ijolii

Indonesian Journal Of Learning and instructional Innovation
Volume 3, Issue 2 (2025), pp. 130-139 | e-ISSN: 3025-8316
https://journal.uns.ac.id/ijolii | https://doi.org/10.20961/ijolii.v3i2.3006

Socio-Scientific Issues (SSI) Approach Implementation to Enhance Students' Creative Thinking Skills: Literature Review

Panji Gumilar[1], Djono[2], Aghilatul Umuda[3], Diah Ayu Puspita Sari[4], Nur Lailatul Fitriyah Abidin[5]
[1,3,4,5] Educational Technology Master's Program, Universitas Sebelas Maret, Surakarta, Indonesia
[2]History Education, Universitas Sebelas Maret, Surakarta, Indonesia
E-mail: [1]panjiberseri@gmail.com*, [2]djono@staff.uns.ac.id, [3]aghilatulumuda691@gmail.com, [4]diahayu1305@gmail.com, [5]fitriabidin2002@gmail.com
*Corresponding Author

Article History: Received: December 14, 2025; Accepted: December 29, 2025; Published: December 31, 2025

ABSTRACT

Creative thinking skills are one of the 21st-century skills that students must possess. This study aims to analyze the implementation of the Socio-Scientific Issues (SSI) approach to improve students' creative thinking skills. The study identified gaps between textbook content and actual student misconceptions in the Indonesian context. The research method used a literature review of scientific articles that align with the research objectives. Scientific articles were sorted using the Publish or Perish (PoP) application version 8 and selected based on the publication period between January 2021 and December 2025, published in journals indexed by Sinta 1 and Sinta 5 and not as a literature review. Three articles were obtained that met the selection criteria and met the article quality assessment. The results of the study indicate that there is a positive impact of implementing the SSI approach on improving students' creative thinking skills. The subject matter taught includes environmental change and conservation as well as green chemistry. The SSI approach can be applied to various learning models, namely Interactive Socio-Scientific Inquiry (ISSI), Problem-Based Learning (PBL), and Project-Based Learning (PjBL).

Keywords: *creative thinking skills, literature review, socio scientific issues*

INTRODUCTION

Creative thinking skills are one of the main foundations of modern education. Progressiveness in various sectors demands educational transformation to develop 21st-century skills including creative thinking, creative thinking, collaboration, innovation, and communication (Andaresta & Irawan, 2025; Mulyono et al., 2023; Tang et al., 2020), as well as developing the ability to apply knowledge in real-world forms (Dewra & Singh, 2025). PISA classifies adolescents' creative thinking skills as encompassing three main elements: creative manifestation, knowledge construction, and innovative problem solving (Karunarathne & Calma, 2024).

Creative thinking skills help build superior human resources (Sakdiah et al., 2023). Academically, creative thinking helps individuals develop fluency, flexibility, originality, and elaboration skills (Santoso et al., 2020). Furthermore, improving creative thinking skills is a factor in shaping progressive and adaptive technology and culture (Beaty et al., 2018; Foster & Schleicher, 2022). As a non-innate ability (Ritter & Mostert, 2017), creativity is seen as a complex phenomenon that is invaluable to human thought (Zhang et al., 2020). Each individual's creative

potential is inherent in cognitive functions, which can be developed through scientific learning and training (Sun et al., 2020).

The results of the 2022 PISA study show that the basic literacy skills of students in Indonesia lag behind those of several OECD (Organization for Economic Co-operation and Development) countries. Reading literacy scores reached only 359 (OECD average 476), mathematics 366 (OECD 472), and science 383 (OECD 485) (Alfaruqi & Nurwahidah, 2025). The OECD 2022 (2023) study showed that only 66% of students in Indonesia lack scientific literacy proficiency. This illustrates students' limitations in understanding and implementing scientific concepts analytically and applicatively. Furthermore, the low level of efforts to develop creative thinking skills can be seen in the results of the 2025 Global Innovation Index (GII), where Indonesia ranked 55th out of 139 countries globally and 12th out of 17 countries in Southeast Asia, East Asia, and Oceania. Indonesia's innovation performance in education has also declined in terms of input innovation, with human capital and research being the worst (WIPO, 2025). These findings indicate low innovation and creativity capabilities among Indonesian students. Therefore, developing learning that is in line with current trends is increasingly urgent.

Students develop an understanding of scientific thinking concepts through science learning (Vosniadou, 2019). Science learning plays a crucial role in building a sustainable society (Yunita & Mandasari, 2025). Science learning teaches students to develop an understanding of scientific thinking concepts, encouraging each individual to reflect on sustainable issues scientifically through scientific inquiry, fact-based learning, and involvement in socio-scientific discussions (Fernández-Huetos et al., 2025; Hogan & O'Flaherty, 2021). The Socio-Scientific Issue (SSI) approach integrates social and scientific factors to address relevant issues (Arthamena et al., 2024; Ke et al., 2021; Zatdni & Mashfufah, 2025) in students' lives, which has implications for creative thinking skills (Sa'diah et al., 2025).

Science and creativity are interrelated. Learning science requires individuals to think creatively (Mulyono et al., 2023). Furthermore, the primary goal of science education is to facilitate the development of creativity (Akram & Rana, 2025). The SSI approach has become essential and integral to science education curricula, pedagogy, and research in various countries over the past few decades (Högström et al., 2025). This approach encourages students to connect learning materials to real-life contexts, including environmental, social, and cultural issues (Andaresta & Irawan, 2025; Arifin & Nyet, 2024; Fujinami et al., 2025). While global studies emphasize the importance of SSI, the implementation in developing countries, particularly within Indonesian science textbooks, remains under-explored. Through the SSI approach, students can build a bridge of understanding between theory and contextual life, as well as develop scientific reasoning and social responsibility (Dusturia et al., 2024), and are closely related to morals and ethics (Andaresta & Irawan, 2025; Anwar & Ali, 2020; Desstya et al., 2024).

However, not many have discussed what learning models can be combined with SSI to improve students' creative thinking skills, what instruments to measure creative thinking after implementing SSI-based learning, what subjects/learning materials are appropriate to be taught using SSI, and the impact of the SSI approach on students' creative thinking skills, so it is necessary to conduct a literature review to analyze the application of the SSI approach in learning.

METHODS

The research method applied in this study is a literature review. This review was conducted by examining scientific articles to uncover several aspects, including substantive findings, methodology on the research topic, and theoretical contributions to the research. The steps of the literature review in this study are outlined in Figure 1 below (Dusturia et al., 2024).

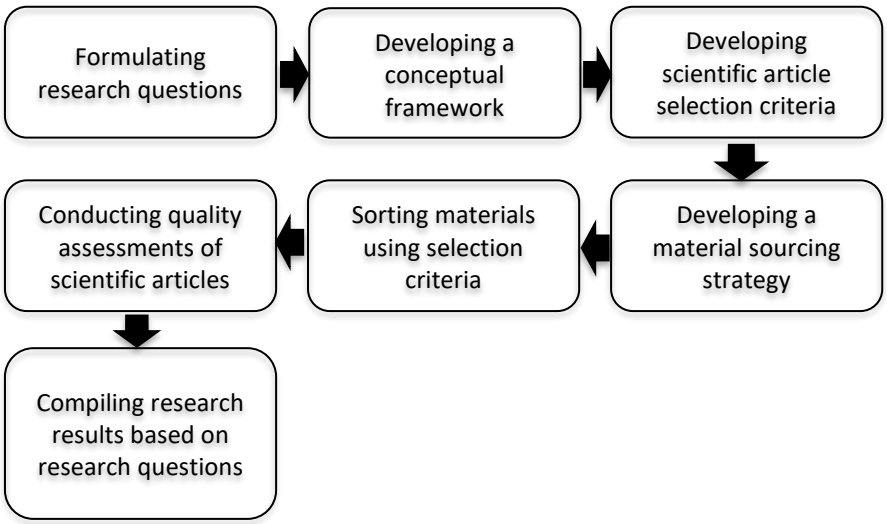

Figure 1. Literature review steps

The following is an explanation of each step in the flow:

Formulating research questions

This research question was formulated with the aim of making it easier for researchers to answer the objectives of the research being conducted.

Table 1.Research Questions and Objectives

Research Questions	Objective
Can the application of the Socio-Scientific Issues (SSI) approach improve students' creative thinking skills?	Determining the influence of the application of the SSI approach in learning on students' creative thinking abilities.
What are the results of students' creative thinking abilities after receiving learning by applying the SSI approach?	Revealing the results regarding students' creative thinking abilities after participating in learning by applying the SSI approach.
What type of instrument is used to measure students' creative thinking abilities?	What type of instrument is used to measure students' creative thinking abilities?

Developing a conceptual framework

A conceptual framework design was developed at this stage to explain the variables in this study. The conceptual framework in this study can be seen in the diagram below.

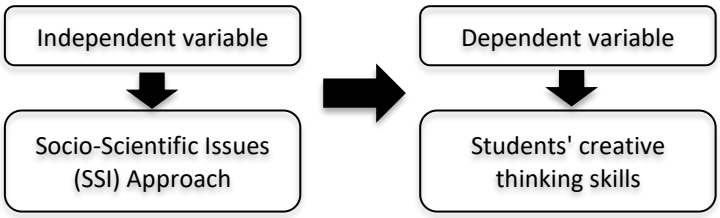

Figure 2.Conceptual framework design

Developing scientific article selection criteria

In this third stage, researchers develop criteria for selecting scientific articles to be reviewed. The selection criteria include acceptance and rejection criteria, as outlined below:

Table 2. Acceptance and Rejection Criteria for Scientific Articles

Acceptance Criteria	Rejection Criteria
Scientific articles were published between 2021 and 2025.	Scientific articles published before 2021.
Contains the application of the SSI approach which is implemented through a learning model and has an impact on students' creative thinking abilities.	Does not include the application of the SSI approach which has an impact on students' creative thinking abilities.
Scientific articles are published in Sinta 1-5 journals.	Articles are not published in journals accredited by Sinta 1-5.
Not a literature review	The article is a literature review

Developing a material sourcing strategy

In this fourth stage, steps were developed to search for scientific articles as material for review. Scientific articles were searched using the Publish or Perish application version 8 by entering several keywords, namely "Socio-Scientific Issue," "SocioScientific Issue," "Socio-Scientific Issue," "SSI," "creative thinking," "creative thinking skills," "creative thinking," "creative thinking skills," with a year limit between 2021 and 2025.

Sorting materials using selection criteria

In this fifth stage, the scientific articles obtained are sorted using the selection criteria as previously determined in the third stage.

Conducting article quality assessments

Scientific articles that have passed the selection criteria are reviewed based on quality criteria by answering the following questions.(Dusturia et al., 2024):

a. Does the article title include the SSI approach and learning model used?
b. Is the research method used appropriate to the purpose of writing this article?

The answers to the two questions above are to determine the learning model applied in the research and also the research methodology used by the researcher.

Synthesis of research results

In this seventh stage, scientific articles that pass the selection criteria are reviewed. The review is conducted to answer the previously established research questions

RESULTS AND DISCUSSION

Sorting materials using selection criteria

Referring to the article search results using the publish or perish application version 8 and applying the keywords "Socio-Scientific Issue", "SocioScientific Issue", "Socio Scientific Issue", "SSI", "creative thinking", "creative thinking skills", "creative thinking", "creative thinking skills" with a publication year range between 2021 and 2025, the results were 95 articles. Furthermore, all articles were reviewed based on predetermined criteria, namely containing the application of the SSI approach in learning and impacting students' creative thinking skills, and scientific articles published in Sinta 1-5 journals. Of the 95 articles, there are six articles containing the SSI approach that impacts students' creative thinking skills. Furthermore, of the six articles, four articles were published in Sinta 1-5 journals.

Conducting article quality assessments

Socio-Scientific Issues (SSI) is a learning approach and requires a learning model to implement it. Of the four articles accepted based on the previous selection criteria, the SSI approach and learning model are listed in the article titles, as shown in the following table:

Table 3. Learning approaches and learning models

Article Code	Approach	Learning model
A1	SSI	Interactive Socio-Scientific Inquiry (ISSI)
A2	SSI	*Problem Based Learning* (PBL)
A3	SSI	*Project Based Learning* (PjBL)
A4	SSI	*Project Based Learning* (PjBL)

The quality assessment of the articles continued by reviewing the research methods applied in each article. Referring to the conceptual framework, the study included SSI as the independent variable with creative thinking skills as the dependent variable with the aim of determining how the application of the SSI approach in learning impacts students' creative thinking skills. The four articles were analyzed and one article did not meet the purpose of this article. This was because the study did not observe the impact of SSI implementation on students' critical thinking skills, but rather conducted a survey of physics teachers' perceptions of the implementation of SSI integrated with STEM based on PjBL used to improve students' creative thinking skills on the topic of renewable energy. The study was not directly applied in classroom learning but rather a survey of teachers' perceptions.

The following three articles align with the purpose of this article. The research methods applied in each article are shown in the table below:

Table 4. Research Methods Applied

Article Code	Research methods
A1	Quasi Experiment
A2	Quasi Experiment
A4	Quasi Experiment

As seen in the table, all articles used a quasi-experimental research method with a pretest-posttest control group design to collect data to determine students' learning outcomes in the form of creative thinking skills. Based on the quality assessment of the articles used in this study, as determined in the writing of this article, namely by answering two questions related to the title and the suitability of the research method, three articles met the criteria. These three articles will then be analyzed in the next stage, namely the synthesis of research results.

Synthesis of research results

This stage is completed by answering the previously formulated research questions. This stage is conducted on three articles that have been sorted using selection criteria and article quality assessments. The list of articles to be analyzed at this stage is listed in Table 5.

Table 5. List of Analyzed Articles

Article Code	Article Title	Publisher Journal	Publication Year	Syntax Index
A1	Interactive Socio-Scientific Inquiry: The Effects on Creative Thinking Skills	Journal of Mathematics and Natural Sciences Education	2022	Sinta 2
A2	The Effectiveness of the Problem Based Learning Model Based on Socio-Scientific Issues on Students' Creative Thinking Skills in Green Chemistry Material	Journal of Chemical Education Research	2024	Sinta 4
A4	The Effectiveness of PjBL-Socio Scientific Issues-Based Student Worksheets on Environmental Change and Conservation Material on the Creative Thinking Skills of High School/Islamic Senior High School Students	Al-Alam: Islamic Natural Science Journal	2025	Sinta 5

Article A1 written by Tasya Indriani & Ummi Nur Afinni Dwi Jayanti (2022). The study was conducted using a control group and an experimental group at the high school level. The control group received the application of conventional learning activities according to the previous teacher's teaching method, while the experimental class carried out learning activities using the Interactive Socio Scientific Inquiry (ISSI) model. The subject taught was biology with the material of environmental changes. Evaluation of creative thinking skills was carried out using a question instrument containing five fill-in-the-blank questions. The fill-in-the-blank question instrument used refers to five indicators of creative thinking skills, namely fluent thinking, flexible thinking, original thinking, detailed thinking, and judgmental thinking. The assessment results showed that the creative thinking skills of the experimental class were higher than those of the control class. The pretest/posttest results of the experimental class were 66.80/91.40 while those of the control class were 64.63/80.93. The effectiveness test used the N-Gain Test with the results of the experimental class compared to the control class being 0.78:0.45 which showed that the application of ISSI was more effective in improving students' creative thinking skills. Furthermore, the hypothesis test using ANCOVA test with a significance level <0.05 shows that H0 is accepted so that the implementation of the ISSI model has an impact on improving students' creative thinking skills. The ISSI learning model helps students to use a scientific approach in analyzing problems and making decisions regarding issues related to social and scientific issues around them. Socio-Scientific Issues (SSI) can create meaningful learning through the exploration of social problems and their implementation in the school environment.

Article A2 written by Putri Nadlifah Tiara Nita & Ella Izzatin Nada (2024). In the learning of green chemistry material for grade X of high school, the researcher aimed to measure the effectiveness of the application of the SSI-based PBL learning model on creative thinking skills in different class groups, namely the experimental class and the control class. The experimental class applied the SSI-based PBL model in learning, while the control class used conventional methods. The test instrument was in the form of 8 open-ended questions adjusted to four indicators of creative thinking skills, namely fluency, flexibility, originality, and elaboration. The pretest/posttest results for the experimental and control classes were 59.87/72.17 and 55.25/64.68, respectively. The effectiveness test used an independent sample t-test while to determine the increase in students' creative thinking skills, an effect size test (Cohend's d) was used. Based on the test results, it shows that the application of PBL-SSI is effective in improving creative thinking skills (t-test 0.001 <0.05) in the moderate category (effect test 0.708). The application of SSI supports PBL, especially in improving divergent thinking and mutual opinion. Divergent and argumentative thinking will stimulate fluency, flexibility, originality, and elaboration in the creative thinking process.

Article A4 written by Messy Naitul & Fitri Arsih (2025). The study was conducted on high school students in phase E (grade 10) for the material of environmental change and preservation. There was one control class and one experimental class. The control class implemented PjBL-based LKPD while the experimental class used PjBL-Socio Scientific Issues (SSI)-based LKPD. The analysis in this study used hypothesis testing and N-Gain testing. The test instrument consisted of 10 questions but the form of the instrument used for the pretest and posttest was not mentioned in this article. The indicators of creative thinking skills measured were fluency, flexibility, originality, and elaboration. The comparison of pretest results between the control class and the experimental class was 33.83: 40.97 and the comparison of posttest results between the control and experimental classes was 58.35: 73.89. The N-Gain test for the control class was 37% while the experimental class was 55% with both in the moderate category. Judging from the increase in students' creative thinking abilities in both the control and experimental classes, it shows that learning that applies LKPD based on PjBL-Socio Scientific Issues (SSI) provides a better impact on improvement compared to LKPD without using the SSI approach. The obstacles faced in this study were that students were not yet accustomed to

answering creative thinking questions, students were shy and not yet accustomed to expressing their creative opinions so that it requires teacher efforts in providing triggers in the form of relevant and meaningful real-world issues to further motivate students in learning.

Socio-Scientific Issues (SSI) emphasizes the implementation of science in life (Ke et al., 2020) where contextual problems are integrated into learnin (Viehmann et al., 2024) which is based on scientific concepts but requires reasoning related to its social dimensions so that it can be responded to appropriately (Owens & Sadler, 2023) so that the integration will increase the relevance of learning (Suryani & Anggraini, 2025). SSI encourages students to face challenges in society through critical, interdisciplinary, and inquiry-based thinking that will impact their conceptual insight and environmental literacy (Lubis et al., 2022; Viehmann et al., 2024). By applying knowledge in a social context and reasoning about the relationship between scientific and social factors, it will influence their position on the complex issues discussed.(Ke et al., 2021). The existence of social conflict that is closely related to science in this approach will require scientific thinking in its presentation.(Arthamena et al., 2024)With these characteristics, the SSI approach can develop problem-solving skills.(Nugroho et al., 2025), in-depth contextual understanding, improving problem-solving skills, critical reasoning, creative thinking, argumentative abilities, motivation, and concern for the environment(Arthamena et al., 2024; Dewi & Yahdi, 2025; Suryani & Anggraini, 2025). Thus, the position of SSI in forming students with scientific insight is no longer debated.(Durak & Topçu, 2021). Its characteristics as an approach are flexible to be applied through various learning models, especially having dominant relevance in problem-based models such as inquiry, PBL, and PjBL (Dewi & Yahdi, 2025). Based on this, the SSI approach can positively correlate with the development of 21st-century skills in students. One important 21st-century skill is creative thinking, alongside critical reasoning, problem-solving, and collaboration.(Dilekçi & Karatay, 2023)The level of creative thinking skills can be measured from four aspects, namely fluency, flexibility, originality, and elaboration (Naitul et al., 2025). These four aspects can be stimulated through the application of SSI in learning activities.(Nadlifah et al., 2024). The characteristics of SSI approach learning activities are open and broad, ultimately developing critical thinking skills optimally (Astari et al., 2025). Finally, SSI-based learning deserves further optimization to foster students' creative thinking skills in the future.

CONCLUSION

Based on the research results referring to three articles obtained from the selection results using several criteria, the implementation of the SSI approach in learning can encourage the improvement of students' creative thinking skills. The assessment of creative thinking skills applies a pretest and posttest design with essay-based questions developed according to creative thinking skill indicators. The material taught to students using the SSI approach includes environmental change and conservation as well as green chemistry for the science grass subject. This study contributes to instructional technology by providing a framework for digitizing SSI-based content that aligns with student conceptions, ultimately enhancing pedagogical practices in 21st-century science education. The SSI approach is implemented using several learning models, namely Interactive Socio-Scientific Inquiry (ISSI), Problem Based Learning (PBL), and Project Based Learning (PjBL).

CONFLICT OF INTEREST

There are no conflicts of interest in the writing of this article.

ACKNOWLEDGEMENTS

The author would like to express sincere gratitude to the Indonesian Journal of Learning and Instructional Innovation for their willingness to publish this article.

REFERENCES

Akram, T. M., & Rana, R. A. (2025). Assessing Prospective Science Teachers' Creative Thinking Ability to Solve Environmental Issues in Higher Education. *Qlantic Journal of Social Sciences and Humanities,* 6(1), 254–265. https://doi.org/10.55737/qjssh.vi-i.25314

Alfaruqi, AZ & Nurwahidah. (2025). Reflection on Indonesia's PISA Scores and the 2024 Madrasah Teacher Competency Assessment Results: Challenges in Enhancing Teacher Competence. *Jurnal Pendidikan IPS*, 15(1), 11–19. https://doi.org/10.37630/jpi.v15i1.2559

Andaresta, DA, & Irawan, E. (2025). Study of Students' Creative Thinking Ability in Socio-Scientific Issues Integrated Science Learning. *Jurnal Pendidikan Dan Pembelajaran IPA Indonesia*, 15(1), 13–24. https://doi.org/10.23887/jppii.v15i1.90153

Anwar, NP, & Ali, MA (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/10.36615/sotls.v4i2.76

Arifin, S., & Nyet, MS (2024). The Effect of Socioscientific Issues Approach and Design Thinking on Entrepreneural Creative Thinking Among Secondary School Students. *International Journal of Modern Education*, 6(21), 611–631. https://doi.org/10.35631/IJMOE.621045

Arthamena, V.D., Ayubi, M., Atun, S., & Suyanta, S. (2024). Use of Socio-Scientific Issues in Chemistry Learning. *Journal of Science Education Research*, 10(1), 38–46. https://doi.org/10.29303/jppipa.v10i1.6285

Astari, WY, Redhana, IW, & Tika, IN (2025). Implications of the Socio-Scientific Issues Approach on Students' Creative Thinking Skills in Science Learning: A Systematic Literature Review. *Journal of Science Education Research*, 11(10), 98–106. https://doi.org/10.29303/jppipa.v11i10.12071

Beaty, R.E., Kenett, Y.N., Christensen, A.P., Rosenberg, M.D., Benedek, M., Chen, Q., Fink, A., Qiu, J., Kwapil, T.R., Kane, MJ, & Silvia, P.J. (2018). Robust prediction of individual creative ability from brain functional connectivity. *Proceedings of the National Academy of Sciences*, 115(5), 1087–1092. https://doi.org/10.1073/pnas.1713532115

Desstya, A., Sayekti, IC, Rahmawati, FP, Hidayati, YM, Kaltsum, HU, Mahya, YMZ, Kamila, SJP, Khotimah, NA, Fidyastuti, N., & Diaz, AM (2024). Development of a Natural and Social Sciences Learning Model Based on Socio Scientific Issues to Strengthen Scientific Literacy of Islamic Elementary School Students. *Journal of Science Education Research*, 10(11), 8703–8711. https://doi.org/10.29303/jppipa.v10i11.9094

Dewi, CA, & Yahdi, Y. (2025). Research Trends on Socio-Scientific Issues in Chemistry Learning: A Systematic Review. *Jurnal Pendidikan MIPA*. https://doi.org/10.23960/jpmipa.v26i1.pp457-475

Dewra, Dr. S. D., & Singh, J. (2025). Innovative Approaches in Modern Education: Bridging Theory and Practice. *International Journal of Scientific Research in Engineering And Management*, 09(05), 1–9. https://doi.org/10.55041/IJSREM46731

Dilekçi, A., & Karatay, H. (2023). The Effects Of The 21st Century Skills Curriculum On The Development Of Students' Creative Thinking Skills. Thinking Skills and Creativity. https://doi.org/10.1016/j.tsc.2022.101229

Durak, B., & Topçu, M. (2021). Socio-Scientific Issues and Model-Based Learning. *IGI Global Scientific Publishing*. 279–297. https://doi.org/10.4018/978-1-7998-4558-4.ch010

Dusturia, N., Nurohman, S., & Wilujeng, I. (2024). Socio-Scientific Issues (SSI) Approach Implementation in Science Learning to Improve Students' Critical Thinking Skills: Systematic Literature Review. *Journal of Science Education Research*, 10(3), 149–157. https://doi.org/10.29303/jppipa.v10i3.6012

Fernández-Huetos, N., Pérez-Martín, J.M., Guevara-Herrero, I., & Esquivel-Martín, T. (2025). Primary-Education Students' Performance in Arguing About a Socioscientific Issue: The Case

of Pharmaceuticals in Surface Water. *Sustainability*, 17(4), 1618. https://doi.org/10.3390/su17041618

Foster, N., & Schleicher, A. (2022). Assessing Creative Skills. *Creative Education*, 13(01), 1–29. https://doi.org/10.4236/ce.2022.131001

Fujinami, K., Shimomae, K., Shimada, K., & Isozaki, T. (2025). Incorporating Socio-Scientific Issues in Science Classes: Co-Teaching with a Social Studies Teacher. *Research in Science Education*, 55(4), 1005–1028. https://doi.org/10.1007/s11165-025-10270-0

Hogan, D., & O'Flaherty, J. (2021). Addressing Education for Sustainable Development in the Teaching of Science: The Case of a Biological Sciences Teacher Education Program. *Sustainability*, 13(21), 12028. https://doi.org/10.3390/su132112028

Högström, P., Gericke, N., Wallin, J., & Bergman, E. (2025). Teaching Socioscientific Issues: A Systematic Review. *Science & Education*, 34(5), 3079–3122. https://doi.org/10.1007/s11191-024-00542-y

Indriani, T., Nur, U., & Dwi, A. (2022). Interactive Socio-Scientific Inquiry: The Effects on Creative Thinking Skills. *Journal of Mathematics and Natural Sciences Education*, 23(8), 995–1005. https://doi.org/http://dx.doi.org/10.23960/jpmipa/v23i3.pp995-1005

Karunarathne, W., & Calma, A. (2024). Assessing creative thinking skills in higher education: Deficits and improvements. *Studies in Higher Education*, 49(1), 157–177. https://doi.org/10.1080/03075079.2023.2225532

Ke, L., Sadler, T., Zangori, L., & Friedrichsen, P. (2020). Students' Perceptions of Socio-Scientific Issue-Based Learning and Their Appropriation of Epistemic Tools for Systems Thinking. International *Journal of Science Education*, 42, 1339–1361. https://doi.org/10.1080/09500693.2020.1759843

Ke, L., Sadler, T., Zangori, L., & Friedrichsen, P. (2021). Developing and Using Multiple Models to Promote Scientific Literacy in the Context of Socio-Scientific Issues. *Science & Education*, 30, 589–607. https://doi.org/10.1007/s11191-021-00206-1

Lubis, SPW, Suryadarma, I., Paidi, P., & Yanto, BE (2022). The Effectiveness of Problem-based learning with Local Wisdom oriented to Socio-Scientific Issues. *International Journal of Instruction*. https://doi.org/10.29333/iji.2022.15225a

Mulyono, Y., Yamtinah, S., & Sarwanto, S. (2023). Development of Critical and Creative Thinking Skills Instruments Based on Environmental Socio-Scientific Issues. *International Journal of Instruction*, 16(3), 691–710. https://doi.org/10.29333/iji.2023.16337a

Nadlifah, P., Nita, T., & Nada, EI (2024). Efektivitas Model Problem Based Learning Berbasis Socio Scientific Issue Terhadap Keterampilan Berpikir Kreatif Siswa Materi Kimia Hijau. *Journal of Chemical Education Research*. 14(2), 136–143. https://doi.org/10.21009/JRPK.142.08

Naitul, M., Arsih, F., & Padang, UN (2025). The Effectiveness of PjBL-Socioscientific Issues-Based Student Worksheets on Environmental Change and Conservation Material on the Creative Thinking Skills of High School/Islamic High School Students. 4(2), 56–63.

Nugroho, A., Sajidan, S., Suranto, S., & Masykuri, M. (2025). The Effects of Socio-Scientific Inquiry Based Learning on Students' Problem-Solving Skills. *Journal of Baltic Science Education*. https://doi.org/10.33225/jbse/25.24.149

Owens, D., & Sadler, T. (2023). Socio-Scientific Issues Instruction for Scientific Literacy: 5E Framing to Enhance Teaching Practice. *School Science and Mathematics*. https://doi.org/10.1111/ssm.12626

Ritter, S. M., & Mostert, N. (2017). Enhancement of Creative Thinking Skills Using a Cognitive-Based Creativity Training. *Journal of Cognitive Enhancement*, 1(3), 243–253. https://doi.org/10.1007/s41465-016-0002-3

Sa'diah, C., Purwanto, A., & Koto, I. (2025). Development of E-Modules Based on Socio-Scientific Issues to Improve the Creative Thinking Skills of High School Students. *Journal of Physics Learning Research*, 16(2), 179–190. https://doi.org/10.26877/jp2f.v16i2.1435

Sakdiah, H., Wahdi Ginting, F., Sri Rezeki, N., & Miranda, A. (2023). The Effect of STEAM Learning and Scientific Attitude on Students' Creative Thinking Skills. Proceedings of Malikussaleh *International Conference on Multidisciplinary Studies (MICoMS*), 3, 00040. https://doi.org/10.29103/micoms.v3i.204

Santoso, IB, Waluyo, J., & Hariyadi, S. (2020). Effectiveness of Science Textbooks Based on Socio-Scientific Issues in Biotechnology Materials To Improve Creative Thinking Ability. *International Journal of Advanced Research*, 08(04), 140–144. https://doi.org/10.21474/IJAR01/10757

Sun, M., Wang, M., & Wegerif, R. (2020). Effects of divergent thinking training on students' scientific creativity: The Impact of Individual Creative Potential and Domain Knowledge. *Thinking Skills and Creativity*, 37, 100682. https://doi.org/10.1016/j.tsc.2020.100682

Suryani, Y., & Anggraini, W. (2025). The Effect of Socio-Scientific Issues Approach on Student Learning Outcomes in Physics Learning: A Review. *MIPA Incandescent Journal*. https://doi.org/10.29303/jpm.v20i3.8861

Tang, T., Vezzani, V., & Eriksson, V. (2020). Developing critical thinking, collective creativity skills and problem solving through playful design jams. *Thinking Skills and Creativity*, 37, 100696. https://doi.org/10.1016/j.tsc.2020.100696

Viehmann, C., Cárdenas, J. M. F., & Peña, C. G. R. (2024). The Use of Socioscientific Issues in Science Lessons: A Scoping Review. *Sustainability*. https://doi.org/10.3390/su16145827

Vosniadou, S. (2019). The Development of Students' Understanding of Science. *Frontiers in Education*, 4, 32. https://doi.org/10.3389/feduc.2019.00032

World Intellectual Property Organization. (2025, December 2). Indonesia Ranking in the Global Innovation Index 2025. WIPO. https://www.wipo.int/gii-ranking/en/indonesia

Yunita, L., & Mandasari, N. (2025). 21st-Century Skills-Oriented Science Education in the Context of Higher Education: A Review. *Panthera: Scientific Journal of Science and Applied Education*, 5(1), 40–49. https://doi.org/10.36312/panthera.v5i1.334

Zatdni, G.F., & Mashfufah, A. (2025). Development of Socio-scientific Issues-Based Teaching Materials on Ecosystem Materials in Elementary School. *Elementary School*, 5(1), 68–78. https://doi.org/10.24036/jlils.v5i1.150

Zhang, W., Sjoerds, Z., & Hommel, B. (2020). Metacontrol of Human Creativity: The Neurocognitive Mechanisms of Convergent and Divergent Thinking. *NeuroImage*, 210, 116572. https://doi.org/10.1016/j.neuroimage.2020.116572