sources, conceptual structure, intellectual structure, and social structure. Based on this aim, the following research questions guided the current study: 1) What is the profile of SSI publication output in 2019-2024?; 2) To what extent are SSI publications distributed among countries and institutions in the world?3) Who are the main authors in SSI research in the world?4) How is the collaboration between the network of authors conducting SSI research in 2019-2024? 5) How to visualize the results of SSI research trends for 2019-2024?

Material and Methods

This study employed a bibliometric review design to systematically map the research landscape of socioscientific issues (SSI) in science learning. Bibliometric analysis was selected because it enables quantitative exploration of publication trends, collaboration networks, citation structures, and thematic developments within a scientific field.

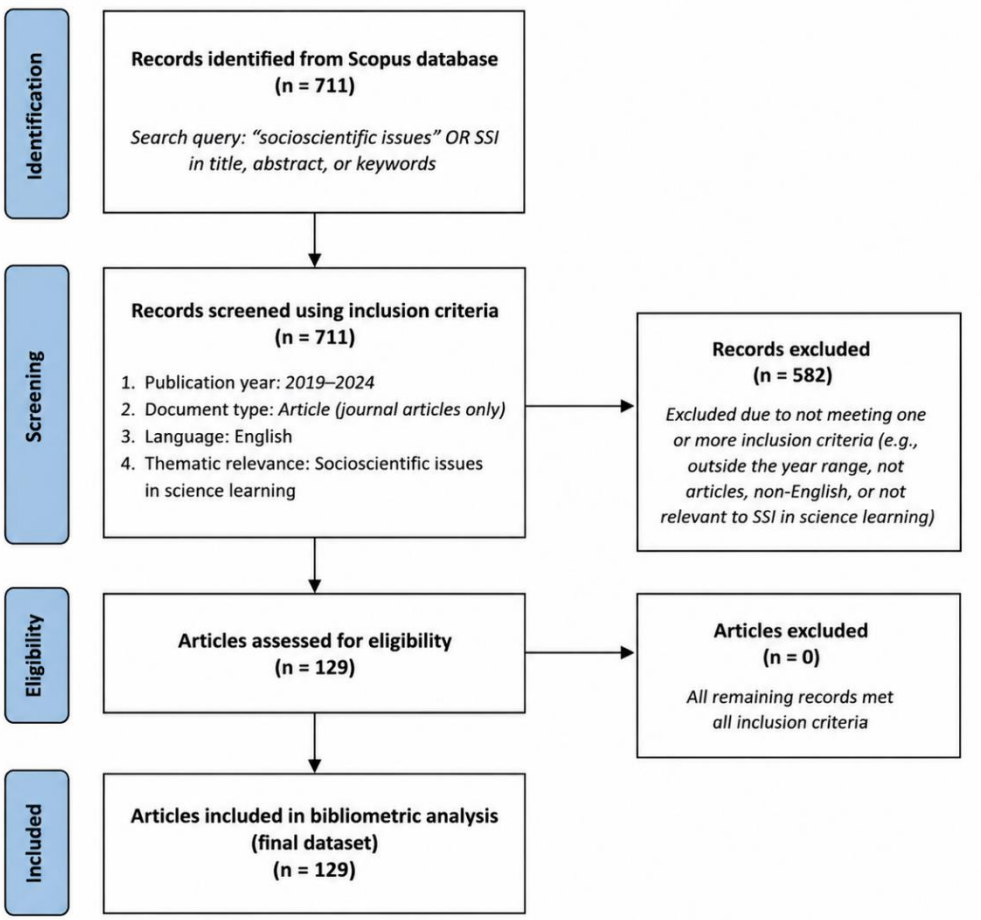

Fig. 1. PRISMA Flow Diagram of Article Selection

A. Data Source and Search Strategy

The bibliographic data were retrieved from the Scopus database because Scopus indexes high-quality international journals and is widely recognized for bibliometric studies in education research. Data retrieval was conducted on March 10, 2026, using the Publish or Perish (PoP) software connected to the Scopus database. The search process used the following search string:

TITLE-ABS-KEY ("socio-scientific issue*" OR "socioscientific issue*")
AND PUBYEAR > 2018
AND PUBYEAR < 2025
AND (LIMIT-TO (DOCTYPE, "ar"))
AND (LIMIT-TO (LANGUAGE, "English"))

The search was limited to publications from 2019 to 2024 to capture recent developments in SSI research following the growing global emphasis on scientific literacy and socioscientific learning approaches.

B. Inclusion and Exclusion Criteria

The inclusion criteria applied in this study were: (1) Articles indexed in the Scopus database; (2) Publications published between 2019 and 2024; (3) Journal articles classified as "article" document type; (4) Articles written in English; and (5) Articles focusing on socioscientific issues in science education or science learning contexts. Meanwhile, the exclusion criteria were: (1) Conference papers, book chapters, reviews, editorials, notes, and errata; (2) Duplicate records retrieved during the export process; (3) Articles unrelated to science learning or science education; and (4) Incomplete bibliographic records.

C. Screening and Deduplication Process

The initial search identified 711 records. The records were subsequently filtered according to the predefined inclusion criteria, including publication year (2019–2024), document type (journal article), language (English), and thematic relevance to socioscientific issues in science learning. After applying these criteria and checking the bibliographic records, 129 articles met all eligibility requirements and were retained as the final dataset for bibliometric analysis. The bibliographic data were then exported in RIS and CSV formats for analysis using VOSviewer and Biblioshiny.

To improve methodological transparency an d reproducibility, this study adopted a PRISMA-inspired flow procedure in selecting bibliometric data. The selection process consisted of four stages: identification, screening, eligibility assessment, and final inclusion. Each stage was conducted systematically using predefined inclusion and exclusion criteria, including publication-year limits, document type, language, thematic relevance, and bibliographic completeness. This procedure ensured that only relevant and high-quality publications were included in the final dataset for bibliometric analysis. The complete article selection process is illustrated in Fig 1.

D. Data analysis

The final dataset of 129 articles was analyzed using VOSviewer version 1.6.19 and Biblioshiny (Bibliometrix package in R). VOSviewer was used to visualize co-authorship and keyword co-occurrence networks using the full-counting method, while Biblioshiny was used to generate descriptive bibliometric indicators, including annual publication trends, country distribution, source analysis, citation analysis, and thematic mapping. For the co-authorship analysis, a maximum of 25 authors per document and a minimum of two documents per author were applied. Keyword co-occurrence analysis was conducted using the keywords available in the bibliographic records. No additional thesaurus-based merging or manual modification of keyword labels was performed.

The analysis focused on three major bibliometric structures, namely:

1. Conceptual structure (keyword co-occurrence and thematic trends),
2. Intellectual structure (citation analysis),
3. Social structure (author and country collaboration networks).

The results of these analyses were interpreted descriptively to identify research trends, collaboration patterns, and potential future directions in SSI research.

Results and Discussions

A. Overview of Publication Trends and Dataset Characteristics

The bibliometric dataset analyzed in this study comprised 129 journal articles indexed in Scopus and published between 2019 and 2024. The descriptive information presented in Table 1 indicates that SSI research in science learning has experienced a positive publication trend, with an annual growth rate of 9.63%. This finding demonstrates increasing scholarly attention toward the integration of socioscientific issues (SSI) into science education research during the last five years.

Table 1. Data Information

Description	Results
Main Information About Data	
Timespan	2019:2024
Sources (Journals, Books, etc)	69
Documents	129
Annual Growth Rate %	9.63
Document Average Age	2.28
Average citations per doc	7.38
References	6880
Document Contents	
Keywords Plus (ID)	279
Author's Keywords (DE)	384
AUTHORS	
Authors	330
Authors of single-authored docs	10
Authors Collaboration	
Single-authored docs	10
Co-Authors per Doc	3.15
International co-authorships %	28.68
Document Types	
article	129

The increasing trend in publications reflects growing global concern about the need for science education to address real-world social problems, ethical dilemmas, environmental sustainability, and scientific literacy. Science education in recent years has gradually shifted from content-oriented teaching to contextualized and socially responsive learning approaches. Therefore, SSI has become an important pedagogical framework because it enables students to connect scientific concepts with social, environmental, ethical, and cultural dimensions. The dataset also shows that the average number of citations per document is 7.38, indicating that

SSI studies have received considerable academic attention and influence in science education research. The relatively high number of references (6,880) indicates that SSI research is theoretically rich and multidisciplinary, drawing on perspectives from science education, environmental education, ethics, STEM education, and literacy studies.

From a collaboration perspective, the average co-authorship rate of 3.15 authors per document and the international collaboration rate of 28.68% indicate that SSI research tends to involve collaborative academic networks. This pattern reflects the interdisciplinary nature of SSI studies, which requires expertise from various fields, including pedagogy, sociology, ethics, and environmental science. Nevertheless, the percentage of international collaboration remains moderate, indicating that cross-border research partnerships in SSI studies still have considerable room for growth. The dominance of author keywords (DE = 384) compared to Keywords Plus (ID = 279) indicates that researchers are actively defining and developing conceptual directions in the SSI field. This finding suggests that the research field continues to develop conceptually, particularly regarding scientific reasoning, moral decision-making, sustainability, and contextual science learning.

B. Leading Authors, Sources, and Country Contributions

An analysis of leading authors reveals that Sadler T.D. was the most prolific contributor to SSI research during the period 2019–2024. This finding is not surprising, as Sadler is widely recognized as a fundamental scholar in research on socioscientific issues, particularly scientific literacy, argumentation, and ethical reasoning in science education. The presence of several influential scholars demonstrates that the intellectual development of SSI research remains connected to established theoretical frameworks and pedagogical traditions.

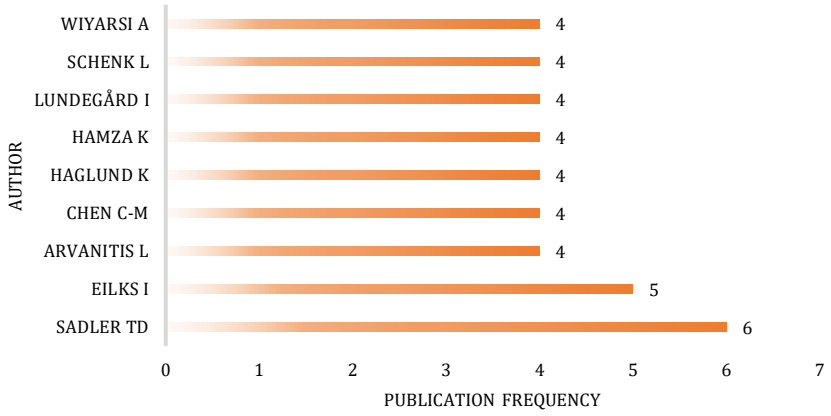

Fig. 2. Top 10 Authors on the SSI Theme

The journal distribution analysis shows that the International Journal of Science Education published the most SSI-related articles, followed by Research in Science Education and the Journal of Research in Science Teaching. These journals are internationally recognized as leading outlets in science education research, indicating that SSI has become an important and

legitimate topic within mainstream science education discourse. The concentration of publications in high-impact journals also demonstrates that SSI research is no longer a peripheral topic but has become increasingly central to contemporary discussions in science education.

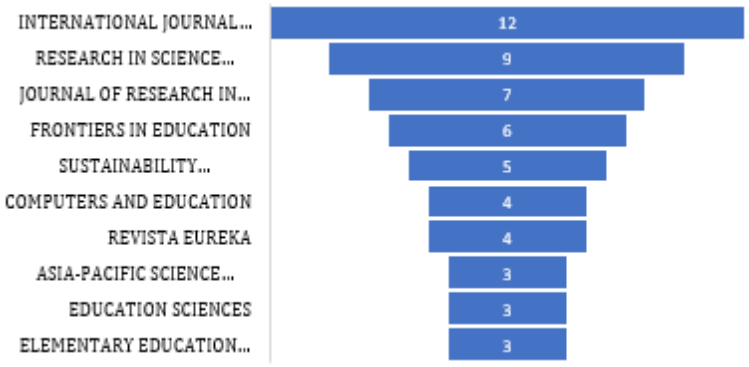

Fig. 3. Distribution of Sources and Number of Articles on The SSI Theme

From the country contribution analysis, the United States emerged as the most productive country, followed by Spain, Indonesia, China, and Turkey. The dominance of the United States and European countries may be associated with their long-standing emphasis on scientific literacy, inquiry-based learning, and citizenship education. In these educational systems, SSI is frequently integrated into science curricula to foster critical thinking, ethical awareness, and evidence-based decision-making.

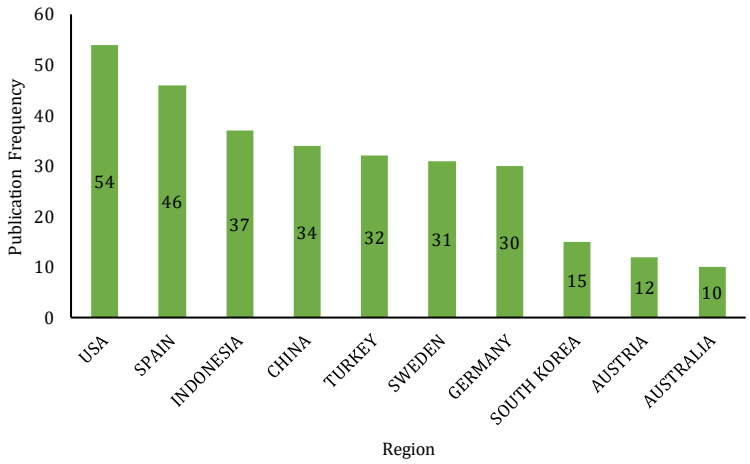

Fig. 4. Number of SSI Publications in the Top 10 Countries

Indonesia ranks among the top contributors, indicating a growing national interest in contextual and socially relevant science learning approaches. This finding may reflect increasing awareness among Indonesian researchers regarding the importance of integrating local environmental and societal issues into science education. However, despite the increasing number of publications, international collaboration networks involving developing countries

remain relatively limited. This suggests that future SSI studies could benefit from stronger cross-national collaborations to enhance research diversity and global perspectives.

C. Intellectual Structure of SSI Research

The intellectual structure of SSI research was analyzed through citation patterns and co-authorship networks generated using VOSviewer. Citation analysis revealed that influential scholars within the field primarily focus on scientific literacy, argumentation, ethical reasoning, decision-making, and contextual science education. These themes form the conceptual backbone of contemporary SSI research and continue to influence the direction of science education studies worldwide.

The co-authorship visualization demonstrates that collaboration among researchers tends to occur within relatively small academic clusters. Several prominent authors occupy central positions in the collaboration network, indicating their important role in shaping and disseminating SSI-related research. Highly connected authors generally contribute not only through publications but also by establishing research communities and collaborative networks across institutions and countries.

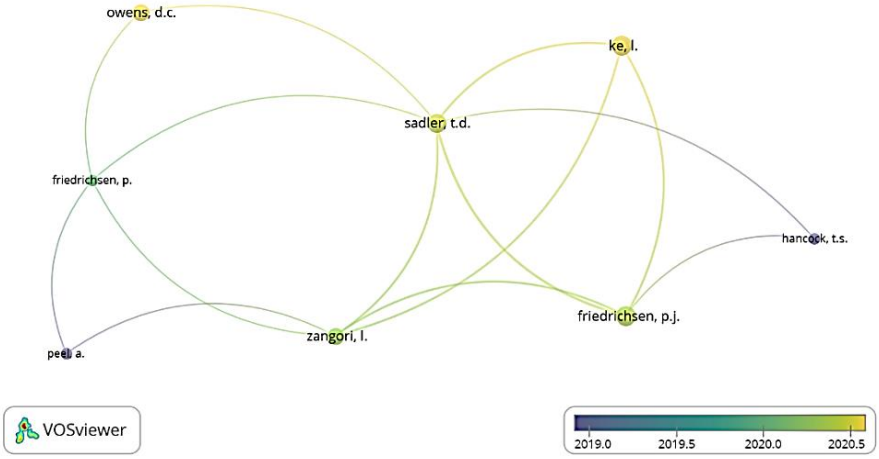

Fig. 5. Co-Authorship Network Visualization of SSI Research

Despite several strong clusters of collaboration, the overall co-authorship structure remains somewhat fragmented. This fragmentation suggests that SSI research is still distributed across multiple thematic and regional communities rather than forming a highly integrated global network. Such a pattern is common in emerging interdisciplinary fields where conceptual approaches and research priorities may differ across countries and educational systems.

The intellectual structure also indicates that SSI research is increasingly influenced by sustainability education, environmental literacy, and socio-ethical dimensions of science learning. This development reflects a broader transformation in science education research,

where scientific knowledge is no longer viewed solely from a cognitive perspective but also in relation to ethical responsibility, citizenship, and societal participation.

The growing integration of interdisciplinary perspectives suggests that SSI research has evolved beyond traditional science-teaching approaches. Researchers are now positioning SSI as a framework for addressing complex societal challenges, including climate change, environmental degradation, biotechnology ethics, and sustainable development. Consequently, SSI research contributes significantly to the transformation of science education toward more socially responsive and humanistic learning paradigms.

D. Conceptual Structure and Thematic Evolution

The conceptual structure of SSI research was examined through co-word analysis and keyword co-occurrence mapping using VOSviewer. The visualization revealed several interconnected thematic clusters representing the dominant research directions within the SSI field. Frequently occurring keywords such as "knowledge," "strategy," "problem," "reasoning," and "scientific literacy" occupied central positions in the network, indicating that these themes have become the core focus of SSI-related studies.

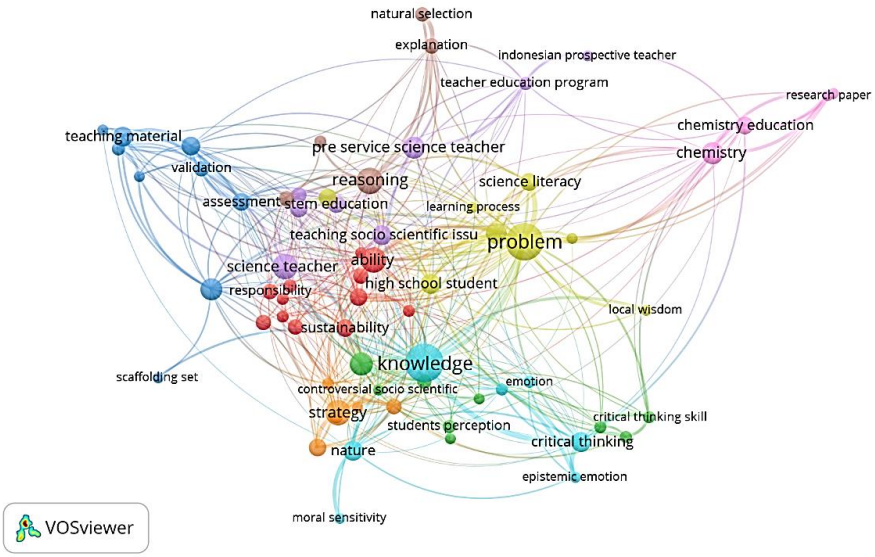

Fig. 6. Co-word Visualization in SSI Research

The strong associations between these keywords indicate that SSI research predominantly emphasizes the cognitive and pedagogical dimensions of science learning. Many studies use SSI as an instructional approach to develop scientific reasoning, argumentation skills, critical thinking, and problem-solving abilities. These themes constitute mature and established research domains in the science education literature. Some emerging themes, such as "moral sensitivity," "scaffolding set," and "local wisdom," are located in less-dense, more peripheral areas of the visualization map. Bibliometric interpretations indicate that peripheral and low-density themes generally reflect underexplored or emerging research topics that have not yet

received substantial scholarly attention. These themes present promising opportunities for future theoretical and empirical development. The thematic evolution identified in this study also reflects important conceptual shifts in SSI research. While previous SSI studies primarily focused on reasoning and decision-making processes, recent studies increasingly incorporate ethical awareness, sociocultural perspectives, and contextual learning approaches [20]. This shift indicates that researchers are beginning to recognize that science learning must not only develop cognitive competencies but also foster moral responsibility and cultural relevance.

The emergence of local wisdom as a research theme is particularly relevant to non-Western educational contexts. Integrating local wisdom into SSI learning can help students connect scientific knowledge with local cultural values, community practices, and environmental issues. Such an approach can strengthen culturally responsive science education and increase the relevance of science learning to students' everyday experiences [21]. The conceptual evolution of SSI research suggests that the field is moving toward a more holistic and socially grounded approach to education that integrates the cognitive, ethical, cultural, and environmental dimensions of science learning. In the present bibliometric mapping, themes located in highly dense and strongly connected regions were interpreted as relatively well-established and frequently represented topics, whereas themes appearing in sparse or peripheral regions were interpreted as less frequently represented and potentially underexplored. Interpretations of research saturation and potential novelty in this study were based on keyword co-occurrence density and thematic distribution, as generated by the VOSviewer visualization in Fig 7.

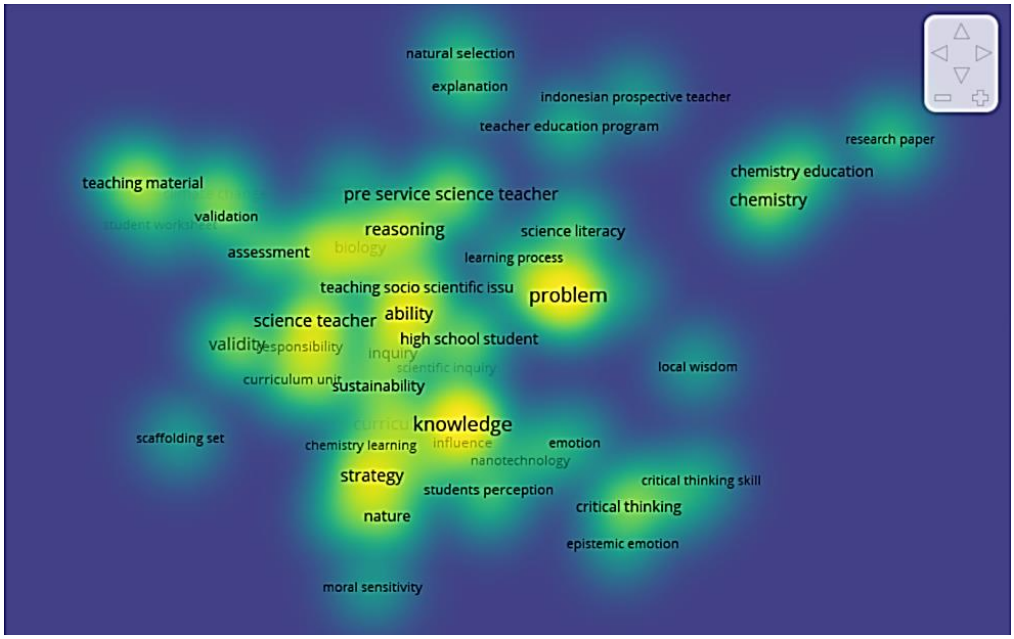

Fig. 7. Density Visualization of SSI Research Themes

E. Emerging Topics and Future Research Directions

The density visualization revealed unequal levels of research attention across SSI-related themes. As shown in Fig. 7, keywords such as "knowledge," "strategy," "problem," and "reasoning" appeared in highly dense and strongly connected regions, indicating that these topics are frequently represented and relatively well established in the analyzed SSI literature. However, their high density should not be interpreted as evidence of research saturation. Rather, it indicates that these themes have received substantial scholarly attention and are strongly connected with other topics in the SSI research network. Future studies may therefore extend these established themes by examining them in new contexts, methodological approaches, or interdisciplinary perspectives.

Themes such as "moral sensitivity," "scaffolding set," and "local wisdom" appeared in less-dense and more peripheral areas of the visualization, indicating that these topics are less frequently represented in the analyzed literature. Their relatively limited presence suggests that they may constitute potentially underexplored directions within SSI research. However, their peripheral position should not be interpreted as direct evidence of novelty; rather, it highlights opportunities for further investigation and theoretical development. The emergence of moral sensitivity reflects a growing interest in the ethical and affective dimensions of science education. Recent educational discourse increasingly emphasizes that science learning should not only develop conceptual understanding but also foster empathy, ethical awareness, and responsible citizenship. Therefore, integrating moral sensitivity into SSI learning may contribute to more humanistic and socially responsive science education practices.

The appearance of local wisdom as an emerging theme indicates increasing scholarly attention toward culturally contextualized science learning. The integration of local knowledge systems into SSI instruction may enhance students' engagement, cultural identity, and environmental awareness. This approach is particularly relevant in developing countries where science education often needs to balance global scientific perspectives with local socio-cultural realities. The findings also suggest that future SSI research should increasingly focus on interdisciplinary and context-sensitive approaches rather than relying solely on traditional cognitive frameworks. Future studies may explore integrating SSI with sustainability education, indigenous knowledge, environmental ethics, digital learning environments, and socio-emotional learning frameworks.

Conclusion

This bibliometric review demonstrates that research on socioscientific issues (SSI) in science learning has grown significantly during the 2019–2024 period, indicating increasing global attention to contextual, ethical, and socially responsive science education. The findings reveal that SSI research has evolved into a multidisciplinary field closely associated with

scientific literacy, reasoning, problem-solving, and inquiry-based learning. The dominance of publications from leading science education journals and productive countries such as the United States, Spain, and Indonesia further confirms the growing international relevance of SSI within contemporary science education discourse. The bibliometric mapping also reveals differences in the relative prominence of research themes. Themes related to "knowledge," "strategy," "problem," and "reasoning" appear to be frequently represented and relatively well-established research areas, as indicated by their high co-occurrence density and strong conceptual connections. In contrast, themes such as "moral sensitivity," "scaffolding set," and "local wisdom" are less frequently represented and located in more peripheral areas of the bibliometric network, suggesting that they may constitute potentially underexplored directions for future SSI research. These findings suggest that future SSI studies are increasingly moving beyond cognitive-oriented perspectives toward ethical, cultural, and socio-emotional dimensions of science learning.

This study contributes theoretically by providing a comprehensive intellectual and conceptual mapping of SSI research trends in science education. The findings may serve as a reference for researchers, curriculum developers, and educators to identify emerging research directions and design more contextualized, culturally responsive, and ethically grounded science learning approaches. In particular, integrating local wisdom and moral sensitivity into SSI-based learning may strengthen the relevance of science education in addressing real-world societal and environmental challenges. This study was limited to Scopus-indexed English-language journal articles and primarily relied on co-occurrence and co-authorship analyses. Future bibliometric studies are recommended to incorporate additional analytical approaches, such as thematic evolution analysis, citation burst detection, overlay visualization, and multi-database comparisons, to gain deeper insights into the dynamic evolution of SSI research.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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