



Socio-Scientific Issues (SSI) Approach Implementation in Science Learning to Improve Students' Critical Thinking Skills: Systematic Literature Review

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Received: November 7, 2023

Revised: December 29, 2023

Accepted: March 25, 2024

Published: March 31, 2024

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DOI: [10.29303/jppipa.v10i3.6012](https://doi.org/10.29303/jppipa.v10i3.6012)

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Abstract: Critical thinking is an ability that students must have in 21st-century learning, especially in science learning. This research aims to analyze the application of the socio-scientific issue approach to improving students' critical thinking skills in science learning. The research method used is a systematic literature review. A systematic literature review was carried out on articles following the research objectives. Articles were obtained using <https://sinta.kemdikbud.go.id/> and selected based on criteria from Sinta S1-S3 published in January 2016 - December 2022. A review of the articles found five articles that met the research criteria and assessed the quality of the study. The research results can conclude that applying the socio-scientific issue approach can improve students' critical thinking skills in science learning. The material taught to students using a socio-scientific issue approach includes environmental pollution, environmental change materials, biodiversity, and global warming. The socio-scientific issue approach can be applied to various learning models, such as problem-based learning, group investigation, and problem-solving.

Keywords: Critical thinking; Science learning; Socio-scientific issues

Introduction

Education is a process of teaching and training each individual to develop their potential. Education in the 21st century is different from previous centuries. The difference lies in the increasingly rapid development of technology and information, which causes the development of science to become even faster. At this time, teachers and students are required to master various skills known as 4C (creative thinking, collaboration, communication, and critical thinking) (Silber-Varod et al., 2019). As times progress, people in a country are encouraged to be able to compete by providing high-quality human resources. Developed countries will be formed through quality resources. Therefore, the development of a country must be connected to the existence of quality education.

Critical thinking is an essential ability for every student to have in 21st-century learning. Critical thinking ability is the process of assessing an idea by analyzing, synthesizing, and evaluating various information to produce a decision that can be explained using evidence, concepts, and methodology as the basis for making a decision (Danczak et al., 2017; Ennis, 2018; Shively et al., 2018). Critical thinking skills play a role in helping students solve both simple and complex problems and also enable students to be able to obtain the truth about information and events that occur in everyday life (Özelçi & Çalışkan, 2019). Students who think critically will try to conduct reasoning acceptable to reason in understanding and making complex choices. Although Indonesia's students have made strides in their academic achievements, their critical thinking abilities still fall within the low category. To

How to Cite:

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. *Jurnal Penelitian Pendidikan IPA*, 10(3), 149-157. <https://doi.org/10.29303/jppipa.v10i3.6012>

assess progress in mathematics and science among various nations, the International Association for Evaluation of Educational Achievement (IEA) conducts the Trends in International Mathematics and Science Study (TIMSS) every four years. The results of this international study show that Indonesia is at the bottom of the ranking. The tests are aimed at grades four elementary and eight middle schools and are divided into two dimensions: content and cognitive. Indonesia's level of critical thinking abilities among its students can be determined through the cognitive dimension. In 2003, Indonesia was ranked 35th among 46 participating countries. In 2007, the country's ranking was 36th out of 49 countries. In 2011, the ranking fell further to 38th out of 42 countries. By 2015, Indonesia's ranking had dropped to 44th out of 49 participating countries (McComas, 2014). Meanwhile, for the next four years, namely in 2019, Indonesia did not participate. These results are strengthened by research conducted by Widyapuraya et al., (2023), which found that students' critical thinking abilities were in the low category, with an average score of 56.71 in science subjects. Similar research results were also obtained by Oktaviyanti & Fadly (2023), who concluded that the results of students' critical thinking abilities in science learning were in the low category with an average score of 32.5. Based on this explanation, a solution is needed to improve the critical thinking skills of Indonesian students.

Solutions that can be applied to overcome problems: The first thing that must be done is to find out the root of the problem that causes students' critical thinking skills in Indonesia to be low. Various factors influence this problem. The first factor assessments carried out by teachers based on Bloom's taxonomy domain are mostly still limited to domains C1 (memorization) and C2 (comprehension) (Daniati et al., 2018). This type of assessment that uses domains allows students to see what is being asked so that students do not have the opportunity to analyze and think more deeply. The second factor is students' low interest in reading. Reading is the key to obtaining various information. Without reading, students' level of knowledge will be low (Larayba et al., 2022). The third factor is that most learning teachers implement is still one-way, so students cannot explore their abilities (Nurhayati et al., 2022). Choosing the right learning approach and model is very important to improve students' critical thinking skills so that later in the learning process, students will not only hear and take notes on the material provided by the teacher but can also think at a higher level, especially critical thinking.

Socio-scientific issues, abbreviated as SSI, are problems in life that are unclear and connected with science. SSI is controversial and complex because it does not have a definite answer to solve it not only with

science but also involves social aspects (Chang et al., 2016; Garrido Espeja & Couso, 2020; Kilinc et al., 2017; Sadler et al., 2016). SSI-based learning has developed rapidly over the last 15 years (Hancock et al., 2019). Learning with SSI involves students in discussions that provide a humanistic and normative context related to science (Erman et al., 2022; Herman, 2018; Ke et al., 2021; Khishfe et al., 2017). SSI can increase students' science knowledge (Chang et al., 2018), motivation and interest in learning about science (Nam & Chen, 2017; Wang et al., 2018). Apart from that, through SSI, students are trained to develop their ability to think complexly to solve fundamental problems (Balgopal et al., 2017; Baytelman et al., 2020; Ke et al., 2020; Wang et al., 2017). SSI applied in learning is generally related to problems that occur in society, for example, genetically modified food, environmental pollution, energy crisis, healthy living, and global warming (El Arbid & Tairab, 2020; Genisa et al., 2020; Lee et al., 2020).

SSI has many advantages when applied in learning, especially science learning. Current SSI research trends continue to develop. However, no one has discussed what learning models can be combined with the SSI approach, the types of instruments used to measure students' critical thinking abilities after implementing learning using the SSI approach, learning materials in science that can be taught to students using the SSI approach, and the impact of the SSI learning approach on students' critical thinking abilities. Therefore, it is necessary to carry out a systematic literature review to analyze the application of the SSI approach in science learning.

Method

The method used in this research is a systematic literature review. A systematic literature review reviews scientific articles that include substantive findings, theoretical contributions, and methodology on a topic being studied. The flow of the systematic literature review can be seen in Figure 1 (Van Klaveren & De Wolf, 2019).

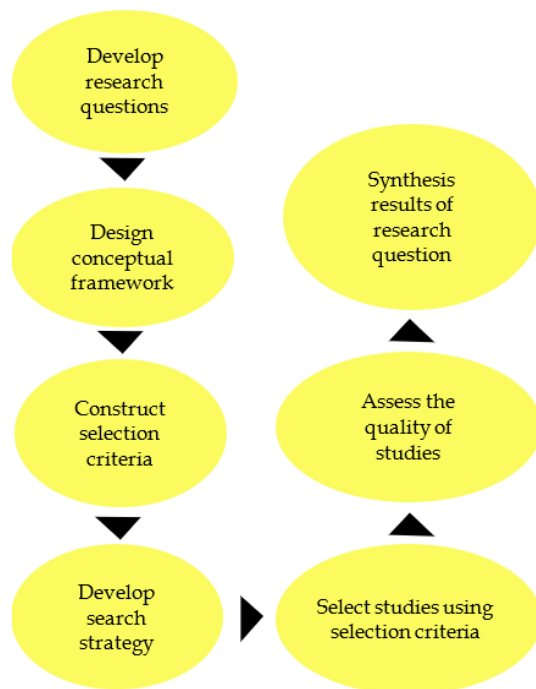


Figure 1. Systematic review process

Further explanation regarding the systematic literature review process is as follows:

Develop research question

At this stage, research questions are prepared to make it easier to answer the research objectives.

Table 1. Research question

Research Question	Purpose
Can applying the SSI approach in science learning improve students' critical thinking abilities?	To determine the influence of the SSI approach in science learning on students' critical thinking abilities
What are the results of students' critical thinking abilities after learning to apply an SSI approach?	To find out the results of critical thinking skills after applying the SSI approach
What instruments are used to measure students' critical thinking abilities?	To find out the instruments used to measure students' critical thinking abilities
What material is taught to students using the SSI approach?	To find out what material is taught to students using the SSI approach

Design conceptual framework

At this stage, a conceptual design is carried out to describe the variables in the research. The conceptual design can be seen in Figure 2.

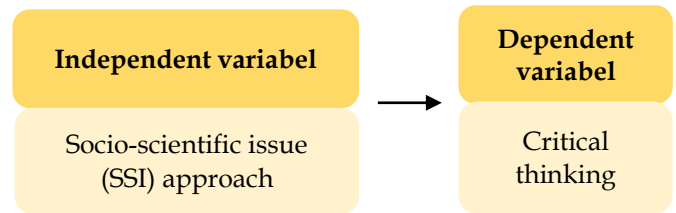


Figure 2. Conceptual framework

Construction selection criteria

At this stage, the criteria for articles to be reviewed are determined. Based on the research objectives, the criteria are as seen in Table 2.

Table 2. Article criteria

Aspect	Criteria
Criteria for accepted articles	<ul style="list-style-type: none"> The application of the SSI approach in science learning has an impact on critical thinking skills. Articles published in January 2016 – December 2022. Sinta accredited articles 1-3
Criteria for rejected articles	<ul style="list-style-type: none"> Articles that do not meet the criteria. Articles published before January 2016 Sinta 4-6 accredited articles and those that have not been accredited

Develop search strategy

At this stage, we determine how to search for articles. Article searches used the address <https://sinta.kemdikbud.go.id/> and Publish or Perish using several keywords, namely "Socio Scientific Issue," "SocioScientific Issue," "Socio-Scientific Issue," "SSI," "critical thinking," "critical thinking skills."

Select studies using selection criteria

At this stage, articles are selected using predetermined criteria.

Assess the quality of studies

The articles obtained are based on predetermined criteria and then reviewed based on the quality of the articles. The selection of article quality is based on the following statements.

Table 3. Questions to assess the quality of the article

No	Question	Purpose
QA1	Does the article title include the SSI approach and learning model used?	To find out whether the article title contains the SSI approach and the learning model used
QA2	Are the research methods used following the purpose of writing this article?	To find out whether the method used is appropriate for writing this article.

Result and Discussion

Select studies using selection criteria

Based on the results of the review via <https://sinta.kemdikbud.go.id/> using the keywords "Socio Scientific Issue," "SocioScientific Issue," "Socio-Scientific Issue," "SSI," "critical thinking," "critical thinking skills," "A total of 301 articles were obtained. The article is then reviewed according to previously determined criteria. These criteria are: 1) The application of socio-scientific issues influences critical thinking skills in science learning; 2) Accredited by Sinta 1-3; and 3) articles published in January 2016 - December 2022. The results of the review obtained 10 articles that met these criteria.

Assess the quality of studies

The article is evaluated by thoroughly examining each section. The selection process is conducted by referring to previously prepared statements. SSI in this research is a learning approach, so a learning model is needed to apply it. A review of 10 articles shows that 5 articles contain the SSI approach and learning model used. Meanwhile, the other 5 articles did not mention the learning model used and only mentioned the SSI approach.

Table 4. Learning approaches and models

Approach	Learning Models
SSI	Problem-based learning (PBL)
SSI	Group investigation (GI)
SSI	Problem-solving

Each article in the analysis used different research methods, but had the same objective - to determine how applying a socio-scientific issue approach affects students' critical thinking abilities in science learning. Out of the 10 articles analyzed, one article did not align with the research in this journal. The unsuitable articles were caused by the use of R&D methods. The use of RnD

Table 5. List of analyzed articles

Article Title	Publisher	Index
Application of the problem based learning model based on socio-scientific issues (SSI) to the critical thinking abilities of junior high school students	JIPVA (Jurnal Pendidikan IPA Veteran)	Sinta 3
Implementation of the socio-scientific issue approach with the investigative group learning model to improve students' critical thinking skills on environmental change materials	Jurnal Penelitian Pendidikan IPA	Sinta 2
Problem-based learning based on socio-scientific issues to develop students' critical thinking and communication skills	Journal of Innovate Science Education	Sinta 3
The effectiveness of problem based learning (PBL) based socioscientific issue (SSI) to improve critical thinking skills	Studies in Learning and Teaching	Sinta 2
The critical thinking skills on global warming issue: effect of the socio-scientific problem approach on problem solving towards student's	Biosfer: Jurnal Pendidikan Biologi	Sinta 2

in this article is limited to expert validation, so it is not yet possible to know the effect of applying a socio-scientific approach to critical thinking skills. Meanwhile, the other nine articles are appropriate. For articles that follow the objectives of this research, the method often used is quasi-experiment. Quasi-experiment is a method that is usually recommended in experimental study. Most quasi-experiments use a pretest-posttest control group design. Additionally, some articles use RnD, true experiments, and there are articles that do not explain the type of method used.

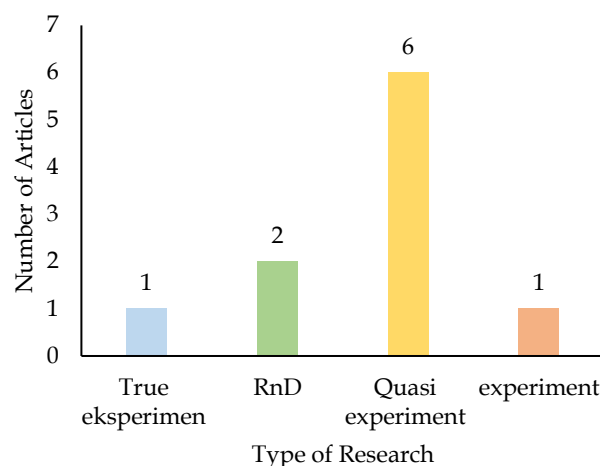


Figure 4. Socio scientific issue research method

Based on the results of the assessment of the quality of the study articles by answering two questions (QA1 and QA2) five articles were obtained, which could be analyzed at the next stage, namely the synthesis of the results.

Synthesis results

Synthesis results are the stage for answering research questions. Synthesis was carried out on five articles that had gone through several stages of review using various criteria.

Based on the results of a review of 5 articles, applying the socio-scientific issue approach can improve students' critical thinking skills in science learning (Fita et al., 2021; Jariah & Aminatun, 2022; Nurhayati et al., 2022; Utomo et al., 2020; Wilsa et al., 2017).

Article 1, written by Utomo et al., (2020). During the study of environmental pollution material, research was conducted with the participation of an experimental group and a control group. The experimental group received treatment through problem-based learning (PBL) based on SSI, while the control group used conventional learning methods. Critical thinking skills were evaluated using an instrument consisting of five essay questions that were designed based on critical thinking indicators according to Peter A. Facione. The results revealed that the experimental group had a higher average score compared to the control group. The experimental group scored an average of 71.66, while the control group scored an average of 64.14. The critical thinking indicator with the highest average value is "providing further explanation," with an average of 18.18%. Learning about SSI teaches students about controversial issues in society that are related to science. Students are introduced to think deeply to solve problems related to these issues so that critical thinking skills can improve.

Article 2, written by Jariah & Aminatun, (2022). In this study, we aim to assess the critical thinking abilities of students in two different groups: the experimental group and the control group. The experimental group used a group investigation learning model with an SSI approach, while the control group followed conventional learning methods. The study was conducted while teaching environmental change materials. The instrument used is a written test in an essay consisting of 10 questions. The questions are arranged based on the indicators analyzing (C4), evaluating (C5), and creating (C6). The research results showed that the experimental class had a higher critical thinking score of 70.10, while the control class obtained a score of 62.86. The results were higher in the experimental class because the treatment given made students more creative, critical, and active in group learning to find answers to problems presented by the teacher regarding controversial issues through activities of investigating problems, collecting data, and communicating results.

Article 3, written by Wilsa et al., (2017). This research was carried out while studying biodiversity material. There are two classes used in this research, consisting of control and experimental classes. Learning in the control class uses the lecture method, while the experimental class uses PBL based on SSI. The number of meetings in this study was eight times. The instrument used is a written test in an essay consisting

of 10 questions. The questions are arranged based on critical thinking indicators, according to Robert Hug Ennis. The results showed that at meetings 1-8, students' critical thinking abilities improved in both classes. However, the improvement in the experimental class was better than the control class. The highest increase in the average score of students' critical thinking abilities was at the 8th meeting. The score obtained by the experimental class at the 8th meeting was 73.9, while the control class was 65.4. Students' critical thinking abilities in experimental classes are higher because PBL based on SSI makes students active in learning through problem-solving activities that involve deep thinking to find answers to these problems so that students' critical thinking abilities can increase. In contrast to learning through the lecture method, students are less able to develop critical thinking skills because they only listen and take notes on the material presented by the teacher.

Article 4, written by Fita et al., (2021). This research was conducted involving two classes. Both classes were given the same treatment, namely implementing PBL based on SSI. The learning material taught to students during study is not written in the article. The instrument used to measure students' critical thinking abilities is a written test in the form of an essay. The indicators used in preparing the questions are not written in the article. The results showed that both classes had identical average post-test scores. The first class got a score of 76.17, while the second class got a score of 78.00. Based on these results, it is known that applying PBL based on SSI improves critical thinking skills in both classes. This learning makes students active in learning activities through discussions with peers and teachers to exchange opinions on controversial issues in everyday life.

Article 5, written by Pauzi & Windiaryani, (2021). This research was carried out when studying global warming material. There were two classes used in the research, consisting of control and experimental classes. The learning control class applies direct learning, while the experimental class applies an SSI approach with a PBL model. The instrument used in the research was written as an essay totaling nine questions. The questions are prepared based on critical thinking indicators, according to Robert Hug Ennis. The research results showed that the experimental class had a higher score of 65.16 than the control class, which scored 50.87. The critical thinking indicator with the highest average score is "analyzing questions". Students in the experimental class scored higher than those in the control class because they were equipped with critical thinking skills through activities that involved analyzing problems in daily life situations. Students can actively seek and process information to explore positive and negative impacts to make good decisions regarding controversial issues in society.

SSI cannot be answered definitively through "yes" or "no" answers procedurally and conceptually related to science. The results of the review of 5 articles align with several studies which state that learning with SSI makes students active in learning through various activities and in-depth thinking to make the right decisions by considering moral, ethical and social aspects (Kärkkäinen et al., 2017; Siew & Rahman, 2022; Tsai, 2018; Vázquez-Alonso et al., 2016). Apart from that, students can build their knowledge through interesting social issues related to science as a context for learning (Chadwick et al., n.d.; Jansong et al., 2022; Karakaya & İrez, 2022; Sakamoto et al., 2021; Sutter et al., 2019; Zangori et al., 2017). Controversial issues that develop in society have been proven to be effectively applied as a context in science learning, which makes students active in conducting discussions and putting forward arguments with a scientific background (Christenson & Chang Rundgren, 2015; Karpudewan & Roth, 2018; Topçu et al., 2018). Students involved in socio-scientific issues can conduct activities by manipulating variables, creating experimental designs, and collecting various data sources for further investigation (Schenk et al., 2021; Wang et al., 2018). Learning that gives students the freedom to think openly and broadly will allow them to hone their critical thinking.

Conclusion

Based on the results of research based on a review of 5 articles obtained from selection results using various criteria, applying the SSI approach in science learning can improve students' critical thinking abilities. Assessing the ability to think critically involves administering a pre-test and a post-test that consists of essay questions, which are organized according to critical thinking ability indicators. The material taught to students using an SSI approach includes environmental pollution, environmental change materials, biodiversity, and global warming. SSI approach can be applied to various learning models, such as problem-based learning, group investigation, and problem-solving.

Author Contributions

The main author, Nida Dusturia, contributed to the idea and drafting of the article. The second and third authors, Sabar Nurohman and Insih Wilujeng contributed to directing and providing input in preparing the article.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

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