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Health issues within the socioscientific context: Systematic literature review

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ABSTRACT
Health issues present significant and complex challenges to society. This study aimed to investigate research trends related to health issues as socioscientific issues (SSI). The SSI articles analysed were from three prominent data sources: Scopus, Google Scholar, and Pubmed. Articles were retrieved via Harzing's Publish or Perish application based on published between 2018 to 2023 and the keyword "Socioscientific Issue". There were 415 articles obtained and screened using the Prisma technique, leaving 81 eligible articles. The articles underwent qualitative content analysis and quantitative bibliometric analysis using the VOSviewer software to determine research topics, research objectives, and the learning model implemented. According to the research findings, qualitative analysis showed the dominant topics were genetic modification (28.3%), COVID-19 (17.2%), and food additives (6.7%). The primary objectives were to develop argumentation skills (16.2%), conceptual understanding (13.7%), and decision-making (11.1%). The frequently implemented learning models were problem-based (28.4%), case-based (24.7%), and inquiry-based learning (16.0%). The quantitative bibliometric analysis revealed the most SSI topics were COVID-19, antibiotic resistance, and obesity. The main objectives were to develop argumentation skills, regulate emotions, and decision-making. The frequently implemented learning models were problem-based, case-based and practice-based learning. Furthermore, exploratory studies on SSI learning within the health context for improving willingness to act, communication and motivation.

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Introduction

Health issues present significant and complex challenges to society. The emergence of various diseases poses potential threats to quality of life, despite rapid advancements in knowledge and treatment technologies, coupled with improvements in healthcare services. Health matters stand as a quintessential contemporary challenge of the 21st century, demanding health literacy for individuals to respond intelligently and responsibly (Subiantoro et al., 2021). Therefore, exploring a range of issues relevant to health and their broader societal impacts can hold great learning value (Lund et al., 2019).

Learning in the primary classroom should engage pupils in science through meaningful and relevant experiences. Pupils will be interested in science by equipping them with skills applicable both in their academic journey and real-world scenarios (Mildenhall et al., 2019). To accomplish this, it is essential to bridge the gap between scientific concepts and their practical application in society (Quigley et al., 2020). One valuable approach to achieve this integration is through socioscientific issues instruction (Ewing & Sadler, 2020) in several topics, including health topics.

Socioscientific Issues (SSI) form the basis of an interdisciplinary learning approach which can increase the relevance of knowledge mastery and its societal utility, aligning with the contemporary objectives of science education (Chen & Xiao, 2021; Ewing & Sadler, 2020). The term "SSI" encompasses a range of social issues characterised by their intricate connections to scientific concepts, procedures and technologies (Zeidler et al., 2002). SSI issues are contemporary and typically encompass a scientific element while also drawing from various scientific disciplines. Moreover, they often entail moral and ethical assessments, further enhancing their multifaceted nature (Sadler & Zeidler, 2005; Zeidler et al., 2002). The SSI topic in learning is a special phenomenon attached to social issues that can liven up the learning atmosphere. This particular phenomenon that has been selected will be followed by interdisciplinary specific ideas (Ewing & Sadler, 2020).

The SSI approach has proven effective in accomplishing multiple learning objectives. It enhances students' informal reasoning by fostering skills in argumentation, connecting these arguments to natural scientific concepts, deciphering data patterns, and evaluating information to devise complex problem-solving solutions (Sadler & Zeidler, 2005). Moreover, SSI cultivates the capacity to engage in discussions, interpret events, and draw conclusions (Dawson & Venville, 2010), thereby playing a pivotal role in elevating students' scientific literacy (Sadler & Zeidler, 2005). Beyond this, SSI learning nurtures a sense of social responsibility (Driver et al., 2000) as students grapple with real-world issues in their surroundings, encouraging them to develop a critical perspective on how to navigate and thrive in society (Yun et al., 2020).

Utilising the appropriate learning model can improve learning outcomes. Socioscientific issues provide a meaningful context for students' real-life experiences. The integration between learning models and SSI holds the potential for mutually reinforcing science education goals (Ke et al., 2021), equipping students with competencies to navigate their future effectively (Zeidler & Nichols, 2009) and make informed decisions based on scientific principles and technology (Bossér & Lindahl, 2019). However, systematic research on the SSI learning models remains relatively limited (Zangori & Forbes, 2014).

A literature review of SSI is useful as a practical reference source for SSI learning trends. Numerous literature reviews have been conducted and published on various research trends within SSI learning. These encompass areas such as addressing sustainable development goals (Hernández-Ramos et al., 2021), mastering pedagogical knowledge (Chen & Xiao, 2021), exploring the potential of SSI learning to boost scientific literacy and science communication (Li & Guo, 2021), developing the SSI approach in physics education (Deta et al., 2021), and preparing students for the 21st century in biology education (Nurtamara et al., 2020). However, there is a noticeable scarcity of studies reviewing SSI learning research within the health context. Hence, this research was undertaken to address the following inquiries:

a) What are the trends in SSI learning research within the health context from 2018 to 2023 based on qualitative content analysis?

b) What are the trends in SSI learning research within the health context from 2018 to 2023 based on quantitative bibliometric analysis?

Methods

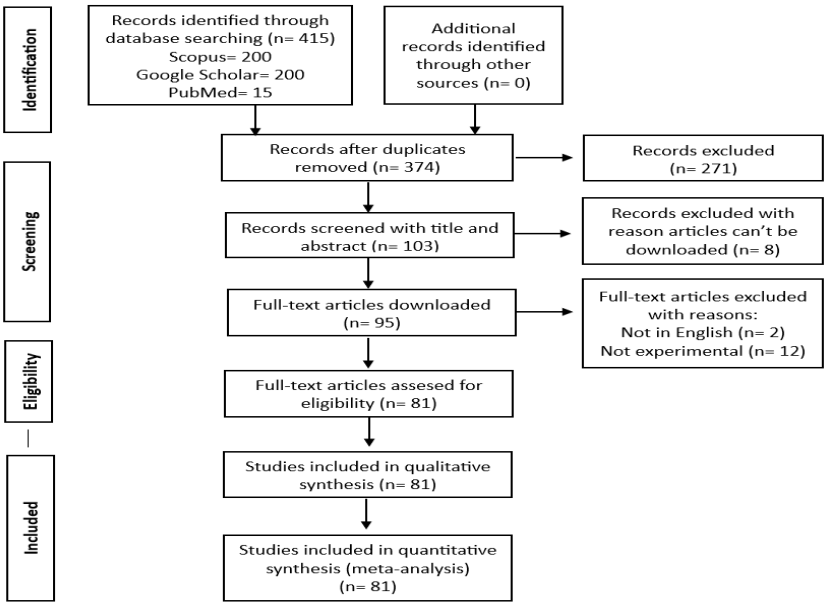
Article Selection

The methodology employed in this literature review follows a series of well-defined steps, drawing inspiration from previous similar studies. The initial step involved the collection of primary data, specifically a selection of articles, through the utilisation of Harzing's Publish or Perish (PoP) publication rating application on August 23, 2024. The chosen keyword for this search was "Socioscientific Issue," and the articles were restricted to those published within the last five years, spanning from 2018 to 2023. This time frame was chosen to ensure the inclusion of the most recent publications, thereby ensuring the relevance of the Socioscientific Issue topics discussed. Three data sources were selected for this search: Scopus, Google Scholar, and PubMed. These choices were made based on accessibility. The fact that Google Scholar offers free access, and Scopus and PubMed only require an API (Application Programming Interface) key. Additionally, the selection of PubMed was aligned with the specific focus of this literature review, which centres on human health.

The obtained articles were then subjected to a filtration process using the prism technique, allowing for the identification of articles eligible for further analysis. Data collection via Harzing's Publish or Perish resulted in a total of 415 articles, distributed as 200 from Scopus, 200 from Google Scholar, and 15 from PubMed. Scopus and Google Scholar were constrained to a maximum of 200 articles each based on the highest citation criteria. These articles were stored in Research Information System files and combined using the Mendeley reference manager (Jumini et al., 2022). The reference manager automatically eliminated duplicate articles. A secondary filtration process involved analyzing titles and abstracts for qualitative content, focusing on human health-related articles. These selected articles were downloaded, and subjected to inclusion criteria such as being in English and of experimental research. The article selection process is depicted in Figure 1.

Figure 1

Flow chart of the article selection using the prisma technique



Dual analysis strategy was employed to ensure a comprehensive understanding of SSI topics, learning objectives and learning models. It is recognising that a holistic approach combining both qualitative and quantitative methodologies yields more insightful results compared to either approach in isolation (Creswell, 2012).

Qualitative Analysis

Qualitative content analysis was conducted to determine research trends encompassing the examination of SSI topics employed, research objectives pursued, and learning models applied to the research in each article. The data was tabulated in the form of percentages and described descriptively. The list of reviewed articles sorted by year of publication can be seen in Appendix 1. It pays particular attention to the topics, research objectives, and SSI learning models implemented.

Quantitative Analysis

The quantitative analysis was conducted with the assistance of VOSviewer version 1.6.20 software to discern research trends in SSI learning within the context of health. Analysis was conducted to determine research trends on the contribution of the author and co-author, SSI topics employed, research objectives pursued, and learning models applied to the research. The bibliometric metadata analysis findings were visualised in a map format using the VOSviewer application (van Eck & Waltman, 2009).

Findings and Discussion

A focused subset of 81 SSI learning articles within the health context was obtained through the prism technique from 415 articles on Socioscientific Issues (SSI) learning. To elucidate research trends within this subset, a combined approach encompassing both qualitative and quantitative analyses was employed.

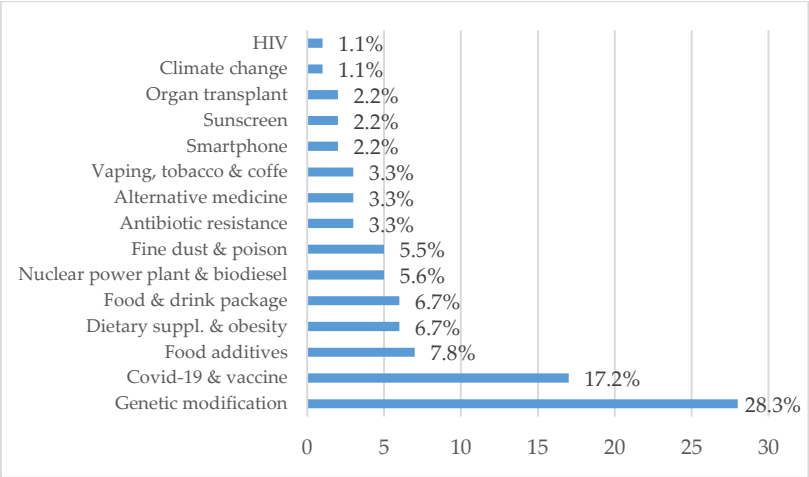
Trends in Research Based on Qualitative Content Analysis

Topics of Socioscientific Issues Learning in the Health Context

The distribution of topics used in SSI learning is shown in Figure 2. The SSI topics most frequently occur are genetic modification, COVID-19 and vaccines. Genetically modified organisms (GMOs) can be applied to plants, animals, and humans (Cebesoy & Rundgren, 2023, Christenson & Walan, 2023).

Figure 2

Topics of socioscientific issues learning in the health context



Genetically Modified Foods (GMF) are produced from GMO. In the last decade, the GMF has often caused controversy because plants are genetically engineered to possess enhanced traits and resistance to pests. The production of GMF involves the use of transgenic drugs and vaccines, which can lead to high costs and ongoing debates regarding the health safety of consuming GMF products (Ceyhan et al., 2021). GMF has been successfully used in SSI learning (Genc & Acar, 2021; Herman et al., 2021; Leung & Cheng, 2020; Muis et al., 2021; Özturk et al., 2021; Wen & Wei, 2018).

COVID-19 and vaccines emerged and started spreading in early 2020 as a global health crisis. The third most frequently explored Socioscientific Issues (SSI) topic is food additives (Capkinoglu et al., 2022; Choi & Lee, 2021; Friedrichsen et al., 2021; Martini et al., 2021; Wiyarsi et al., 2021). Although the utilisation of food additives as an SSI learning topic remains relatively limited, there is a growing recognition of its potential benefits. Many educators traditionally prioritize content delivery as the primary educational objective, but SSI learning has proven to be a valuable approach for enhancing students' broader skill set. By incorporating SSI topics such as food additives, educators can effectively cultivate students' communication abilities, problem-solving skills, critical thinking, scientific inquiry aptitude, social and environmental awareness, literacy, higher-order thinking capabilities, creativity, and collaborative competencies (Nida et al., 2021).

The least frequently addressed topics are climate change, biodiesel, and HIV. Climate change and biodiesel are subjects extensively studied due to their significant environmental implications. Climate change is one of the most pressing problem for today's global community (Prasad, 2022). Meanwhile, HIV, while a complex and vital topic with far-reaching consequences for both health and a nation's resilience if not properly managed, remains relatively underrepresented in the literature. It appears that discussions surrounding HIV are predominantly confined to medical advancements and health ethics within the context of SSI learning. It is warranting further exploration (Fan et al., 2020).

The Objectives of Socioscientific Issues Learning in the Health Context

Various objectives of SSI learning are presented in Table 1. The primary objective is to enhance argumentation skills (Atabey, 2021; Bächtold et al., 2023; Baytelman et al., 2020; Capkinoglu et al., 2022; Fan et al., 2020; Georgiou et al., 2020; Johnson et al., 2020; Lee & Tran, 2023; Rietz et al., 2021; Torres & Cristancho, 2018). This result is the same as that found by Falah et al. (2024). Argumentation is a central tenet of critical thinking (Ennis 1985). Concerning SSI, students need argumentation to justify their decisions and evaluate the decisions. An argument should be supported by scientific evidence (Kacar & Balim, 2021).

Table 1

The objectives of socioscientific issues learning in the health context

Objectives of Socioscientific Issues Learning	n	%
Argumentation	19	16.2
Conceptual understanding	16	13.7
Decision making	13	11.1
Critical thinking	10	8.5
Reasoning	8	6.8
Perception	8	6.8
Epistemological cognition and HoM	8	6.8
Moral, emotions, empathy, and ethical	8	6.8
Attitude and disposition	7	6.0
Literacy	6	5.1
Responsibility, awareness, and willingness to act	6	5.1
Creativity and communication	3	2.6
Engagement and motivation	3	2.6

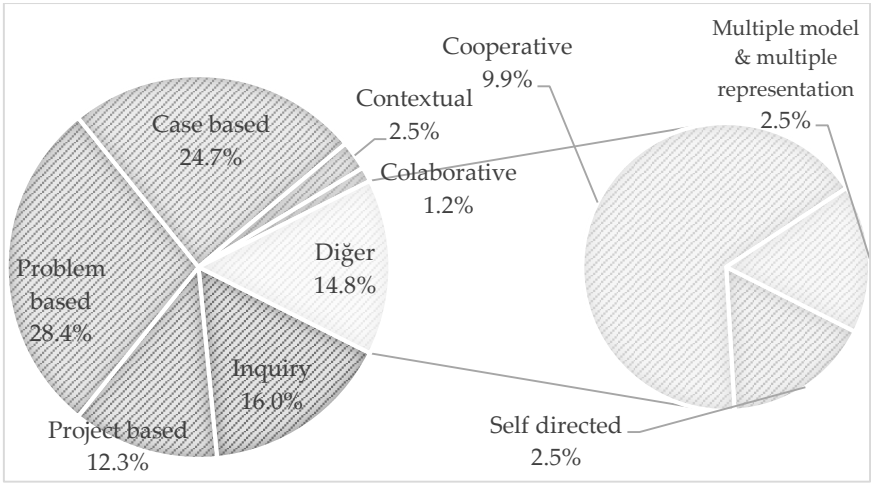
The second most prevalent objective in Socio-scientific Issues (SSI) learning is enhancing student conceptual understanding. Providing adequate and clear knowledge will help students understand concepts (Golestaneh & Mousavi, 2024). Several studies have succeeded in improving conceptual understanding using SSI learning (Altan et al., 2018; Annisa & Subiantoro, 2022; Christodoulou et al., 2021; Karakaya & İrez, 2022; Kärkkäinen et al., 2019; Ke et al., 2021; Lin et al., 2020; Lund et al., 2019; Subiantoro et al., 2021). Research objectives to improve literacy are few, this is also the same as the results of a study on scientific literacy assessment (Istyadji & Sauqina, 2023). However, an aspect of SSI learning that remains relatively underexplored is the cultivation of student creativity. There has been limited research in this area, with only one study dedicated to fostering students' public awareness of air pollution (Kim, et al., 2020).

The Models of Socioscientific Issues Learning in the Health Context

The learning model implemented into SSI learning is shown in Figure 3. The most commonly utilized SSI learning model is Problem-Based Learning (PBL). PBL provides opportunities for teachers facilitating students to solve a problem through group work (Muhfahroyin et al., 2023). Several researchers have successfully implemented PBL using health issues (Cian et al, 2020; Genc & Acar, 2021; Gul & Akcay, 2020; Leung, 2020; Martini et al., 2021; Minken et al., 2021; Özturk et al., 2021; Purwati et al., 2019; Seiter & Fuselier, 2021; Sibic & Topcu, 2020; Subiantoro et al., 2021; Sparks et al., 2022; Tyrrell & Calinger, 2020; Wiyarsi et al., 2021). This finding aligns with the conclusions drawn from a literature review study by Hernández-Ramos et al. (2021).

Figure 3

The learning models of socioscientific issues in the health context



Case-based learning (CBL) is the second most frequently implemented SSI learning model within the health context. CBL in science education has developed rapidly (Dewi & Rahayu, 2023). PBL and CBL learning models in the health context cannot be compared to which is better. PBL uses open inquiry, while CBL uses guided inquiry. Both have strengths and weaknesses, although CBL allows for a wider range of problem-solving skills (Srinivasan et al., 2007). Several researchers have successfully implemented CBL using health issues (Adal et al., 2022; Aydin et al., 2019; Baytelman et al., 2020; Büssing et al., 2020; Dalaila et al., 2022; de Freitas et al., 2023; Herman et al., 2022; Kammerer et al., 2021; Lee et al., 2020; Namdar et al., 2020; Nida et al., 2021; Yerdelen et al., 2018).

Trends in Research Based on Bibliometric Quantitative Analysis

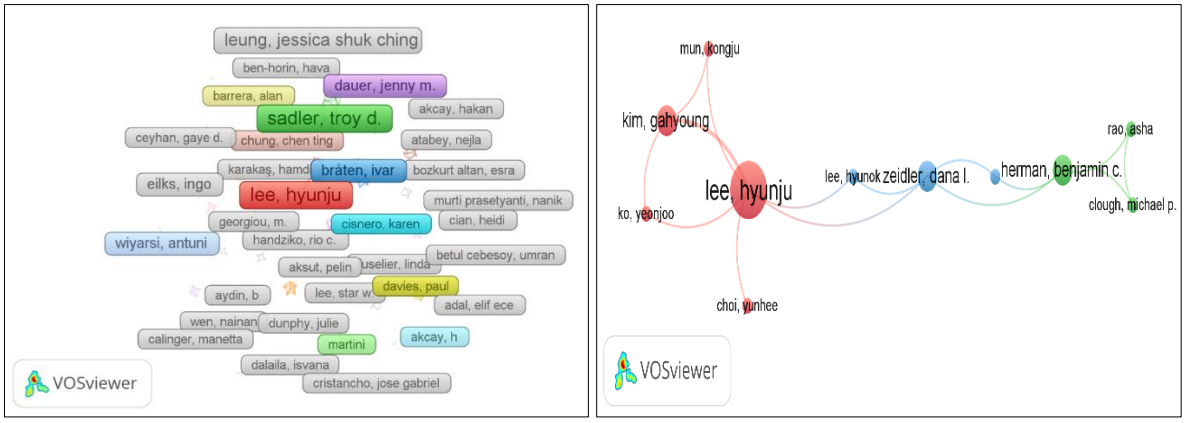
The analysis of research trends encompasses the examination of the contribution of authors, SSI topics employed, learning objectives pursued, and learning models implemented. Notably, a total of 213 authors have contributed to this endeavour, collectively producing 81 published articles.

Contribution of Author and Co-Author

It is essential to assess the contributions made by authors and co-authors because they have been meritorious in the advancement of SSI research and learning, especially within the realm of human health. The contribution of the authors is presented in Figure 4. The author with the highest number of publication documents can be identified by the size of the label, and this confirmed by analyzing metadata. Based on Figure 4, the top three authors with the highest number of published documents, in descending order, are Troy D. Sadler, Lee Hyunju, and Jessica Shuk Ching Leung.

Figure 4

Authors and co-authors of research on socioscientific issues learning in the health context



Metadata in Vosviewer showed the number of documents from the authors is Troy D. Sadler (5), Patricia Friedrichsen (5), Lee Hyunju (4), Laura Zangori (4), Leung (3), and Li Ke (3 articles). It is worth noting that in Figure 4, both Laura Zangori and Li Ke are not visible because their labels are obscured by the Troy D. Sadler label, which is part of the same green cluster. The shared label colour indicates that these authors are connected because they have contributed to articles in the same journal (van Eck & Waltman, 2009).

Several authors have conducted collaborative research, as can be seen in Figure 4. Lee Hyunju is the author with the highest level of collaboration, working alongside six other authors. Dana L. Zeidler and Benjamin C. Herman have collaborated with four other authors each. Notably, the collaboration between Lee Hyunju, Dana L. Zeidler, and Lee Hyunok has focused on researching the various challenges faced by students and educators during the transition from traditional learning to SSI learning. They employed case-based learning (Lee et al., 2020).

Topics of Socioscientific Issues Learning in the Health Context

The variety of SSI topics used in learning are shown in Figure 5. All of the topics meet the requirements of the SSI used in learning. SSI is a special phenomenon attached to social issues that can liven up the learning atmosphere. This particular phenomenon that has been selected will be followed by interdisciplinary specific ideas (Ewing & Sadler, 2020). SSI topics were characterized by their intricate connections to scientific concepts, procedures, and technologies (Zeidler et al., 2002), contemporary, often entail moral and ethical assessments (Sadler & Zeidler, 2004), open-ended, complex, controversial (Atabey, 2021), and allowed from multiple viewpoints (Sadler & Zeidler, 2005).

Figure 5

The topics of socioscientific issues learning in the health context

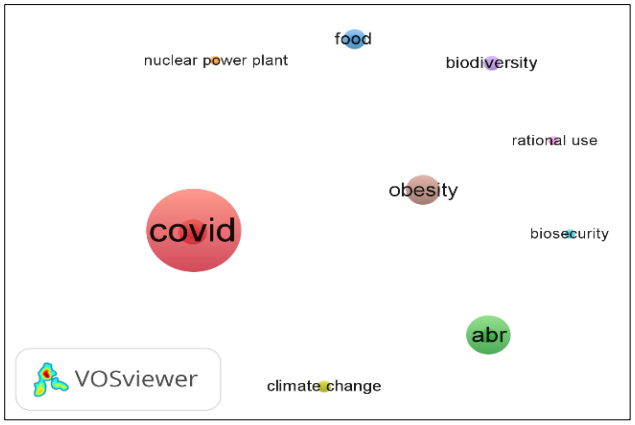


Figure 5 shows the most frequent SSI topic is COVID-19. Based on metadata, the topic of covid appeared as many as 36 occurrences. Several studies have successfully used topics on COVID and vaccination to develop a variety of student skills (Atabey, 2021; Estigarribia et al., 2022; Ha et al., 2022; Han-Tosunoglu & Ozer, 2022; Herman et al., 2022; Karakaş, 2022; Ke et al., 2021; Lee & Tran, 2023; Salman & Yilmaz, 2021; Sulistiani et al., 2022; Subiantoro et al., 2021). COVID-19 represents a contemporary pandemic disease that swiftly evolved into a global health crisis. Within a short timeframe, it had far-reaching impacts on various sectors, including education, the economy, and social life (Atabey, 2021). Many learning models were developed during the COVID pandemic (Karaarslan-Semiz et al., 2023; Putri et al., 2022; Sasmito & Sekarsari, 2022). The COVID-19 pandemic stands out as one of the most formidable and challenging topics of our era, given its multifaceted nature, encompassing scientific, social, and ethical dimensions (Han-Tosunoglu & Ozer, 2022).

Health-related topics such as antibiotic resistance (Owens et al., 2019; Peel et al., 2019; Sagmeister et al., 2021) are still relatively underutilised in the context of Socioscientific Issues (SSI) learning. However, the issue of antibiotic resistance, characterised by the emergence and proliferation of antibiotic-resistant pathogenic microorganisms, presents a multifaceted challenge to public health. This complex problem spans various fields of science, ranging from medicine to politics and economics, making it a suitable candidate for interdisciplinary exploration within SSI learning. Integrating antibiotic resistance topics into SSI learning holds particular relevancy for students' future development, as it can foster a sense of responsibility towards addressing critical health issues (Sagmeister et al., 2021). This emphasis on responsibility aligns with one of the key objectives of the "Global Action Plan on Antibiotic Resistance" strategy, which seeks to enhance awareness and understanding to promote the responsible use of antibiotics (World Health Organization, 2015).

The results of this bibliometric analysis diverge from the findings of qualitative content analysis, highlighting the significance of both approaches. In the qualitative content analysis, the primary topic is genetic modification, with a total of 31 studies identified. This discrepancy arises because authors may not consistently include "genetic modification" as a keyword in their articles, rendering it undetectable by the VOSviewer system, which relies on keyword terms for analysis. Therefore, to ensure a more comprehensive understanding, it is essential to combine both software-assisted quantitative analysis and qualitative content analysis in research endeavours.

The Objectives of Socioscientific Issues Learning in the Health Context

The various objectives of SSI learning are presented in Figure 6 which shows the primary objective of SSI learning is the enhancement of argumentation skills. Argumentation is a fundamental practice in science to support or justify the claims. Learning argumentation skills is a critical part of science education. The quality of an argument or justifications used in an argument is also associated with content knowledge and rationalistic informal reasoning, characterized by the use of logic and reason. Argumentation skills align with the ability to apply the process of science (Lee & Tran, 2023).

Figure 6

The objectives of socioscientific issues learning in the health context

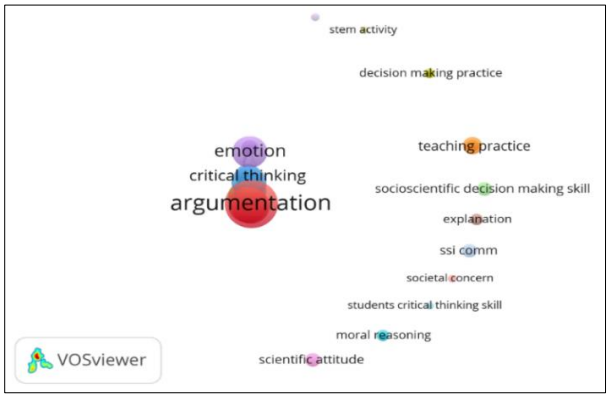


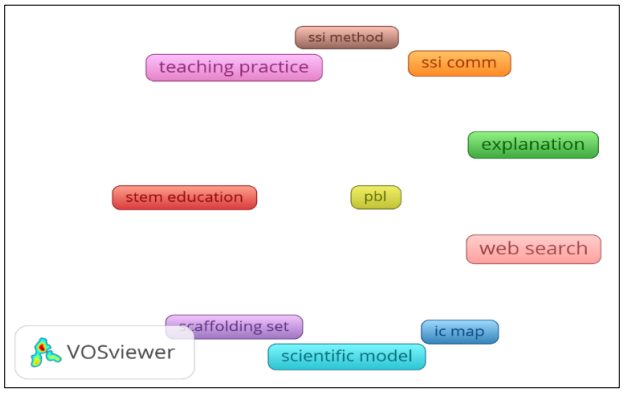
Figure 6 also shows the second major objective of SSI learning research is regulating emotion. The important role emotions play in engaging students with socio-scientific issues cannot be disregarded. Students are emotionally connected with health issues (Lombard et al., 2020), including biosecurity (Ram et al. 2020). The third learning objective that appears on the visual map is critical thinking. However, confirmation of the metadata in Vosviewer shows that the third most common occurrence is decision making which is divided into 2 keywords.

The Learning Models of Socioscientific Issues in the Health Context

The learning model implemented into SSI is shown in Figure 7. The most commonly utilized in a sequence, include problem-based learning (PBL), case-based (CBL) and practice-based learning.

Figure 7

The models of socioscientific issues learning in the health context



The majority of labels visible on the map depict learning models and learning methods. This occurs because bibliometric analysis relies on keywords from article titles and abstracts during the full counting process, even though many articles do not explicitly mention the names of the learning methods employed within these sections. Therefore, to provide a more comprehensive overview, this map analysis was complemented by metadata item analysis which reveal the primary SSI learning models used. CBL and PBL are two approaches that can introduce real-world complexity into the classroom to reduce the gap between academic training and professional practice. PBL is more complex than CBL because it requires students to create a solution without direct help from the educator (Pinto, 2023).

The Relationship Between Topics, Objectives, and Learning Models of Socioscientific Issues in the Health Context

The main goal of interdisciplinary education is sustainable education to face the world's challenges and fight for human rights. Education is expected to be able to increase global awareness and foster cognitive, social and behavioural competencies that support goals (UNESCO, 2023). Therefore, the relationship between SSI topics, objectives, and learning models is focused on the major SSI learning objectives obtained in this study which include developing argumentation, regulating emotional objects and decision making, as presented in Figure 8.

Figure 8

The relationship between topics, objectives, and learning models of socioscientific issues learning

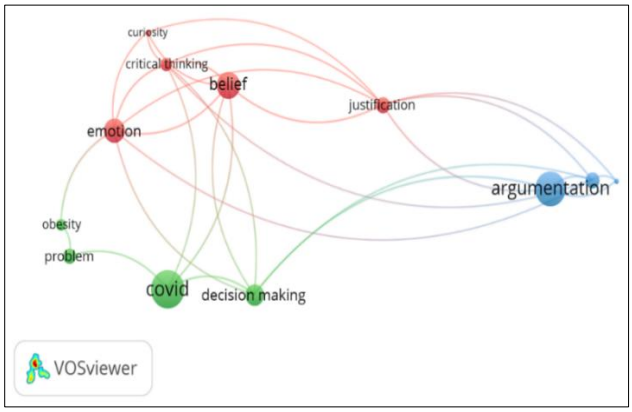


Figure 8 shows that argumentation is connected to justification and decision-making. This indicates that argumentation skills have been successfully developed along with justification and decision making skills. In Figure 8, it also appears that decision-making is connected with argumentation, belief, and critical thinking. This indicates that decision-making skills play an important role in these connected skills. The decision-making is also connected to COVID, this indicates that the COVID-19 topic can be used to develop decision-making (Sadler et al., 2021). Emotions play a role in critical thinking, belief justification, decision-making, and curiosity. In addition, the topic of obesity was successfully used to improve emotion objects (Leung & Cheng, 2023). In Figure 8, there is also a problem label representing problem-based learning (PBL) connected to obesity and emotion, this indicates that SSI learning within the topic of obesity using PBL has been successfully implemented for regulating emotions.

Conclusion and Implications

The qualitative content analysis and quantitative bibliometric analysis of 81 articles from Scopus, PubMed, and Google Scholar in Socioscientific Issues (SSI) reveals trends in SSI learning within the health context research. Qualitative content analysis reveals the dominant topics were genetic modification (28.3%), COVID-19 (17.2%), and food additives (6.7%). The primary objectives were to develop argumentation skills (16.2%), conceptual understanding (13.7%), and decision-making (11.1%). The frequently implemented learning models were problem-based (28.4%), case-based (24.7%), and inquiry-based learning (16.0%). The quantitative bibliometric analysis reveals the most SSI topics were COVID-19, antibiotic resistance, and obesity. The main objectives were to develop argumentation skills, emotions, and decision-making. The frequently implemented learning models were problem-based, case-based and practice-based learning. Both results of qualitative analysis and quantitative analysis reinforce each other. A major implication is these findings can be used as a practical source of information for researchers and educators in determining learning objectives, models, and SSI topics within the health context. The following are two points of recommendations for researchers regarding SSI studies. There is potential to conduct SSI to develop argumentation, regulate emotion, and decision-making for students, especially in health education. The scope of this research is still too broad, further exploration is needed to improve willingness to act, communication and motivation which still receives limited attention.

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Appendix 1

List of articles reviewed

No.	Publication	Topics of SSI	Research Objectives	Learning Models
1	Wen, N., & Wei, R. (2018). Examining effects of informational use of social media platforms and social capital on civic engagement regarding genetically modified foods in China. *International Journal of Communication.*	Genetically modified foods	Examine the willingness to speak as a predictor of civic engagement	Project-based learning
2	Torres, N., & Cristancho, J. G. (2018). Analysis of the forms of argumentation of teachers in training in the context of a socio-scientific issue. *Journal of Turkish Science Education.*	Consumption of coffee	Analyze the forms of argumentation	Case-based learning
3	Altan, E. B., Ozturk, N., & Turkoglu, A. Y. (2018). Socio-scientific issues as a context for STEM education: a case study research with pre-service science teachers. *European Journal of Educational.*	GMO	Determine students' evaluations of the use of SSI in STEM education	STEM Problem-based learning
4	Yerdelen, S., Cansiz, M., Cansiz, N., & Akcay, H. (2018). Promoting preservice teachers' attitudes toward socioscientific issues. *Journal of Education in Science.*	GMF, alternative medicine, organ transplant	Promote students' attitudes toward SSI	Case-based learning
5	Yapicioglu, A. E., & Aycan, S. (2018). Pre-service science teachers' Decisions and types of informal reasoning about the socioscientific issue of nuclear power plants. *Educational Policy Analysis and Strategic Research*.	Nuclear power plants	Effect on decisions, positions, and level of informal reasoning	Case-based instructional activities
6	Aydin, F., Aksut, P., & Demir S. N. (2019). The usability of infographics within the framework of learning outcomes containing socioscientific issues. *Cumhuriyet International Journal of Education.*	Packaged food	Examine the views usability of infographics in order to raise awareness of issue	Case study learning
7	Kärkkäinen, S., Hartikainen-Ahia, A., … (2019). Adolescents' learning and experiences of solving the need for dietary supplementation through socioscientific issue (SSI) method. *Health Education.*	Dietary supplementa-tion	Develop information seeking and critical thinking skills for solving problem	Three stage models learning

8	Kim, G. Ko, Y., & Lee, H. (2019). The effects of community-based socioscientific issues program (SSI-COMM) on promoting students' sense of place and character as citizens. *International Journal of Science and Mathematics Education.*	Fine dust	Promote students' sense of place and character of citizen	Community-based SSI (SSI-COMM) Program
9	Öztürk, A., & Doğanay, A. (2019). Development of argumentation skills through socioscientific issues in science course: A collaborative action research. *Turkish Online Journal of Qualitative Inquiry*.	Genetic tests in health insurance dan GMO products	Develop argumentation skills	Problem based learning
10	Purwati, R., Suranto, … (2019). Problem-based learning modules with socio-scientific issues topics to closing the gap in argumentation skills. *TOJET: The Turkish Online Journal of Educational Technology*	GMO	Improve argumentation skills	Problem based learning
11	Lund, E. S., Bråten, I., ... (2019). Direct and indirect effects of textual and individual factors on source-content integration when reading about a socio-scientific issue. *Reading and Writing.*	Sun exposure	Determine direct and indirect effects on readers' ability to integrate information	Case based learning
12	Wiyarsi, A., & Çalik, M. (2019). Revisiting the scientific habits of mind scale for socio-scientific issues in the Indonesian context. *International Journal of Science Education*.	Alternative medical treatment	Develop scale measuring the Indonesians' scientific habits of mind levels	Problem based learning
13	Peel, A., Zangori, ... (2019). Students' model-based explanations about natural selection and antibiotic resistance through socio-scientific issues-based learning. *International Journal of Science Education.*	Antibiotic resistance and natural selection	Explore students' explanation ability	Model-based explanations (MBEs)
14	Çalik, M., & Karatas, F. O. (2019). Does a "science, technology and social change" course improve scientific habits of mind and attitudes towards socioscientific issues? *Australian Journal of Teacher Education.*	Vaccination, health risk of modern technologies, and herbal medicines,	Improve students' habits of mind and attitudes towards SSI	Inquiry based STSC learning
15	Sagmeister, K. J., Schinagl, ... (2021). Students' experiences of working with a socio-scientific issues-based curriculum unit using role-playing to negotiate antibiotic resistance. *Frontiers in Microbiology.*	Antibiotic resistance	Develop multiple perspectives and responsibility	Collaborative based learning included a mini congress

16	Büssing, A. G., Dupont, J., & Menzel, S. (2020). Topic specificity and antecedents for preservice biology teachers' anticipated enjoyment for teaching about socioscientific issues: investigating universal values and psychological distance. *Frontiers in Psychology*.	Preimplantation genetic diagnosis	Develop universal value of benevolence	Case based learning
17	Tyrrell, D. C., & Calinger, M. (2020). Breaking the COVID-19 ice: integrating socioscientific issues into problem-based learning lessons in middle school. *Edmedia.*	Covid-19 (vaccine and ventilators)	Engage a motivational and scientific literacy	Problem based learning
18	Fan, Y. C., Wang, T. H., & Wang, K. H. (2020). Studying the effectiveness of an online argumentation model for improving undergraduate students' argumentation ability. *Journal of Computer Assisted Learning.*	HIV/ AIDS	Enhancing rrgumentation ability	IpadE Training embeds with a web-based model
19	Lombard, F., Schneider, D. K., … (2020). Balancing emotion and reason to develop critical thinking about popularized neurosciences. *Science & Education.*	Stem cells as potential cures for diseases	Developing critical thinking, emotional empathy and cognitive empathy	Project based learning
20	Kim, G., Mun, K., & Lee, H (2020). Exploration of Middle School Students' Ideas of Fine Dust Issues Using Issue Concept Maps. *Asia-Pacific Science Education.*	Fine dust	Exploring students' ideas and enhancing awareness	SSI Program using issue concept map (ic map)
21	Lin, J. W., Cheng, T. S., … (2020). The effects of socioscientific issues web searches on grade 6 students' scientific epistemological beliefs: the role of information positions. *International Journal of Science Education.*	Smartphone usage and nuclear power plant	Enhancing scientific epistemological belief (SEB)	Discovery-based web searches Program
22	Ke, L., Sadler, … (2020). Students' perceptions of socio-scientific issue-based learning and their appropriation of epistemic tools for systems thinking. *International Journal of Science Education.*	Vaping unit (electronic cigarettes)	Enhancing students' positive perceptions and epistemic thinking	Inquiry learning
23	Gul, M. D., & Akcay, H. (2020). Structuring a new socioscientific issues (SSI) based instruction model: Impacts on pre-service science teachers' (PSTs) critical thinking skills and dispositions. *International Journal of Research in Education and Science.*	Climate change	Fostering critical thinking and dispositions	Problem based learning

24	Namdar, B., Aydin, B., & Raven, S. (2020). Preservice science teachers' informal reasoning about hydroelectric power issue: the effect of attitudes towards socio-scientific issues and media literacy. *(IJRES)*.	Hydroelectric power plant	Examine the role of media literacy as major predictors of informal reasoning	Case based learning
25	Lee, H., Lee, H., & Zeidler, D. L. (2020). Examining tensions in the socioscientific issues classroom: students' border crossings into a new culture of science. *Journal of Research in Science Teaching.*	Genetic modification technology	Explore the tensions to navigate students across the subcultures of science and science education	Case study
26	Ram, R. (2020). Engaging young people in science education through socioscientific issues of biosecurity. *Kotuitui.*	Biosecurity of exporting product	Investigate the emotionally connected engagement	Interpretative inquiry Program
27	Nurtamara, L., & Prasetyanti, N. M. (2020). The Effect of Biotechology Module with Problem Based Learning in the Socioscientific Context to Enhance Students' Socioscientific Decision Making Skills. *International Education Studies.*	Farm and food biotechnology	Enhance decision making skills	Problem based learning
28	Georgiou, M., Mavrikaki, … (2020). Investigating the impact of the duration of engagement in socioscientific issues in developing Greek students' argumentation and informal reasoning skills. *American Journal of Educational Research.*	Genetically modified foods	Develop argumentation and informal reasoning skills	Research project (RP) Group Program
29	Johnson, J., Macalalag, A. Z., & Dunphy, J. (2020). Incorporating socioscientific issues into a STEM education course: exploring teacher use of argumentation in SSI and plans for classroom implementation. *Disciplinary and Interdisciplinary Science Education Research.*	Collony collapse disorder (CCD)	Explore scientific argumentation skills and plan implementation ability	Project based program
30	Leung, J. S. C. & Cheng, M. M. W. (2020). Conceptual change in socioscientific issues: learning about obesity. *International Journal of Science Education*	GMF	Enhance the number of multiple dimensions	SSI teaching and learning
31	Cian, H. (2020). The influence of context: comparing high school students' socioscientific reasoning by socioscientific topic. *International Journal of Science Education*.	GMO	Comparing students' reasoning sophistication levels	Online problem-based survey Program

32	Leung, J. S. C. (2020). A practice-based approach to learning nature of science through socioscientific issues. *Research in Science Education.*	Obesity	Improve students' use of NOS understanding for actively applying.	Practice based learning
33	Nida, S., Rahayu, S., & Eilks, I. (2020). A survey of Indonesian science teachers' experience and perceptions toward socio-scientific issues-based science education. *Education Sciences*.	Food biotechnology and food ingredients	Explore Indonesian science teachers' experience and perceptions toward SSI	Science pedagogies-based SSI Program
34	Baytelman, A., Iordanou, K., & Constantinou, C. P. (2020). Epistemic beliefs and prior knowledge as predictors of the construction of different types of arguments on socioscientific issues. *Journal of Research in Science Teaching.*	vaccines, consumption of bottled vs tap water, and high-voltage lines	Investigate students' epistemic beliefs and prior knowledge as predictors of argument	Cased based learning
35	Sibic, O., & Topcu, M. S. (2020). Pre-service Science Teachers' Views towards Socio-scientific Issues and Socio-scientific Issue-based Instruction. *Journal of Education in Science Environment and Health.*	Biotechnology (GMO, cloning, organ donation, and stem cells)	Explore students' views towards SSI and SSI based instruction	SSI based instruction
36	Minken, Z., Macalalag, Jr., A., ... (2021). Development of teachers' pedagogical content knowledge during lesson planning of socioscientific issues. *International Journal of Technology in Education.*	GMO	Develop teachers' pedagogical content knowledge	Professional development workshop series
37	Salman, M., & Yilmaz, A. (2021). The relationship between the attitude towards socioscientific issues and views on COVID-19 and vaccine. *International Journal of Psychology and Educational Studies.*	Covid-19 and vaccine	Examine the relationship between attitude towards SSI and health literacy	Case based Program
38	Muis, K. R., Chevrier, M., Denton, C. A., & Losenno, K. M. (2021). Epistemic emotions and epistemic cognition predict critical thinking about socio-scientific issues. *Frontiers in Education*.	Genetically modified foods	Examine the role of epistemic emotion and epistemic cognition as predictor of critical thinking	Project based learning
39	Subiantoro, A. W., Handziko, R. C., & Wibowo, Y. (2021). A narrative inquiry of socio-scientific issues-based e-learning development in biology to promote student health literacy. *Biosfer: Jurnal Pendidikan Biologi.*	Covid-19	Promote students' health literacy	Inquiry based e-learning
40	Dauer, J. M. (2021). Students' Civic Engagement Self-Efficacy Varies Across Socioscientific Issues Contexts. *Frontiers in Education.*	Food insecurity	Investigate students' feelings of self-efficacy for civic engagement	STEM-cased-based learning

41	Subiantoro, A. W., Treagust, D., & Tang, K. S. (2021). Indonesian Biology Teachers' Perceptions about Socio-Scientific Issue-Based Biology Instruction. *Asia-Pacific Science Education*.	Food preservatives	Promote the implementation of SSI-based instruction in class rooms	Professional development program on SSI-based teaching and learning
42	Atabey, N. (2021). Science teachers' argument types and supporting reasons on socioscientific issues: COVID-19 pandemic. *International Journal of Psychology and Educational Studies.*	Covid-19 vaccination	Improve students' argumentation qualifications	Case-based learning
43	Owens, D. C., Sadler, T. D., & Friedrichsen, P. (2019). Teaching practices for enactment of socio-scientific issues instruction: An instrumental case study of an experienced biology teacher. *Research in Science Education*.	Antibiotic resistance	Identify science teaching practices for enactment on SSI instruction	Instrumental context-case study
44	Tülin, G., & Acar, F. E. (2021). Perspectives related to socio-scientific issues according to the scientific attitude points of secondary school students. *Journal of Psychology and Educational Studies*.	GMO foods and organic products	Investigate the perspectives related to SSI according to scientific attitudes	Problem based learning
45	Christodoulou, A., Levinson, R.,… (2021). The use of cartography of controversy within socioscientific issues-based education: students' mapping of the badger-cattle controversy in England. *International Journal of Science Education.*	Bovine tuberculosis from badger-cattle	Examine the pedagogical potential to unravel the complexity and to communicate SSI	SSI-based education
46	Friedrichsen, P. J., Ke, L., … (2021). Enacting co-designed socio-scientific issues-based curriculum units: a case of secondary science teacher learning. *Journal of Science Teacher Education.*	Obesogenic junk food	Enacting co-designed SSI-based curriculum units	SSI professional development within multiple case studies
47	Wiyarsi, A., Prodjosantoso, A. K., & Nugraheni, A. R. E. (2021). Promoting students' scientific habits of mind and chemical literacy using the context of socio-scientific issues on the inquiry learning. *Frontiers in Education*.	Abused food additive	Promote students' scientific habits of mind and chemical literacy	Inquiry learning
48	Herman, B. C., Newton, M. H., & Zeidler, D. L. (2021). Impact of place-based socioscientific issues instruction on students' contextualization of socioscientific orientations. *Science Education*	Genetically modified foods	Investigate of ecological worldviews, social and moral compassion	Place-based SSI instruction

49	Ke, L., Sadler, T. D., … (2021). Developing and using multiple models to promote scientific literacy in the context of socio-scientific issues. *Science &Education*.	Covid-19 pandemic	Promote understanding, decision making, and scientific literacy	Multiple scientific learning models
50	Kammerer, Y., Gottschling, S., & Bråten, I. (2021). The role of internet-specific justification beliefs in source evaluation and corroboration during web search on an unsettled socio-scientific issue. *Journal of Educational Computing Research*	Sunscreen containing nanoparticles	Enhancing students' justification beliefs	Case-based learning
51	Nida, S. Marsuki, M. F., & Eilks, I. (2021). Palm-oil-based biodiesel in Indonesia: a case study on a socioscientific issue that engages students to learn chemistry and its impact on society. *Journal of Chemical Education.*	Palm oil based biodiesel	Developing scientific literacy and responsible citizens	Case based learning
52	Martini, Widodo, W., … (2021). Improving undergraduate science education students' argumentation skills through debates on socioscientific issues. *Jurnal Pendidikan IPA Indonesia.*	Nuclear powerplant, food preservation, and GMO	Improving argumentation skills	Problem based learning
53	Rietz, L., Jönsson, A., & Lundström, M. (2021). Students' use of justifications in socioscientific argumentation. *Nordina.*	Food package containing polyfluoro-alkyl subtances (PFAS)	Explore students' justification in argumentation	Socio-scientific argumentati-on (SSA) instruction learning
54	Ceyhan, G. D., Lombardi, D., & Saribas, D. (2021). Probing into pre-service science teachers' practices of scientific evaluation and decision-making on socio-scientific issues. *Journal of Science Teacher Education.*	Genetically modified foods	Investigate students'critical evaluation and decision-making practices	Evidence based learning
55	Choi, Y., & Lee, H. (2021). Exploring the effects of implementing a research-based ssi program on students' understanding of ssi and willingness to act. *Asia-Pacific Science Education.*	Artificial food additives	Fostering student's understanding and willingness to act	Socioscientific inquiry based learning (SSIBL)
56	Seiter, K. M., & Fuselier, L. (2021). Content knowledge and social factors influence student moral reasoning about CRISPR/Cas9 in humans. *Journal of Research in Science Teaching.*	CRISPR/Cas9 as genetic modified technology	Promotes the development of moral reasoning	Problem based learning

57	Özturk, N., Altan, B. E., & Turkoglu, A. Y. (2021). Discussing socio-scientific issues on twitter: the quality of pre-service science teachers' arguments. *Journal of Education in Science, Environment and Health.*	Influenza vaccines	Develop argumentation qualities	Case based learning
58	Estigarribia, L., Chalabe, J. K. T., … (2022). Co-design of a Teaching-Learning Sequence to Address COVID-19 as a Socio-scientific Issue in an Infodemic Context. *Science & education.*	Covid-19	Develop on critical thinking and awareness of the responsibilities	Didactic Teaching Learning Sequence (TLS)
59	Han-Tosunoglu, C., & Ozer, F. (2022). Exploring pre-service biology teachers' informal reasoning and decision-making about COVID-19. *Science and Education.*	Covid-19 and social isolation	Investigating informal reasoning and decision making mode	Problem based learning
60	Erman, E. (2022). Using scaffolding Set to help student addressing socio-scientific issues in biochemistry classes. *International Journal of Instruction.*	Impaired biochemical processes in cells	Explain ability	Cooperative learning
61	Sulistiani, Kartimi, & Sahrir, D. C. (2022). E-modules with android appy pie based on socio-scientific issues to improve students' critical thinking skills. *Journal of Education Technology*.	Virus	Develop critical thinking skills	Problem based learning
62	Ha, H., Park, W., & Song, J. (2022). Preservice elementary teachers' socioscientific reasoning during a decision-making activity in the context of COVID-19. *Science & Education.*	Covid-19	Examine students' decision making activity	Multiple perspectives group discussion
63	Dawson, V., & Venville, G. (2022). Testing a methodology for the development of socioscientific issues to enhance middle school students' argumentation and reasoning. *Research in Science and Technological Education.*	Dam water for drinking	Enhance students' argumentation, critical thinking, reasoning, and decision making	Problem based learning
64	Dalaila, I., Widiyaningrum, P., & Saptono, S. (2022). Developing e-module based on socio-scientific issues to improve students scientific literacy. *Journal of Innovative Science Education*.	Immune system	Develop E-modul to improve students' scientific literacy	Case based learning

65	Annisa, D. N., & Subiantoro, A. W. (2022). Mobile augmented reality in socioscientific issues-based learning: the effectives on students' conceptual knowledge and socioscientific reasoning. *Jurnal Pendidikan IPA Indonesia*.	Tobacco	Investigate students's conceptual knowledge and reasoning	Mobile augmented reality in SSI-based learning
66	Şasmazoren, F., Karapinar, … (2022). The Effect of Using Scientific Scenarios in Teaching Socioscientific Issues in Science Course on Students' Logical Thinking Skills. *Kuramsal Eğitimbilim.*	DNA and genetic code	Develop students' logical thinking skills	Inquiry based learning
67	Karakaya, E., & İrez, O. S. (2022). The relationship between understanding the nature of scientific knowledge and reasoning and decision making in socioscientific issues. *Hacettepe Egitim Dergisi*.	Cholesterol levels	Investigate the relationship between uderstanding, konwledge, reasoning, and decision making	Study group cooperative discussion
68	Capkinoglu, E., Leblebicioglu, G., ... (2022). The impact of peer review on pre-service science teachers' written arguments about socioscientific issues related to chemistry. *International Journal of Progressive Education*.	Chemical additives in food	Investigate the impact of peer review on developing students' arguments	Argument driven inquiry (ADI) model learning
69	Karakaş, H. (2022). The effect of socioscientific issues-based discussions on increase of attitudes of primary school teacher candidates towards the life science teaching. *Journal of Turkish Science Education.*	Biotechnological vaccination	Determine the effect of SSI-based activites on the attitudes	SSI-based discussion
70	Herman, B. C., Clough, M. P., & Rao, A. (2022). Socioscientific issues thinking and action in the midst of science-in-the-making. *Science & Education.*	Covid-19	Determine students' perception about Covid-19 science and sociocultural	Case based learning
71	Walker, J. T. (2022). Critical biomaking: socioscientific issues as contexts for life science maker education. In *Proceedings of International Conference of the Learning Sciences, ICLS*	GMO	Develop critical problem solving and the problematizations of practice	SSI-STEM framed biomaker workshop
72	Sparks, R. A., Jimenez, P. C., ... (2022). Using critical integrative argumentation to assess socioscientific argumentation across decision-making contexts. *Education Sciences.*	Food security	Examine students' socioscientific argumentation across decision making	Critical integrative argumentation (CIA) learning

73	Adal, E. E., & Cakiroglu, J. (2022). Investigation of preservice science teachers' nature of science understanding and decision making on socioscientific issue through the fractal model. *Science & Education.*	Healthy meat	Develop decision-making skill and NOS understanding	Case-based learning
74	Bächtold, M., Pallarès, G., … (2023). Combining debates and reflective activities to develop students' argumentation on socioscientific issues. *Journal of Research in Science Teaching.*	GMF	Develop argumentation skills	Collaborative learning
75	Ben-Horin, H., Kali, Y., & Tal, T. (2023). The fifth dimension in socio-scientific reasoning: promoting decision-making about socio-scientific issues in a community. *Sustainability*.	Asthma in community	Develop decision-making and reasoning	İnquiry learning
76	Cebesoy, U. B., & Rundgren, S. N. C. (2023). Embracing socioscientific issues-based teaching and decision-making in teacher professional development. *Educational Review*.	GMO	Develop decision-making	Case based learning
77	Christenson, N., & Walan, S. (2023). Developing pre-service teachers' competence in assessing socioscientific argumentation. J*ournal of Science Teacher Education.*	GMO	Enhance argumentation	Case based learning
78	de Freitas, A. C., do Nascimento, … (2023). Biodiversity and citizenship in an argumentative socioscientific process. *Sustainability.*	Honey bee nutrient	Develop argumentation	Problem based learning
79	Garthwaite, K., Birdsall, S., & France, B. (2023). Exploring risk perceptions: a new perspective on analysis. *Cultural Studies of Science Education.*	İodium fluoroacetate	Enhance awareness	İnqury learning
80	Lee, S. W., & Tran, S. (2023). Students Need More than Content Knowledge To Counter Vaccine Hesitancy. *Journal of Microbiology & Biology Education*.	COVID-19	Develop argumentation	Case based learning
81	Leung, J. S. C., & Cheng, M. M. W. (2023). Prioritizing emotion objects in making sense of student learning of socioscientific issues. *Journal of Research in Science Teaching.*	Obesity	Regulate emotions	Problem base learning