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Socio-Scientific Issues (SSI) Approach to Physics Learning: A Systematic Literature Review

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Abstract

Physics learning in the 21st century requires instructional approaches that develop students' conceptual understanding while fostering their ability to analyze and make informed decisions regarding complex real-world issues. The Socio-Scientific Issues (SSI) approach has emerged as a promising strategy for connecting physics concepts with social and environmental contexts. This study aims to systematically examine the application of the Socio-Scientific Issues (SSI) approach in physics learning during the period 2015–2025. Specifically, this study identifies topic trends, learning models, the implementation of the SSI approach, and its impact on the physics learning process. The method used is a Systematic Literature Review (SLR) following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Data were collected from the ScienceDirect and Google Scholar databases using the keywords "Learning Outcomes", "Physics Learning", and "Socio-Scientific Issues". A total of 22 articles met the inclusion criteria and were included in the final synthesis. The results indicate that climate change is the most frequently addressed topic in implementing the SSI approach in physics learning, with junior high school being the dominant educational level represented in the reviewed studies. Furthermore, the SSI approach has proven effective in improving students' scientific argumentation skills and strengthening their understanding of physics concepts in real-life contexts. These findings suggest that integrating socio-scientific issues into physics learning provides a meaningful and contextual strategy for enhancing science education.

Keywords: Learning Outcomes; Physics Learning; Socio-Scientific Issues.

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INTRODUCTION

21st-century education demands the development of students' skills not only in the cognitive domain but also in critical thinking, decision-making, and social awareness (Kennedy & Sundberg, 2020; Malik, 2018). In this context, science learning, especially physics, plays an important role in equipping students to understand natural phenomena and simultaneously respond to global topics (Adebisi, 2016). However, the approach to learning physics in secondary schools still focuses on conceptual and mathematical aspects; the relationship between physics concepts and social reality is often ignored (Bao & Koenig, 2019; Bigozzi et al., 2018). This makes it difficult for students to know the relevance of physics in everyday life (Reddy & Panacharoensawad, 2017; Santyasa et al., 2020).

The Socio-Scientific Issues (SSI) approach opens up opportunities to link physics concepts to global issues such as climate change, renewable energy, and information technology (Siribunnam et al., 2019;

Zeidler & Sadler, 2023). In this context, students can learn to consider the social, economic, and ethical impacts of applying science (Bencze et al., 2020; Mang et al., 2021). The SSI approach also emphasizes the importance of argumentative discussion and collaboration, which supports students' scientific communication skills (Widiyawati, 2020). In the learning process, teachers act as facilitators who help students explore various views on the issues raised (Hancock et al., 2019; Johnson et al., 2020; Panissal & Hervé, 2022). This makes physics learning more meaningful and relevant to real life (Mathers et al., 2024).

Although the SSI approach has been widely applied in science learning in various countries, its implementation in the context of physics learning still shows significant variation, both in the application model, materials, and assessments used (Kolong et al., 2023). In addition, previous studies have predominantly focused on evaluating the effectiveness of SSI in specific instructional settings, while comprehensive evidence synthesizing its implementation patterns, research trends, and reported outcomes in physics education remains limited. This fragmentation makes it difficult to obtain a holistic understanding of how the SSI approach has evolved and been implemented across different contexts. Therefore, a systematic study is needed to identify research trends, implementation characteristics, and the educational impacts of the SSI approach in physics learning.

The implementation of the SSI approach in physics learning requires adjustments in learning planning, topic selection, and assessment strategies(Hancock et al., 2019). Previous studies have shown that teachers need to design learning activities that encourage students to explore socio-scientific issues through scientific inquiry, discussion, and reflective reasoning (Ariesta & Purwanti, 2019; Silvia et al., 2024; Tekin et al., 2020). In addition, assessment within the SSI approach extends beyond conceptual understanding to include critical thinking, scientific argumentation, and decision-making skills (Kolong et al., 2023; Yacoubian & Khishfe, 2018). However, the implementation of SSI continues to face practical challenges, including limited instructional resources, teacher readiness, and difficulties in integrating SSI into curricula that remain focused on factual knowledge (Bossér et al., 2015; Kinskey & Newton, 2024). These variations in implementation and the challenges reported across different educational contexts highlight the need for a systematic review to map the instructional models, learning topics, assessment approaches, and implementation strategies adopted in physics education. Such a synthesis can provide a comprehensive understanding of current research trends, identify existing gaps, and inform future development of the SSI approach.

Previous studies have consistently reported that the Socio-Scientific Issues (SSI) approach can enhance students' critical thinking, scientific decision making, and scientific attitudes. In physics education, the SSI approach has also been shown to improve students' critical thinking skills (Jumadi & Dwandaru, 2023; Suprapto & Admoko, 2021; Tullah et al., 2025). Nevertheless, several studies have identified challenges in implementing the SSI approach, including limited teacher understanding of socio-scientific issues, insufficient professional preparation, and the need for more effective strategies to integrate SSI into physics curricula. Furthermore, previous studies have employed a wide range of SSI instructional strategies, including group discussions, debates, and scientific projects, resulting in diverse implementation practices across educational contexts. Although these studies demonstrate the educational potential of the SSI approach, the existing evidence remains fragmented, with limited synthesis of how instructional models, learning topics, assessment approaches, and implementation strategies have evolved in physics education. This gap highlights the need for a systematic literature review to provide a comprehensive overview of research trends and identify directions for future studies.

This study contributes to the literature by conducting a systematic literature review of studies implementing the Socio-Scientific Issues (SSI) approach in physics education. Beyond examining the impact of the SSI approach on student learning outcomes, this review maps the instructional models, physics topics, educational levels, participant characteristics, and assessment approaches reported in previous studies. Furthermore, it identifies research patterns, existing limitations, and potential directions for future studies to support the effective integration of the SSI approach in physics education.

Based on the identified research gap, this study aims to systematically map the implementation of the Socio-Scientific Issues (SSI) approach in physics learning through a systematic literature review.

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The study is designed to answer the following research questions: (1) What are the publication trends of research on the implementation of the SSI approach in physics learning? (2) What educational levels, physics topics, learning models, and assessment methods have been reported in SSI-based physics learning? (3) What evidence has been reported regarding the impact of the SSI approach on students' learning outcomes in physics learning? By answering these questions, this study provides a comprehensive overview of current research and establishes an evidence base to support the development of more contextual and socially relevant physics learning.

METHODS

This study applies a literature review method based on the PRISMA guidelines (Schmid et al., 2020). The procedure consists of identification, screening, eligibility, and inclusion. The research procedure carried out is shown in Figure 1.

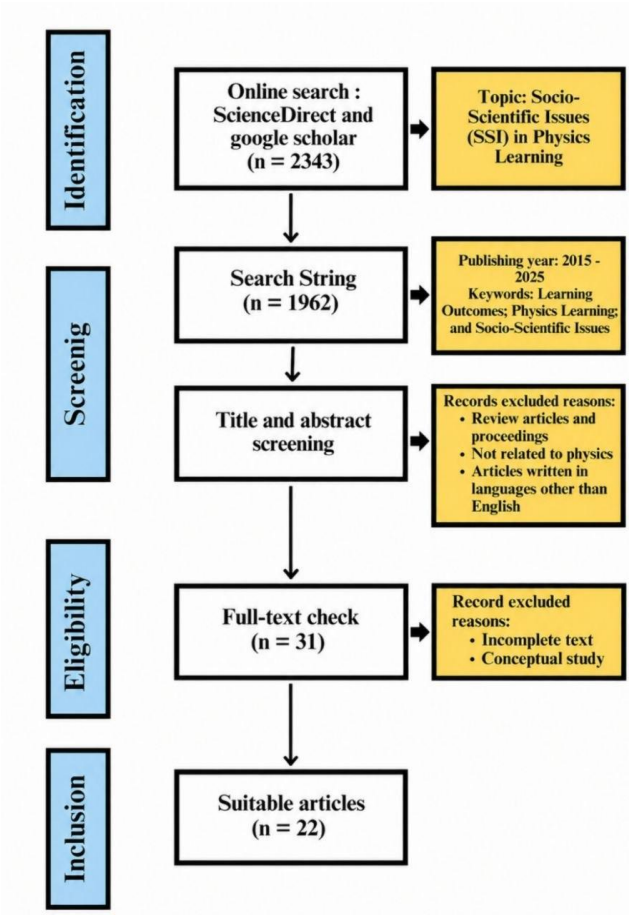


Figure 1. PRISMA flow diagram of article selection process

Figure 1 illustrates the PRISMA flow diagram of the study selection process. The initial database search identified a total of 2,343 records, comprising 2,010 records from Google Scholar and 333 records from ScienceDirect. After applying the predefined search strategy, removing duplicate records, and conducting title, abstract, and full-text screening, 22 articles fulfilled the eligibility criteria and were included in the final review. To facilitate a systematic synthesis, relevant information from each selected study was organized using a structured data extraction form. The extracted information included the author(s), publication year, educational level, physics topic, learning model, and the main findings related to the implementation and impact of the SSI approach in physics learning. The search was limited to articles published between 2015 and 2025. In the screening stage, duplicate articles were removed, and titles and abstracts were reviewed to ensure relevance to the research topic.

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The inclusion criteria for this study comprised articles focusing on the implementation of the Socioscientific Issues (SSI) approach in physics learning, empirical or development research articles, articles published in peer-reviewed journals, and articles written in English. Meanwhile, the exclusion criteria included articles that were not related to physics learning, conceptual papers without empirical data, incomplete articles, articles published outside the specified publication period, and articles written in languages other than English.

In the eligibility stage, full-text articles were assessed based on the inclusion and exclusion criteria. A total of 22 articles met the inclusion criteria and were included in the final review. The overall article selection process is illustrated using a PRISMA flow diagram (Figure 1), which shows the number of articles identified, screened, excluded, and included in each stage. Data were analyzed descriptively by categorizing the studies based on learning models, forms of SSI implementation, impacts on learning outcomes, education levels, and physics subject matter. This approach allows for systematic mapping and identification of research trends and gaps.

RESULTS AND DISCUSSION

Results

A total of 22 selected articles were systematically analyzed and categorized into four main aspects: learning models and implementation of the SSI approach in physics learning, the impact of the SSI approach on learning outcomes, the level of education, and physics subject matter.

Learning models and implementation of the SSI approach in physics learning

The Socio-Scientific Issues (SSI) approach in science learning is a space for students to be actively involved in scientific issues that are relevant to social life. Through this approach, students are invited to develop critical thinking skills, decision-making, and evidence-based argumentation in real contexts. Selecting an appropriate learning model is an important aspect. The learning model used through the SSI approach facilitates interaction, collaboration, and exploration of scientific issues in a reflective and responsible manner. These models reflect various strategies that can be used to link science learning to broader social and ethical contexts. Table 1 presents the distribution of learning models used in implementing the SSI approach in physics learning, along with their frequency across the reviewed studies.

Table 1. Learning model with SSI approach

No	Author	Learning Model	Frequency
1	Aviandari et al., 2022	Place-Based Education	1
2	Widiyawati, 2020	Scientific Literacy-Oriented	1
3	Pertiwi et al., 2023	Conventional	1
4	Febriani et al., 2023	Project-Based Learning	1
5	Husniyyah et al., 2023; Putri et al., 2018; Suprapto & Admoko, 2021	Problem-Based Learning	3
6	Irananda & Rosdiana, 2022	Mind Mapping Strategy	1
7	Tekbiyik, 2015	Jigsaw Collaborative Learning	1
8	Lestari et al., 2021	Guided Inquiry Learning with comic media	1
9	Cheung et al., 2024	Reading Science Intervention (ChatGPT Integration)	1
10	Wahidah et al., 2024	Debate based on Socio-Scientific Issues	1
11	Yaumi & Taufikurohmah, 2019	Dick and Carey Model (This is an instructional design model used to develop learning materials rather than a classroom learning model)	1

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Several studies did not examine classroom learning models but instead focused on developing SSI-based instructional materials. These studies are presented separately in Table 2 under the category of SSI-Based Instructional Material Development.

Table 2. SSI-based instructional material development

No	Author	Instructional Material	Frequency
1	Hariapsari et al., 2018; Nuraini et al., 2023; Rahayu et al., 2017; Saefullah et al., 2021	SSI-Based Teaching Materials	4
2	Silvia et al., 2024; Tekin et al., 2020	SSI-Based Modules	2
3	Asi et al., 2021; Tullah et al., 2025	SSI-Based E-Book	2
4	Atabey & Topcu, 2017	SSI-Based Curriculum Development	1

Furthermore, the learning models are classified according to their implementation forms. This classification aims to show how each learning model is used in each field of study to integrate SSI values, as well as how the approach impacts the learning process and student outcomes. The classification of learning models and their implementation forms through the SSI approach is presented in Table 3.

Table 3. Implementation of the SSI model in physics learning

No	Classification	Implementation
1	Place-Based Education	• Relating the coffee brewing process to physics concepts (heat, pressure, force).
2	Scientific Literacy-Oriented	• SSI is used as a context for scientific inquiry, discussion, and evidence-based reasoning.
3	Conventional	• SSI is incorporated into teacher-centered instruction through contextual examples and classroom discussions.
4	Project-Based Learning	• Students investigate socio-scientific issues by designing and completing physics-related projects.
5	SSI-Based on teaching materials	• The issue of tidal flooding is linked to Newton's law of gravity • Designing learning devices with social issues (vibration, sound) • Developing RPP and LKS on the theme of environmental pollution • Textbook on climate change and its impact on life
6	Problem-Based Learning	• Students face real cases and discuss to find scientific solutions. • Climate change cases solved through SSI-based PBL.
7	One-Shot Case Study	• Students analyze driving behavior and traffic light kinematics.
8	Mind Mapping Strategy	• SSI is used as the basis for concept mapping by students
9	SSI-based Modules	• Students are given modules with energy issues and scientific debates. • Temperature and heat topics with social issues, interactive e-module
10	Dick and Carey Model	• SSI is integrated into teaching materials to support the exploration of socio-scientific issues.
11	Jigsaw Collaborative Learning	• Nuclear discussion, pro-con arguments in groups
12	Guided Inquiry Learning with comic media	• SSI issues are featured in comics, discussions, and inquiries.
13	SSI-Based E-Book	• Static fluid topic linked to social issues, using an interactive flipbook. • Peat issues and climate change in an interactive e-book.
14	Reading Science Intervention (ChatGPT	• Reading texts about climate change from AI, examining them holistically.

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No	Classification	Implementation
	Integration)	
15	Debate based on Socio-Scientific Issues	• Debate on the issue of space debris to build scientific argumentation skills
16	SSI-based Curriculum Development	• Development of a lesson unit on global warming using the SSI approach, involving discussion, experiments, field visits, information searches, and argumentation.

The impact of the SSI approach on learning outcomes

The SSI approach is a learning strategy that can have a positive impact on students. The most prominent impact is increasing scientific literacy. In addition, the SSI approach also has a strong impact on improving the quality of scientific argumentation and critical and collaborative thinking skills. Other impacts include increased awareness of global issues and analytical skills, the ability to compile claims-evidence-reasoning, increased relevance of science, positive attitudes and rational decision-making, improved learning outcomes, and development of epistemic evaluation and critical awareness. Table 4 summarizes the various impacts of the SSI approach on students' learning outcomes as reported in the reviewed studies.

Table 4. Impact of the SSI approach on learning

No	References	Impact	Frequency	Measurement
1	Aviandari et al., 2022; Hariapsari et al., 2018; Husniyyah et al., 2023; Putri et al., 2018; Saefullah et al., 2021; Silvia et al., 2024; Yaumi & Taufikurohmah, 2019	Improving scientific literacy	7	• Observation rubrics • Pre-test and post-test • Documentation • Questionnaire
2	Widiyawati, 2020	Enhance awareness of global issues and analytical skills	1	• Essay test
3	Pertiwi et al., 2023	Improve the ability to compile claims-evidence-reasoning	1	• Pre-test and post-test
4	Jumadi & Dwandaru, 2023; Suprapto & Admoko, 2021; Tullah et al., 2025	Improve critical and collaborative thinking skills	3	• Interviews, • Pre-test and post-test • Questionnaire
5	Nuraini et al., 2023	Increasing the relevance of science to real life	1	• Questionnaire
6	Atabey & Topcu, 2017; Rahayu et al., 2017; Tekin et al., 2020; Wahidah et al., 2024	Improving the quality of scientific argumentation	4	• Essay test • Observation rubrics
7	Tekbiyik, 2015	Promote positive attitudes and rational decision making	1	• Pre-test and post-test
8	Lestari et al., 2021	Improving interest and achievement in learning science	1	• Pre-test and post-test • Questionnaire
9	Asi et al., 2021; Irananda & Rosdiana, 2022	Improving learning outcomes	2	• Pre-test and post-test
10	Cheung et al., 2024	Developing epistemic evaluation and critical awareness	1	• Observation rubrics

The reviewed studies demonstrate that the impact of the SSI approach in physics learning extends

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beyond improving students' cognitive achievement to fostering a broad range of competencies required for meaningful science learning. The identified outcomes encompass scientific literacy, scientific argumentation, critical thinking, collaboration, epistemic evaluation, and evidence-based decision making, indicating that SSI supports the integration of conceptual understanding with higher-order thinking skills. To provide a clearer overview of the distribution of these reported impacts, the frequency of each impact category is presented in the bar chart shown in Figure 2.

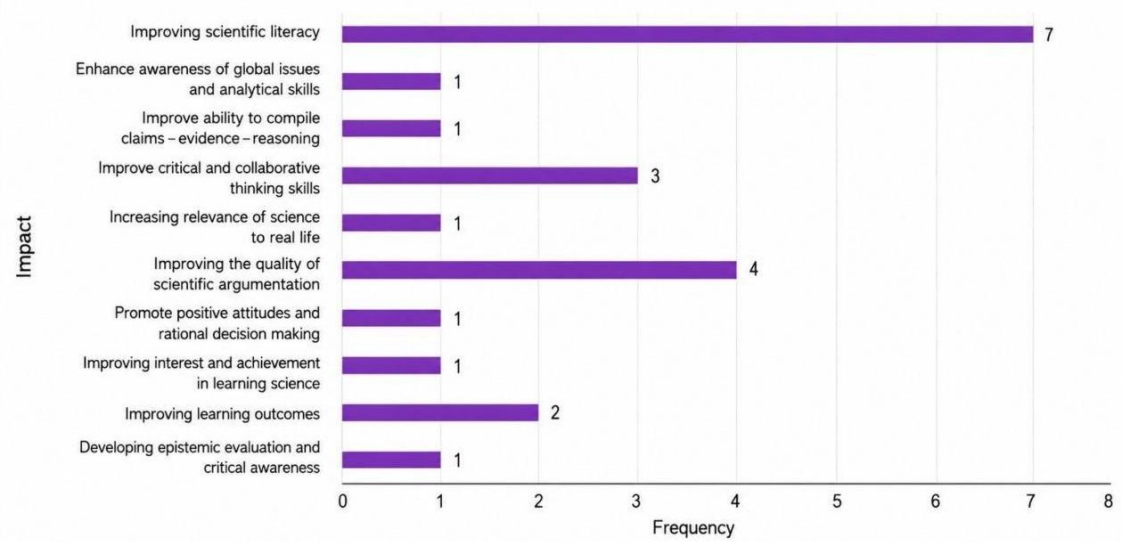


Figure 2. Frequency distribution of the identified impacts of the SSI approach in physics learning

Figure 2 highlights that improving scientific literacy was the most frequently reported impact, followed by improvements in the quality of scientific argumentation, critical and collaborative thinking skills, and learning outcomes. This distribution suggests that the primary contribution of the SSI approach in physics learning lies in strengthening students' conceptual understanding and developing scientific competencies that are essential for addressing authentic socio-scientific challenges.

Classification based on level of education

The educational levels included in this review comprise junior high school, senior high school, and higher education. Elementary school was not included because this review was specifically designed to examine the implementation of the SSI approach in physics learning within the educational levels defined by the research objectives. Among the included studies, junior high school was the most frequently investigated level, with 11 articles, followed by higher education with 7 articles and senior high school with 4 articles. The classification of studies based on educational level is presented in Table 5.

Table 5. Classification based on level of education

No	Level Of Education	Frequency
1	Higher Education	7
2	Senior High School	4
3	Junior High School	11

Classification based on the physics subject matter

The findings indicate that the SSI approach has been implemented across diverse physics subject areas. To provide a more consistent classification, related topics were grouped into broader thematic categories. As shown in Table 6, Environmental and Climate Issues was the most frequently investigated theme, followed by Thermodynamics and Energy, while other studies addressed

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Mechanics, Astronomy and Space Science, and Waves and Oscillations.

Table 6. Classification based on physics subject matter

No	Subject Matter	Frequency
1	Environmental and Climate Issues	9
2	Thermodynamics and Energy	5
3	Mechanics	3
4	Waves and Oscillations	1
5	Astronomy and Space Science	2
6	Momentum and Impulse	1
7	Interdisciplinary Science	1

Discussion

Publication Trends of Research on the Implementation of the SSI Approach in Physics Learning

The Socio-Scientific Issues (SSI) approach in physics learning is a strategy that aims to link physics concepts with relevant and contextual social issues in real life (Figueira & Nardi, 2023). This approach not only helps students understand the material more meaningfully but also encourages them to think critically (Jumadi & Dwandaru, 2023; Suprapto & Admoko, 2021; Tullah et al., 2025), make decisions, and build awareness of scientific issues that impact society (Tekbiyik, 2015; Widiyawati, 2020). The increasing number of publications on the implementation of the Socio-Scientific Issues (SSI) approach in physics learning during 2015–2025 reflects a growing recognition that physics education should extend beyond conceptual and mathematical mastery to include the application of scientific knowledge in addressing real-world societal issues. This trend aligns with the broader shift toward competency-based education, which emphasizes scientific literacy, critical thinking, and evidence-based decision-making.

Unlike SSI research in general science and biology, where SSI are inherently embedded in topics such as genetics, biodiversity, and environmental sustainability, the integration of SSI into physics presents distinct pedagogical challenges. Physics is traditionally characterized by abstract concepts, mathematical reasoning, and quantitative problem-solving, making it necessary to balance conceptual rigor with the open-ended discussion and argumentation that define SSI learning. The reviewed studies suggest that this balance is achieved by embedding physics concepts within authentic contexts, such as climate change, renewable energy, and environmental pollution, allowing students to apply theoretical knowledge without diminishing the disciplinary foundations of physics.

Although publication trends indicate growing interest in SSI-based physics learning, the number of studies remains relatively limited compared with SSI research in broader science education. This finding highlights that the application of SSI in physics is still an emerging field with substantial opportunities for further development. Unlike previous SLRs that primarily emphasized scientific literacy, ethical reasoning, and decision-making across science disciplines, the present review demonstrates that physics education places additional emphasis on integrating these competencies with conceptual understanding and quantitative reasoning. This distinctive characteristic underscores SSI's unique contribution to physics education and suggests the need for further research involving a wider range of physics topics, instructional approaches, and educational contexts to strengthen the evidence base for SSI implementation in physics learning.

Learning Models, Physics Topics, Educational Levels, and Assessment Methods Reported in SSI-Based Physics Learning

The implementation of the Socio-Scientific Issues (SSI) model in physics learning shows that the SSI approach is integrated into various learning models. This approach enriches the learning process by linking controversial and relevant scientific issues to real life (Bezen, 2024; Chowdhury, 2016; Nida et al., 2021). For example, in the Place-Based Education (Aviandari et al., 2022) and Scientific Literacy-Oriented (Widiyawati, 2020) models, issues such as the concept of force in physics and climate change

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are used as starting points for scientific discussions. This approach makes students not only understand concepts but also develop critical thinking skills in social and environmental contexts. Furthermore, the use of project-based and problem-based learning models shows the potential of SSI in increasing student engagement (Febriani et al., 2023). Through Project-Based Learning, students are invited to create projects that solve social problems, while in Problem-Based Learning, students are faced with real cases such as climate change to analyze and find solutions (Husniyyah et al., 2023; Putri et al., 2018). This shows that SSI is able to develop collaboration skills (Jumadi & Dwandaru, 2023; Suprapto & Admoko, 2021; Tullah et al., 2025), problem solving (Tekbiyik, 2015), and students' scientific argumentation skills, because they must consider various perspectives and scientific evidence in the problem-solving process (Atabey & Topcu, 2017; Rahayu et al., 2017; Tekin et al., 2020; Wahidah et al., 2024).

On the other hand, the use of technology and digital media also appears significant in the implementation of SSI (Dayan & Tsybulsky, 2024; Tan et al., 2024). Several approaches, such as SSI-based Modules (Tekin et al., 2020), interactive e-books (Asi et al., 2021; Tullah et al., 2025), and Guided Inquiry Learning using comic media (Lestari et al., 2021), utilize media as a means to explain social and scientific issues in an interesting and easy-to-understand way for students. This supports students' emotional and cognitive engagement, especially in understanding abstract topics such as energy and the laws of physics, such as static fluids. In addition, models such as Dick and Carey and Reading Science Intervention show how texts and literacy sources can be used to instill a deeper understanding of science and social issues (Cheung et al., 2024; Yaumi & Taufikurohmah, 2019). Integration of SSI into learning not only improves conceptual understanding but also helps shape students' character and social awareness (Nuraini et al., 2023; Widiyawati, 2020). In a model such as SSI-based Curriculum Development, students are not only invited to learn about global topics but are also involved in activities such as research, field trips, and presentations that encourage 21st-century skills (Aviandari et al., 2022; Febriani et al., 2023). Thus, the implementation of SSI has proven to be flexible and effective for various levels and learning contexts, and is relevant in building students who are not only academically intelligent but also care and are responsible for community and environmental issues (Asi et al., 2021).

The next aspect analyzed in this study is the level of education targeted for the implementation of the Socio-Scientific Issues (SSI) approach in physics learning according to Table 5. The level of education plays an important role in determining the strategy, approach, and effectiveness of SSI implementation (Newton & Zeidler, 2020). Differences in the cognitive characteristics of students at each level certainly affect how a socio-scientific issue is packaged and studied. The selection of the level of education reflects the focus of developing certain competencies, such as scientific literacy, critical thinking, and rational decision-making, environmental awareness, collaboration skills, and the quality of scientific argumentation (Atmatzidou & Demetriadis, 2016; Caena & Redecker, 2019; Vieira & Tenreiro-Vieira, 2016).

The large number of studies at the junior high school level is due to the characteristics of students who are at the early formal thinking development stage (Fuad et al., 2017). At this stage, students begin to be able to think abstractly, logically, and systematically, although they still need a lot of guidance. This ability makes them ideal subjects to explore various innovative learning approaches. In addition, the junior high school level is an important transition period from concrete learning in elementary school to more complex understanding in high school (Herrmann-Abell & DeBoer, 2018). At this level, it is clearer how well students are able to respond to contextual issues in learning. The use of SSI in junior high schools encourages students to think critically, improve scientific literacy and argumentation skills, and problem-solving (Hariapsari et al., 2018; Putri et al., 2018; Yaumi & Taufikurohmah, 2019). Through SSI-based learning, students not only understand scientific concepts, but also learn to become ethical citizens who are socially and environmentally responsible. The character of junior high school students who are beginning to think abstractly is a strong reason why SSI is effective in increasing scientific awareness (Asi et al., 2021).

At the senior high school level, implementing SSI is more complex. At this level, the critical and analytical thinking skills of high school students are more developed than at the previous level

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(Atmatzidou & Demetriadis, 2016). Students are invited to explore science issues in a broader social context, such as Newtonian gravity, static fluids, temperature, and heat. Teachers can facilitate discussions, debates, and problem-based projects that require students to take positions and consider various ethical and scientific perspectives, and provide e-books or e-modules that can encourage students to search for and evaluate information from various sources independently.

Research at the higher education level tends to focus more on developing SSI-based learning models or designs and implementing SSI through discussion activities (Garrido Espeja & Couso, 2020; Widiyawati, 2020). This shows that universities have a strategic role in designing learning that can equip students with critical thinking and decision making skills (Jamil et al., 2024; Plummer et al., 2022). The use of the SSI approach encourages students to be more active in exploring science issues that are relevant to real life. The SSI-based learning model is designed to foster ethical awareness, argumentation skills, and multidisciplinary understanding. Implementing discussions in SSI-based learning provides space for students to express various points of view scientifically and responsibly (Widiyawati, 2020). This can produce graduates who not only master academic content but also have social sensitivity.

The physics topics used are very diverse. Each topic has different characteristics. These topics include heat (Irananda & Rosdiana, 2022) and pressure (Aviandari et al., 2022), the solar system (Pertiwi et al., 2023; Wahidah et al., 2024), momentum and impulse (Febriani et al., 2023), interdisciplinary science (Husniyyah et al., 2023), energy (Tekin et al., 2020), natural disasters (Lestari et al., 2021), nuclear energy (Tekbiyik, 2015), environmental pollution (Rahayu et al., 2017), and temperature (Silvia et al., 2024). The diversity of these topics shows that the Socio-Scientific Issues (SSI) approach can be applied to various concepts in physics learning. Each topic was chosen because it is closely related to real issues that are relevant to students' daily lives. For example, the topic of energy is often associated with issues of sustainability and renewable resources. The topics of environmental pollution and natural disasters are used to build students' awareness of the impact of human activities on nature (Lestari et al., 2021; Rahayu et al., 2017). Heat and temperature are often integrated with the phenomenon of global climate change. Meanwhile, the solar system and basic physics provide opportunities to foster curiosity and critical thinking about the universe. This approach can be used as a reference for teachers to link physics concepts with scientific literacy and informed decision making. Thus, selecting varied topics enriches learning and increases the relevance of physics material in social and scientific contexts.

Climate change is a topic that is often encountered when using the SSI approach. This is because climate change is directly related to people's lives and has broad social impacts (Cheung et al., 2024; Putri et al., 2018; Saefullah et al., 2021; Widiyawati, 2020; Yaumi & Taufikurohmah, 2019). This topic provides students with space to develop critical thinking and decision making skills based on scientific data and social values. In SSI-based learning, students are invited to analyze various perspectives on the causes and solutions to climate change. Teachers can link climate change material to environmental policies, consumption behavior, and individual and collective responsibilities. The use of real case studies such as carbon emissions, global temperature rise, and melting polar ice caps strengthens the relevance of the material for students. This approach opens up space for discussion on ethics and environmental awareness. Therefore, climate change is an ideal topic to foster students' scientific literacy as well as social awareness.

Other materials such as Newtonian gravity (Nuraini et al., 2023), kinematics (Suprapto & Admoko, 2021), vibrations, waves, and sound (Hariapsari et al., 2018), and static fluids (Tullah et al., 2025) require a deeper understanding of the concept. Through the SSI approach, these materials can be done by reconstructing teaching materials, creating interactive flipbooks, and conducting analysis in everyday life. The Socio-Scientific Issues (SSI) approach encourages students to not only understand physics concepts theoretically, but also to relate them to relevant social issues. With this approach, students are invited to think critically and make decisions based on scientific facts and social values (Rahayu et al., 2017; Tekbiyik, 2015). Interactive flipbooks designed with the SSI approach can contain case studies, interactive videos, and reflective questions that stimulate students' thinking. In addition,

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activities such as group discussions and problem-based projects can strengthen conceptual understanding and collaborative attitudes. Reconstruction of teaching materials is important so that the material is more contextual and aligned with students' needs and characteristics. Thus, implementing the SSI approach not only improves conceptual understanding but also forms students who are sensitive to real issues in society.

To determine the impact of learning with the SSI approach, researchers conducted assessments adjusted to the selected model. The assessments used include pre-tests and post-tests to determine student learning outcomes. Although most studies employed a pre-test and post-test approach, the assessment instruments varied in terms of the competencies assessed, question formats, and evaluation criteria. Some studies measured conceptual understanding using objective or essay tests, whereas others assessed broader competencies through classroom discussions to evaluate critical thinking and scientific argumentation, project creation that can improve collaboration skills, observation and documentation as material to deepen analysis, questionnaires, and essay tests.

Evidence Regarding the Impact of the SSI Approach on Students' Learning Outcomes

The Socio-Scientific Issues (SSI) approach in science learning from secondary school to higher education levels has been shown to have a significant positive impact on students. One of the main impacts is increased scientific literacy, which includes understanding scientific concepts and the ability to apply them in real-life contexts (Aviandari et al., 2022; Hariapsari et al., 2018; Husniyyah et al., 2023; Putri et al., 2018; Saefullah et al., 2021; Silvia et al., 2024; Yaumi & Taufikurohmah, 2019). Students become more aware of complex global issues (Widiyawati, 2020). The ability to construct arguments based on claim-evidence-reasoning (CER) also develops, which strengthens the scientific thinking process in responding to various social and environmental phenomena (Pertiwi et al., 2023).

In addition, the SSI approach encourages the improvement of critical and collaborative thinking skills (Jumadi & Dwandaru, 2023; Suprapto & Admoko, 2021; Tullah et al., 2025). In discussions and debates related to socio-scientific issues, students are trained to evaluate various points of view, weigh relevant evidence, and express opinions logically and based on data. This also improves the quality of their scientific argumentation (Atabey & Topcu, 2017; Rahayu et al., 2017; Tekin et al., 2020; Wahidah et al., 2024). The relevance between science and everyday life becomes more real, which makes learning more meaningful and contextual. Thus, students not only learn theory, but also how to apply scientific knowledge to understand and solve real problems (Nuraini et al., 2023). Another positive impact of implementing the SSI approach is an increase in positive attitudes towards science and rational decision-making abilities (Tekbiyik, 2015). Students show a higher interest in science learning and show improvements in their academic achievement (Lestari et al., 2021). This approach also supports the development of epistemic evaluation, namely the ability to assess the validity and sources of scientific information, and increases critical awareness of the various information they receive (Cheung et al., 2024). With this, SSI makes science learning more holistic, contextual, and relevant to the challenges of the 21st century (Anwar & Ali, 2020).

Research Gaps in the Implementation of SSI in Physics Learning

Despite the positive impacts identified, this review also reveals several important research gaps in the implementation of the SSI approach in physics learning. Most studies focus on short-term learning outcomes such as scientific literacy and argumentation skills, while long-term impacts such as students' ethical reasoning, decision-making consistency, and socio-scientific responsibility remain underexplored. There is also limited research examining the integration of SSI within a comprehensive physics curriculum. Most studies implement SSI as a supplementary strategy rather than embedding it systematically into curriculum design, indicating a need for curriculum-level innovation that aligns SSI with core physics competencies. The dominance of qualitative and small-scale studies suggests a lack of large-scale experimental or longitudinal research. Future studies should employ more robust research designs to strengthen empirical evidence regarding the effectiveness of SSI in physics education. Although digital media integration has begun to emerge, studies combining SSI with

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advanced technologies such as artificial intelligence, simulations, or data-driven learning are still limited, opening opportunities for future research in developing technology-enhanced SSI learning environments. Most studies are concentrated at the junior high school level, indicating an imbalance in research distribution. Further investigation is needed at the senior high school and higher education levels to understand how SSI can support more advanced conceptual and analytical learning in physics.

CONCLUSION

This systematic literature review demonstrates that research on the implementation of the Socio-Scientific Issues (SSI) approach in physics learning has shown an increasing trend during the 2015–2025 period, reflecting growing interest in connecting physics concepts with authentic socio-scientific contexts. The findings indicate that SSI has been implemented across junior high school, senior high school, and higher education, with Environmental and Climate Issues emerging as the most frequently addressed theme. The implementation of SSI is predominantly supported by student-centered pedagogical approaches, such as Problem-Based Learning, Project-Based Learning, Place-Based Education, Guided Inquiry, and Scientific Literacy-Oriented learning, complemented by diverse assessment methods tailored to the intended learning outcomes. Overall, the reviewed studies consistently report that the SSI approach improves students' learning outcomes while fostering critical thinking, scientific argumentation, collaboration, and evidence-based decision-making, demonstrating its effectiveness in connecting abstract physics concepts with meaningful real-world contexts without compromising conceptual understanding. These findings provide practical guidance for physics educators in selecting appropriate instructional approaches and assessment strategies for SSI implementation. Future research should expand the application of SSI to a wider range of physics topics and educational contexts, while developing more valid and reliable assessment instruments to comprehensively evaluate its impact on students' conceptual understanding and higher-order thinking skills.

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Conflict of Interest

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Author Contributions

M.A., F.F., and P.S.M. contributed to conceptualization, methodology, investigation, data curation, formal analysis, and writing the original draft. All authors contributed to reviewing and editing the manuscript, reviewed and approved the final version, and agreed to be accountable for their contributions.

Data Availability Statement

The data supporting the findings of this study consist of information extracted from the published articles included in the systematic literature review. Further information regarding the extracted data is available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

Ethical approval and informed consent were not applicable to this study because it involved a systematic review of previously published literature and did not involve the recruitment of human participants or the collection of primary data from individuals.

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Generative AI Declaration

The authors did not use generative AI tools in the preparation of this manuscript.

REFERENCES

Adebisi, A. T. (2016). Towards Acquisition of Physics Knowledge and Overview of Strategies on Sustainable National Development and Disaster Management. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS)*, *7*(4), 271–275.

Anwar, N. P., & Ali, M. A. (2020). The effect of socio-scientific issue (SSI) based discussion: A student-centred approach to the teaching of argumentation. *Scholarship of Teaching and Learning in the South*, *4*(2), 35–62. https://doi.org/https://doi.org/10.36615/sotls.v4i2.76

Ariesta, F. W., & Purwanti, E. (2019). *Build critical thinking skills of elementary school students through comics social science based-problem. In WoMELA-GG 2019: The 1st Workshop on Multimedia Education, Learning, Assessment and its Implementation in Game and Gamification in conjunction with COMDEV 2018*. WOMELA-GG .

Asi, M., Retnoningsih, A., & Irsadi, A. (2021). Effectiveness of Interactive E-Book Global Warming and Climate Change Integrated Socio Scientific Issues Peat Ecosystem. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 240–244. https://doi.org/10.29303/jppipa.v7ispecialissue.1039

Atabey, N., & Topcu, M. S. (2017). The Development of a Socioscientific Issues-Based Curriculum Unit for Middle School Students: Global Warming Issue. *International Journal of Education in Mathematics, Science and Technology*, *5*(3), 153–153. https://doi.org/10.18404/ijemst.296027

Atmatzidou, S., & Demetriadis, S. (2016). Advancing students' computational thinking skills through educational robotics: A study on age and gender relevant differences. *Robotics and Autonomous Systems*, *75*, 661–670.

Aviandari, S., Suprapto, N., & Arymbekov, B. (2022). Exploration of socio-scientific issuess through coffee brewing methods to explore physics literacy: place based educayion at SK Coffee Lab Kediri. *Studies in Philosophy of Science and Education*, *3*(1), 41–51. https://doi.org/10.46627/sipose

Bao, L., & Koenig, K. (2019). Physics education research for 21st century learning. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), 2. https://doi.org/10.1186/s43031-019-0007-8

Bencze, L., Pouliot, C., Pedretti, E., Simonneaux, L., Simonneaux, J., & Zeidler, D. (2020). SAQ, SSI and STSE education: defending and extending "science-in-context." *Cultural Studies of Science Education*, *15*(3), 825–851. https://doi.org/10.1007/s11422-019-09962-7

Bezen, S. (2024). Comparative Evaluation of Socioscientific Issues in Secondary Physics Curriculum and Textbooks. *E-Kafkas Eğitim Araştırmaları Dergisi*, *11*(4), 510–523. https://doi.org/10.30900/kafkasegt.1469478

Bigozzi, L., Tarchi, C., Fiorentini, C., Falsini, P., & Stefanelli, F. (2018). The influence of teaching approach on students' conceptual learning in physics. *Frontiers in Psychology*, *9*(DEC), 2474. https://doi.org/10.3389/fpsyg.2018.02474

Bossér, U., Lundin, M., Lindahl, M., & Linder, C. (2015). Challenges faced by teachers implementing socio-scientific issues as core elements in their classroom practices. *European Journal of Science and Mathematics Education*, *3*(2), 159–176.

Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (Digcompedu). *European Journal of Education*, *54*(3), 356–369. https://doi.org/10.1111/ejed.12345

Cheung, K. K. C., Pun, J. K. H., & Li, W. (2024). Students' Holistic Reading of Socio-Scientific Texts on Climate Change in a ChatGPT Scenario. *Research in Science Education*, *54*(5), 957–976. https://doi.org/10.1007/s11165-024-10177-2

Chowdhury, M. A. (2016). The Integration of Science-Technology-Society/Science-Technology-Society-Environment and Socio-Scientific-Issues for Effective Science Education and Science Teaching. *Electronic Journal of Science Education*, *20*(5), 19–38.

Dayan, E., & Tsybulsky, D. (2024). Designing and teaching socio-scientific issues online: digital curation

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in the science classroom. *International Journal of Science Education*, 1–20. https://doi.org/10.1080/1046560X.2025.2561731

Febriani, Jumadi, & Dwandaru, W. S. B. (2023). Socio-scientific issues in physics learning to improve students' critical thinking skills. *Revista Mexicana de Fisica E*, *20*(1). https://doi.org/10.31349/RevMexFisE.20.010202

Figueira, M. J. D. S., & Nardi, R. (2023). Engaging students from introductory physics courses in socio-scientific debates. *The Physics Teacher*, *61*(3), 204–206.

Fuad, N. M., Zubaidah, S., Mahanal, S., & Suarsini, E. (2017). Improving Junior High Schools' Critical Thinking Skills Based on Test Three Different Models of Learning. *International Journal of Instruction*, *10*(1), 101–116.

Garrido Espeja, A., & Couso, D. (2020). Introducing model-based instruction for SSI teaching in primary pre-service teacher education. *Science Teacher Education for Responsible Citizenship: Towards a Pedagogy for Relevance Through Socioscientific Issues*, 153–171.

Hancock, T. S., Friedrichsen, P. J., Kinslow, A. T., & Sadler, T. D. (2019). Selecting Socio-scientific Issues for Teaching: A Grounded Theory Study of How Science Teachers Collaboratively Design SSI-Based Curricula. *Science and Education*, *28*(6–7), 639–667. https://doi.org/10.1007/s11191-019-00065-x

Hariapsari, K. W., Tukiran, T., & Sudibyo, E. (2018). Validity of Teaching Materials Based on Socio-Scientific Issues Approach on the Topic of Vibration, Waves, and Sound. *Journal of Physics: Conference Series*, *1108*(1). https://doi.org/10.1088/1742-6596/1108/1/012034

Herrmann-Abell, C. F., & DeBoer, G. E. (2018). Investigating a learning progression for energy ideas from upper elementary through high school. *Journal of Research in Science Teaching*, *55*(1), 68–93. https://doi.org/10.1002/tea.21411

Husniyyah, A. A., Erman, E., Purnomo, T., & Budiyanto, M. (2023). Scientific Literacy Improvement Using Socio-Scientific Issues Learning. *IJORER : International Journal of Recent Educational Research*, *4*(4), 447–456. https://doi.org/10.46245/ijorer.v4i4.303

Irananda, A. G., & Rosdiana, L. (2022). Effectiveness of socio-scientific issues with mind mapping strategy on students learning outcomes on heat topic. *Jurnal Pijar Mipa*, *17*(5), 638–642. https://doi.org/10.29303/jpm.v17i5.3708

Jamil, M., Abdul Hafeez, F., & Muhammad, N. (2024). Critical Thinking Development for 21 st Century: Analysis of Physics Curriculum. *Journal of Social & Organizational Matters*, *2*(3), 1–10. https://doi.org/10.56976/jsom.v3

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*, *2*(1), 9. https://doi.org/10.1186/s43031-020-00026-3

Jumadi, J., & Dwandaru, W. S. B. (2023). Socio-scientific issues in physics learning to improve students' critical thinking skills. *Revista Mexicana de Física E*, *20*(1 Jan-Jun).

Kennedy, T. J., & Sundberg, C. W. (2020). 21st century skills. *Science Education in Theory and Practice: An Introductory Guide to Learning Theory*, 479–496.

Kinskey, M., & Newton, M. (2024). Teacher candidates' views of future SSI instruction: a multiple case study. *Disciplinary and Interdisciplinary Science Education Research*, *6*(1). https://doi.org/10.1186/s43031-024-00098-5

Kolong, A. I., Salic-Hairulla, M., Buan, A. T., & Pitiporntapin, S. (2023). Science teachers and students' perspectives on SSI-based instruction: basis on the development of SSI-based curricular resources. *Thabiea : Journal of Natural Science Teaching*, *6*(1), 1–24.

Lestari, R., Haryono, T., & Erman, E. (2021). Using Comic-Based Socio-Scientific Issues in inquiry learning to increase interest and achievement in science learning. *Thabiea : Journal of Natural Science Teaching*, *4*(1), 62–81.

Malik, R. S. (2018). Educational challenges in 21st century and sustainable development. *Journal of Sustainable Development Education and Research*, *2*(1), 9–20.

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https://doi.org/https://doi.org/10.17509/jsder.v2i1.12266

Mang, H. M. A., Chu, H. E., Martin, S. N., & Kim, C. J. (2021). An SSI-Based STEAM Approach to Developing Science Programs. *Asia-Pacific Science Education*, *7*(2), 549–585. https://doi.org/10.1163/23641177-bja10036

Mathers, B., Johnson, J., Kaufmann, A., Sinni, N., Louis, E., & Henneman, E. (2024). Developing student agency through authentic application of socioscientific issues in STEM classrooms. *Turkish Journal of Education*, *13*(5-Special Issue), 508–534. https://doi.org/10.19128/turje.1507933

Newton, M. H., & Zeidler, D. L. (2020). Developing socioscientific perspective taking. *International Journal of Science Education*, *42*(8), 1302–1319.

Nida, S., Mustikasari, V. R., & Eilks, I. (2021). Indonesian Pre-Service Science Teachers' Views on Socio-Scientific Issues-Based Science Learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(1), 1–11. https://doi.org/10.29333/ejmste/9573

Nuraini, Y., Saefullah, A., Septiyanto, R. F., Guntara, Y., Jamaludin, U., & Rostikawati, D. A. (2023). Reconstruction of digital teaching materials with Socio-Scientific Issues (SSI) context on newton's gravity-tidal flood content. *Journal of Physics: Conference Series*, *2596*(1). https://doi.org/10.1088/1742-6596/2596/1/012057

Panissal, N., & Hervé, N. (2022). *Teaching SSI: Implications with Respect to Teachers' Professional Identity. In Innovative Approaches to Socioscientific Issues and Sustainability Education: Linking Research to Practice*. Springer Nature Singapore.

Pertiwi, H., Fitria Amalia, I., & Gumilar, S. (2023). Application of the Socio-Scientific Issues (SSI) learning approach to the Solar System learning to improve written argumentation skills. In *Research in Phyiscs Education* (Vol. 2, Number 1).

Plummer, K. J., Kebritchi, M., Leary, H. M., & Halverson, D. M. (2022). Enhancing critical thinking skills through decision-based learning. *Innovative Higher Education*, *47*(4), 711–734.

Putri, P. D., Tukiran, T., & Nasrudin, H. (2018). The effectiveness of problem-based Learning (PBL) models based on socio-scientific issues (SSI) to improve the ability of science literacy on climate change materials. *JPPS (Jurnal Penelitian Pendidikan Sains)*, *7*(2), 1519–1524.

Rahayu, S., Meyliana, M., Arlingga, A., Reny, R., Siahaan, P., & Hernani, H. (2017). Development of Lesson Plans and Student Worksheets Based Socio-Scientific Issues on Pollution Environmental Topic. *Journal of Physics: Conference Series*, *895*(1). https://doi.org/10.1088/1742-6596/895/1/012150

Reddy, B., & Panacharoensawad, B. (2017). Students Problem-Solving Difficulties and Implications in Physics: An Empirical Study on Influencing Factors. *Journal of Education and Practice*, *8*(14), 59–62.

Saefullah, A., Guntara, Y., & Rostikawati, D. A. (2021). Implementation of the use of textbooks with the context of socio scientific issues on climate change materials and its impact on life to improve students' scientific literacy. *Gravity: Jurnal Ilmiah Penelitian Dan Pembelajaran Fisika*, *7*(2).

Santyasa, I. W., Rapi, N. K., & Sara, I. W. W. (2020). Project based learning and academic procrastination of students in learning physics. *International Journal of Instruction*, *13*(1), 489–508. https://doi.org/10.29333/iji.2020.13132a

Schmid, C. H., Stijnen, T., & White, I. (2020). *Handbook of meta-analysis*. CRC Press.

Silvia, R. M., Hertanti, E., & Suryadi, A. (2024). Development of E-Modules Based on Socio-Scientific Issues to Improve Students' Science Literacy Skills on Temperature and Heat Materials. *Jurnal Penelitian Pembelajaran Fisika*, *15*(4), 425–433. https://doi.org/10.26877/jp2f.v15i4.1141

Siribunnam, S., Bednarova, R., & Nuangchalerm, P. (2019). The effect of SSI overlap STEM Education on Secondary Students' Socio-scientific decision making. *Journal of Physics: Conference Series*, *1340*(1), 012006. https://doi.org/10.1088/1742-6596/1340/1/012006

Suprapto, N., & Admoko, S. (2021). Kinematics of "traffic Light": A Socio Scientific Issue Performed by Undergraduate Physics Students. *Journal of Physics: Conference Series*, *1899*(1). https://doi.org/10.1088/1742-6596/1899/1/012149

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Tan, K. L., Chi, C. H., & Lam, K. Y. (2024). Survey on Digital Sovereignty and Identity: From Digitization to Digitalization. *ACM Computing Surveys*, *56*(3). https://doi.org/10.1145/3616400

Tekbiyik, A. (2015). The use of jigsaw collaborative learning method in teaching socio-scientific issues: The case of nuclear energy. *Journal of Baltic Science Education*, *14*(2), 237–253.

Tekin, N., Aslan, O., & Yılmaz, S. (2020). Improving Pre-Service Science Teachers' Content Knowledge and Argumentation Quality through Socio-Scientific Issues-Based Modules: An Action Research Study. *Journal of Science Learning*, *4*(1), 80–90. https://doi.org/10.17509/jsl.v4i1.23378

Tullah, H., Aprilia, A., & Dwandaru, W. S. B. (2025). Development of Physics E-book based on Socio Scientific Issues Assisted by Heyzine Flipbook on Static Fluid Topic to Improve Students' Critical Thinking and Collaboration Skills. *Jurnal Penelitian Pendidikan IPA*, *11*(1), 155–162. https://doi.org/10.29303/jppipa.v11i1.8984

Vieira, R. M., & Tenreiro-Vieira, C. (2016). Fostering scientific literacy and critical thinking in elementary science education. *International Journal of Science and Mathematics Education*, *14*(4), 659–680.

Wahidah, A. I., Supeno, S., & Hana Siswati, B. (2024). Implementation of Socio-Scientific Issues inScience Learning to Improve Argumentation Skills: A Case of Space Debris Debate. *Jurnal Pendidikan Progresif*, *14*(2), 1141–1151. https://doi.org/10.23960/jpp.v14.i2.202482

Widiyawati, Y. (2020). Global warming & climate change: Integration of socio-scientific issues to enhance scientific literacy. *Journal of Physics: Conference Series*, *1511*(1). https://doi.org/10.1088/1742-6596/1511/1/012071

Yacoubian, H. A., & Khishfe, R. (2018). Argumentation, critical thinking, nature of science and socioscientific issues: a dialogue between two researchers. *International Journal of Science Education*, *40*(7), 796–807. https://doi.org/10.1080/09500693.2018.1449986

Yaumi, & Taufikurohmah, T. (2019). Development of science learning material with socio-scientific issues (ssi) on climate change materials to improve science literacy of junior high school students. *JPPIPA (Jurnal Penelitian Pendidikan IPA)*, *4*(2), 56–63. http://journal.unesa.ac.id/index.php/jppipa

Zeidler, D. L., & Sadler, T. D. (2023). *Exploring and expanding the frontiers of socioscientific issues. In Handbook of research on science education* . Routledge.

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