



Implementation of Socio-Scientific Issues (SSI) in Improving Chemical Literacy of Senior High School Students: A Systematic Literature Review

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Abstract: This systematic literature review analyzes the implementation of the Socio-Scientific Issues (SSI) approach in senior high school chemistry learning and its contribution to students' chemical literacy. Following the PRISMA guidelines, 20 peer-reviewed national and international journal articles published between 2017 and 2025 were selected based on inclusion and exclusion criteria. The results show that SSI is applied through learning models such as Learning Cycle 5E, guided inquiry, and project-based learning using real-world issues including waste management, environmental pollution, alternative energy, and addictive substances. The implementation of SSI improves students' chemical literacy across conceptual, epistemic, and affective dimensions, while also fostering critical thinking, scientific argumentation, evidence-based decision making, and social awareness. SSI-based modules and e-modules are reported to be valid, practical, and effective in increasing student motivation and participation. Challenges include teachers' readiness, limited instructional time, and the availability of contextual learning resources. Further studies are needed to explore diverse SSI contexts and to develop comprehensive chemical literacy assessment instruments.

Keywords: Socio-Scientific Issues, chemical literacy, chemistry learning, high school.

Abstrak: Abstrak: Penerapan Isu-Isu Sains dan Masyarakat (SSI) dalam Peningkatan Literasi Kimia Siswa Sekolah Menengah Atas: Tinjauan Literatur Sistematis. Tinjauan literatur sistematis ini bertujuan untuk menganalisis penerapan pendekatan Isu-Isu Sains dan Masyarakat (SSI) dalam pembelajaran kimia di sekolah menengah atas dan dampaknya terhadap peningkatan literasi kimia siswa. Tinjauan ini mengikuti pedoman PRISMA dengan menganalisis 20 artikel jurnal nasional dan internasional yang telah direview oleh rekan sejawat yang diterbitkan antara tahun 2017 dan 2025. Studi yang relevan dipilih berdasarkan kriteria inklusi dan eksklusi yang berfokus pada implementasi SSI dalam pembelajaran kimia dan hubungannya dengan literasi kimia siswa. Temuan menunjukkan bahwa pendekatan SSI diimplementasikan melalui berbagai model pembelajaran, termasuk Siklus Pembelajaran 5E, penyelidikan terarah, dan pembelajaran berbasis proyek, menggunakan isu-isu dunia nyata seperti pengelolaan limbah, polusi lingkungan, energi alternatif, dan zat adiktif. Penerapan SSI secara konsisten meningkatkan literasi kimia siswa dalam dimensi konseptual, epistemik, dan afektif. Selain itu, pembelajaran berbasis SSI meningkatkan keterampilan berpikir kritis, argumen ilmiah, pengambilan keputusan berbasis bukti, dan kesadaran sosial. Media pembelajaran seperti modul berbasis SSI dan e-modul dilaporkan valid, praktis, dan efektif dalam meningkatkan motivasi dan partisipasi aktif siswa. Namun, beberapa tantangan masih ada, terutama terkait kesiapan guru, waktu pembelajaran yang terbatas, dan ketersediaan sumber belajar kontekstual. Secara keseluruhan,

pendekatan SSI efektif dalam mengembangkan literasi kimia multidimensi dan mendukung pembelajaran kimia berbasis konteks yang selaras dengan tujuan pendidikan abad ke-21. Penelitian lebih lanjut disarankan untuk mengeksplorasi konteks SSI yang lebih beragam dan mengembangkan instrumen penilaian literasi kimia yang komprehensif.

Kata kunci: *Socio-Scientific Issues, literasi kimia, pembelajaran kimia, SMA.*

▪ INTRODUCTION

21st century education requires students to have critical thinking skills, be creative, be able to collaborate, and communicate effectively. Modern science learning should not be oriented towards developing cognitive aspects, but also involves science literacy, especially chemical literacy, so that students are able to deal with complex social, environmental, and technological problems in everyday life (Pambudi et al., 2018)(Redhana & Suardana, 2021). Chemical literacy is important to equip students to understand chemical concepts while linking them to contemporary social issues and plays an important role in equipping students not only to master theory, but also to be able to use scientific knowledge to make responsible decisions on real-world problems. This research confirms that the characteristics of chemistry that involve the interconnection between macroscopic, submicroscopic, and symbolic representations make chemistry learning very potential to develop critical thinking skills, information literacy, and 21st century competencies if designed contextually and meaningfully (Redhana, 2019; Widiastari & Redhana, 2021).

The Socio-Scientific Issues (SSI) learning approach is very relevant in bridging chemistry learning with real contexts. SSI highlights science-related social issues that are controversial and close to students' lives, thus providing opportunities to practice critical thinking, argumentation, and science-based decision-making skills. Several studies have shown that SSI-based learning can significantly improve students' science literacy and chemical literacy (Hikami et al., 2025). However, the implementation of SSI in schools still faces obstacles. For example, research in Banyumas High School shows that although teachers have implemented SSI, students' environmental awareness is still moderate (70-71%), and science literacy in the aspects of science knowledge and competence is in the range of 58-59%, so that more effective strategies are needed to build caring and critical attitudes towards social and environmental issues (SSI-Based Science Learning Profile in Banyumas High School).

Apart from learning models, the development of SSI-based media and devices such as modules and e-modules has also proven effective in improving students' understanding and chemical literacy. (Lestari et al., 2025) developed an SSI-based e-module that obtained high validity (92%) and was considered capable of fostering scientific thinking skills and active participation of students in digital learning. These findings are in line with the results of international research by (Sutiani et al., 2025) in Chemistry Teacher International, which shows that SSI-based learning is effective in improving multidimensional chemical literacy-including conceptual, epistemic, and affective aspects-and contributes positively to motivation and chemistry learning outcomes.

However, various international reports show that the science literacy and critical thinking skills of Indonesian students are still in the low category. According to PISA 2022 data, Indonesian students' science literacy scores averaged 383, far below the OECD average (485), and only about 34% of students reached the minimum proficiency

level (Level 2) in explaining scientific phenomena in simple terms (PISA, 2022). This situation indicates that science education, including chemistry, still tends to focus on mastering procedural concepts and does not provide enough space for the development of scientific reasoning and critical reflection (Suardana et al., 2018).

However, previous studies still have two significant gaps that need to be addressed. First, research on the implementation of SSI has largely been limited to improving science literacy and conceptual understanding alone, while comprehensive studies on the effectiveness of SSI in enhancing multidimensional chemistry literacy—encompassing conceptual, epistemic, and higher-order thinking skills—remain very limited. Second, current research trends are dominated by cognitive aspects such as argumentation, problem-solving, and critical thinking, whereas aspects of transfer skills, creativity, and science-based decision-making have not been systematically explored.

Thus, a clear research gap in this study is the lack of a comprehensive study examining the implementation of the Socio-Scientific Issues (SSI) approach to improving high school students' chemistry literacy, which simultaneously addresses conceptual and epistemological aspects as well as 21st-century skills (creativity, knowledge transfer, and decision-making) within the context of real-world socio-scientific problems. Therefore, it is important to conduct a systematic study regarding the implementation of SSI in improving high school students' chemistry literacy. This study is expected to provide a comprehensive overview of the effectiveness of SSI, identify implementation constraints, and uncover research gaps that can drive the development of chemistry learning models that are more contextual, critical, and oriented toward 21st-century literacy.

▪ **METHOD**

This study employed a qualitative research approach using a systematic literature review (SLR) design to comprehensively examine previous studies related to the implementation of Socio-Scientific Issues (SSI) in chemistry learning and its contribution to students' chemical literacy. The SLR method was selected to synthesize empirical evidence from various studies, identify research trends, evaluate the effectiveness of SSI-based learning, and reveal existing research gaps in the field of chemical education. This approach enables a structured, transparent, and reproducible review process to ensure the reliability and validity of the findings (Moher et al., 2009).

Type Of Research

This research uses the Systematic Literature Review (SLR) method, following the PRISMA (Preferred Reporting Items For Systematic Reviews and Meta-Analyses) guidelines. This method is used to identify, evaluate, and synthesize various relevant research results regarding the implementation of the Socio-Scientific Issues (SSI) approach in learning chemistry at the high school level, with the aim of finding patterns, trends, effectiveness, and gaps in existing research. Systematic Literature Review was chosen because it is able to provide a comprehensive and evidence-based review of how SSI is applied in the context of chemistry learning and its effect on students' chemical literacy.

Tabel 1. Research Question (RQ)

| No | Research Question | Analysis Conducted |
|----|---|--|
| 1 | How is the implementation of Socio-Scientific Issues (SSI) approach in learning chemistry in high school? | Analyze the design, model, or approach of SSI used in chemistry learning. |
| 2 | What is the impact of the implementation of SSI on improving the chemical literacy of high school students? | Analysis of research results related to the influence of SSI on aspects of chemical literacy (conceptual, epistemic, and affective). |
| 3 | What are the obstacles or factors that affect the success of SSI implementation in chemistry learning? | Identify barriers to the application of SSI and supporting factors for its success based on the results of previous research. |

Research Procedures

Articles in the literature review were obtained from three digital libraries, namely Google Scholar, SINTA and Garuda Kemdikbud. The research literature search used the keywords: “Socio-Scientific Issues”, “Socio & Scientific Issues”, “SSI in Chemistry learning”, “chemical literacy”, and “Improving the science literacy of high school students”. The literature search was conducted from 2017 to September 2025. The selection of articles was carried out using inclusion and exclusion criteria to determine the main research in accordance with the focus of the study. The exclusion and inclusion criteria are presented in Table 2 below.

Table 2. Exclusion and Inclusion Criteria

| Exclusion Criteria | Inclusion Criteria |
|--|--|
| Article not accessible in its entirety. | Articles published between 2017-2025. |
| Research does not discuss the SSI approach. | Research topics include the application of Socio-Scientific Issues (SSI) in chemistry learning. |
| Abstract or research data is incomplete. | The research subjects are high school students. |
| Research does not address chemical literacy or science literacy. | The research examines the relationship between SSI and the improvement of students' chemical literacy. |
| Articles are opinion pieces, conceptual reviews, or proceedings. | Articles are available in full text and published in national and international accredited journals. |

After determining the inclusion and exclusion criteria, the next stage is the selection of articles to be reviewed. The data obtained from the articles were analyzed using the descriptive narrative method. The process of article identification, screening, eligibility assessment, and final inclusion was conducted following the PRISMA guidelines. The detailed selection process is presented in Figure 1.

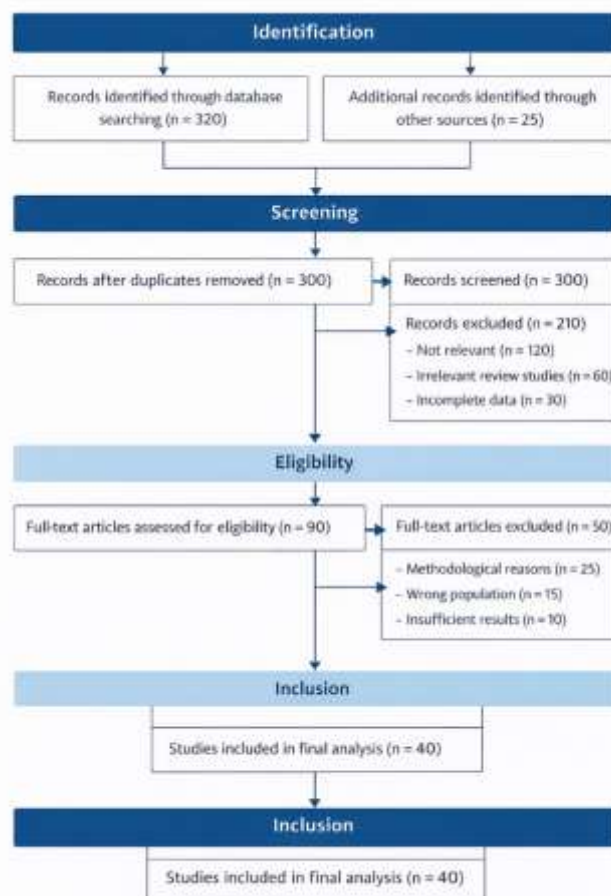


Figure 1. Flow Diagram of the Study Selection Process

▪ RESULT AND DISCUSSION

The results of the literature review show that the SSI approach has great potential in improving students' chemical literacy. In general, SSI plays a role in connecting abstract chemical concepts with real social and environmental phenomena, thus helping students understand the meaning of science in everyday life (Dewi & Rahayu, 2022; Sulistina et al., 2024). This approach encourages students to develop critical thinking skills, conduct scientific argumentation, and make evidence-based decision making (Sutiani et al., 2025). Therefore, SSI learning is in line with the 21st century education paradigm that emphasizes 4C abilities, namely critical thinking, communication, collaboration, and creativity. In the context of chemistry learning, the SSI approach through the use of multiple representation-based chemistry teaching materials significantly improves students' critical thinking skills, because the presentation of concepts through macroscopic, submicroscopic, and symbolic representations helps students build a more complete conceptual understanding and strengthen their ability to analyze and explain chemical phenomena, so SSI-based learning supported by diverse representations has great potential in improving students' chemical literacy in a multidimensional manner (Widiandari & Redhana, 2021).

Based on the results of a systematic review of several articles analyzed, it shows that the SSI approach plays a significant role in improving the chemical literacy of high school students, both from conceptual, epistemic, and affective aspects. SSI-based learning is proven to provide a real context that connects chemical concepts with social and environmental phenomena so as to encourage students to think scientifically, argue, and make evidence-based decisions (Rahayu, 2019; Sulistina et al., 2024). The application of SSI in various learning models such as Learning Cycle 5E, guided inquiry, and project-based learning shows positive results in improving concept understanding and scientific explanation skills. Quasi-experimental studies prove that guided inquiry-based SSI not only improves chemical literacy, but also concern for environmental issues.

This is in line with international research by Sutiani et al., 2025 in *Chemistry Teacher International* and (Hikami et al., 2025) in *Science Education International*, which confirmed that SSI effectively develops multidimensional chemical literacy and strengthens students' critical thinking skills. In addition to improving learning outcomes, SSI is also proven to develop students' social awareness and scientific empathy, which are key features of 21st century learning (Redhana & Suardana, 2021).

In addition to the learning model, the SSI approach is also widely integrated in the development of learning media such as interactive modules and e-modules. Several studies (Sofiana & Wibowo, 2019) show that SSI-based digital media have a high level of validity (88-92% on average) and are able to increase student motivation and active participation in the learning process. The SSI-based assessment instrument developed by Fadlila Hanan & Kristianingrum, 2024 also showed high reliability in measuring students' scientific explanation skills, showing that SSI can be a framework for authentic scientific thinking assessment. Globally, research corroborates the finding that SSI is relevant for building students' socioscientific reasoning, scientific empathy, and reflective ability towards contemporary social issues. However, several national studies such as by (Wardani & Nofiana, 2024) show that the implementation of SSI in schools still faces obstacles, especially in teacher readiness and the availability of contextual learning resources. Therefore, efforts to increase teacher capacity and develop hybrid learning models that integrate SSI with digital technology are needed to expand the impact of chemical literacy in the 21st century education era.

In the epistemic aspect, SSI learning trains students to think scientifically through data analysis, argumentation and evaluation of information sources. They learn to assess the truth of a claim based on scientific evidence and principles, rather than just passively accepting knowledge. The SSI approach improves students' scientific reasoning and scientific explanation skills. Meanwhile, in the affective aspect, students show an increase in social and environmental awareness and a caring attitude towards global problems (Fadlila Hanan & Kristianingrum, 2024). Research by (Sutiani et al., 2025) dan (Rosmayuni et al., 2024) proved that SSI-based learning not only shapes critical thinking skills, but also develops empathy and social responsibility for chemical issues that impact society. These results reinforce the finding that SSI consistently improves multidimensional chemical literacy, which includes conceptual, functional, and more reflective scientific literacy.

And in the epistemic aspect, the effectiveness of SSI in improving chemical literacy is strengthened by student involvement in the process of building evidence-based scientific explanations. It is emphasized that a deep understanding of chemical concepts is highly dependent on students' ability to integrate macroscopic, submicroscopic, and symbolic representations coherently. This is in line with the findings in this study that

SSI-based learning supported by multiple representations can improve students' scientific explanation skills and scientific reasoning. Thus, SSI acts as a pedagogical context that encourages the construction of a more complete and meaningful mental model of chemistry (Suja et al., 2020).

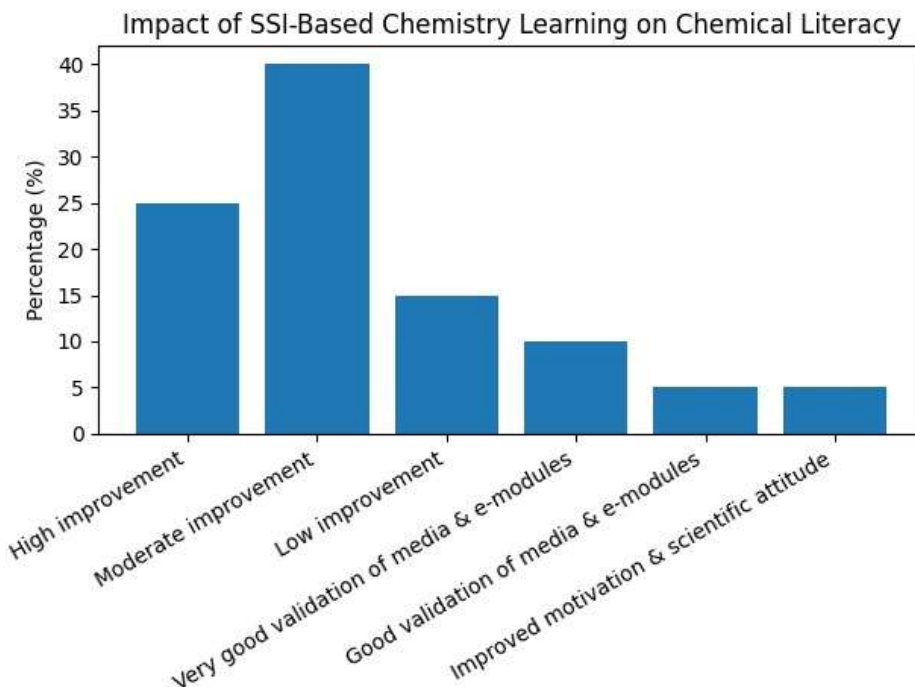


Figure 2. Summary of Chemical Literacy Outcomes in SSI-Based Chemistry Learning

Based on the statistical diagram illustrating the impact of the application of the Socio-Scientific Issues (SSI) approach on improving the chemical literacy of high school students, it can be seen that the majority of studies show an increase in the medium (40%) and high (25%) categories, while a smaller proportion falls into the low category (15%). This indicates that the implementation of SSI is able to have a positive influence on students' ability to understand chemical concepts while fostering social awareness and scientific attitudes. However, this success is influenced by a number of important factors, such as instructional design, teacher readiness, and learning context, and is also faced with several obstacles in its implementation (Erniwati et al., 2020).

The figure is a bar chart summarizing the impact of Socio-Scientific Issues (SSI)-based chemistry instruction on students' chemistry literacy. In addition to the improvement categories, the chart also shows that the validation of instructional materials and e-modules falls into the "very good" (10%) and "good" (5%) categories, and that there was a 5% increase in motivation and scientific attitudes. Overall, these findings reinforce that the SSI approach makes a positive contribution to improving students' chemistry literacy. The diagram was obtained through a systematic literature review (SLR) process, which involved grouping findings from various selected articles based on the level of literacy improvement, then quantifying them as percentages and presenting them in a bar chart to facilitate interpretation.

One of the main factors for the successful implementation of SSI is the contextual and collaborative learning design. When teachers are able to link real social issues with the chemistry concepts taught, students become more active in thinking critically and are

able to apply their scientific knowledge to everyday life situations. In addition, the use of well-validated media and e-modules also supports learning effectiveness. The data shows that 15% of studies highlighted the validation of media and e-modules in the good to excellent category, which means that learning tools play an important role in facilitating students' exploration of scientific and social issues independently (Ningthias et al., 2024).

However, there are still obstacles in implementing SSI in schools, especially in the aspect of teacher readiness and limited learning time. Many teachers are not accustomed to designing learning based on complex social issues, so the implementation of SSI is still theoretical and has not fully evoked students' reflective abilities. In addition, the lack of learning resources integrated with the local context is also an obstacle to more meaningful implementation. As a result, some studies (15%) only showed low literacy improvement. Another influencing factor is students' motivation and scientific attitudes, which in some studies (5%) were reported to increase after the implementation of SSI. This indicates that the success of SSI depends not only on the materials and methods, but also on a classroom atmosphere that supports active participation and open discussion. Therefore, the success of SSI is largely determined by a combination of teacher competence, quality of learning media, learning environment support, and students' emotional and social engagement in the learning process (Nurhadi, 2022; Arthamena et al., 2024)

The obstacles to the implementation of the SSI approach found in various studies cannot be separated from the fundamental problems in chemistry learning, especially related to misconceptions and weak conceptual changes in students. Chemistry learning that does not emphasize real context and does not explore students' initial conceptions tends to produce persistent misconceptions. This finding is in line with the results of the study in this SLR which identified that the limited readiness of teachers and the lack of contextual learning resources are the main factors for the low effectiveness of SSI in several studies. Thus, SSI requires not only the selection of relevant social issues, but also a learning design that consciously facilitates students' conceptual change (Gani et al., 2017).

The synthesis of all articles reviewed confirms that the implementation of the SSI approach has great potential in shaping the comprehensive chemical literacy of high school students. This approach has proven successful in combining three crucial dimensions, namely scientific knowledge, social awareness, and ethical responsibility for the environment. SSI-based learning design has proven effective in improving the understanding of chemical concepts while sensitizing students to the social impact of the application of chemistry in society. By linking abstract chemistry concepts with contextual phenomena in everyday life (e.g. waste, pollution, or alternative energy issues), SSI functions optimally as a bridge between scientific knowledge and real life, making it a highly relevant strategy for building 21st century literacy (Mukti & L.F.X, 2025).

Research trends of the last five years show a significant increase in the use of SSI, which is integrated into various modern learning models, such as Learning Cycle 5E, project-based learning, and problem-based learning. This implementation pattern shows that SSI is increasingly recognized as an effective pedagogical framework and is in line with the direction of Merdeka Belajar Curriculum, which encourages contextual and problem-based learning. Successful implementation usually involves the stages of introducing relevant social issues, linking them to chemistry concepts, and guiding students to conduct analysis and argumentative discussions to draw scientific evidence-based decisions.

Despite the confirmed effectiveness of SSI, this review identified two major research gaps. First, previous research still tends to focus on environmental and energy topics, while other relevant chemical issues such as food chemistry, health, and chemical technology have not been widely explored as the context of SSI. Second, there are still limitations in the development of SSI-based chemical literacy assessment instruments that are able to measure conceptual, epistemic, and affective aspects in a balanced manner. Therefore, further research needs to be directed at exploring more diverse SSI contexts and strengthening teachers' abilities in designing lessons that integrate social issues with chemical concepts effectively.

▪ CONCLUSION

The SSI learning approach is effective in improving the chemical literacy of high school students multidimensionally, including conceptual, epistemic, and affective aspects. SSI connects chemistry concepts with social, environmental, and technological issues that are real in students' lives so as to encourage critical thinking skills, scientific argumentation, and scientific evidence-based decision making. Commonly used learning models involve Learning Cycle 5E, guided inquiry, and project-based learning that raise real issues such as waste, pollution, and alternative energy. SSI-based learning media such as interactive modules and e-modules are proven to be valid, practical, and increase student motivation and participation. The main constraints of SSI implementation are teacher readiness, time constraints, and lack of learning resources integrated with local contexts. Nevertheless, SSI succeeded in fostering students' social awareness, environmental care attitude, and scientific attitude as part of 21st century education. However, current research focuses more on environmental and energy issues, while other chemistry issues such as food chemistry and health are still less explored. Limitations are also found in the comprehensive SSI-based chemical literacy assessment instrument.

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