Socioscientific Issue-Based Science Learning: How It Relates to Sustainable Education?

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Abstract

Education for Sustainable Development can be developed by incorporating key sustainable development issues included in the Socioscientific issue (SSI). In science learning, SSI can help students contribute to decision-making, understand the nature of science, gain experience in discussing controversial issues, and increase their environmental awareness. The research surveyed the implementation of science teachers' SSI-based science learning (Biology / Physics / Chemistry). The research population was 39 high schools in Banyumas Regency, consisting of 14 public and 25 private high schools. The research subjects were science teachers (biology/physics/chemistry) and students in those high schools—sample collection using simple random sampling. Data collection instruments used include questionnaires, interview sheets, and observation sheets. Data collection methods include Surveys, interviews, and observation. The data analysis is carried out in three ways: data reduction, data presentation, and verification/conclusion. The data analysis technique was carried out using the percentage technique. The results showed that the profile of SSI-based science learning in high schools in the Banyumas district, both in public and private high schools, is in the excellent category with a percentage value of 84.5%, which means that high school teachers in the Banyumas district have integrated SSI well into classroom learning activities. Aspects of design elements in SSI-based learning have an average percentage of 86.7% (excellent), aspects of student experience have an average percentage of 83.1% (excellent), and aspects of teacher attributes have an average percentage of 83.6% (excellent).

Keywords: education for sustainable development, socioscientific issue, science learning

1. Introduction

The Merdeka Belajar Curriculum is a new policy issued by the Ministry of Education and Culture that is a step in transforming education to realize Indonesia's excellent human resources with the character of the Pancasila Student Profile. The Merdeka Curriculum is designed to develop simple, flexible principles that are easy to implement and focus on developing students' competencies and characters (Wahyudin et al., 2024). The Merdeka Curriculum is designed to encourage learners' creativity, problem-solving, collaboration, and life skills that are relevant to real-world needs, so that the Merdeka Curriculum provides opportunities for learners to develop sustainable skills (Vioreza et al., 2023). In the context of the Sustainable Development Goals (SDGs), empowering the Merdeka Curriculum can integrate the principles and values of sustainable development through education, known as Education for Sustainable Development (ESD). The ESD program can encourage learners to acquire the knowledge, skills, attitudes, and values needed to shape a sustainable future (Shulla et al., 2020).

ESD programs can be developed by incorporating key sustainable development issues into teaching and learning, such as climate change, disaster risk reduction, and biodiversity issues (Shulla et al., 2020), which are included in the Socioscientific issue (SSI). SSI represents significant social issues related to science in social aspects (Anagün & Özden, 2010). SSI can describe social problems related to the conceptual context of science, procedural science, or technology. SSI can also be a complex and controversial societal issue with substantive connections to scientific ideas and principles (Zeidler, 2014). Applying SSI in learning facilitates learners' ability to make decisions relevant

to everyday life (Kinskey & Zeidler, 2021).

Applying SSI in learning encourages students to discuss and develop solutions to various problems in science-related aspects of life (Sıbıç & Topçu, 2020). In general, SSI is controversial and dilemmatic, so in solving SSI problems, students should consider moral and ethical reasoning when making the right decision (Rahayu, 2019). The resolution of SSIs allows many solutions to emerge (Sadler, 2011). Decision-making related to SSI is essential in developing students' scientific literacy. Using SSI in learning does not separate the understanding between what is being learned and what happens in the environment (Sadler, 2011; Saija et al., 2022). Thus, SSI-based learning, especially in science learning, makes students' learning more meaningful (Rahayu, 2019).

SSI-based learning in the ESD framework emphasizes the importance of problem-solving, collaboration, and entrepreneurship skills that can be used to create innovative solutions that support sustainable development and encourage learners' ability to think critically and analytically and make decisions collaboratively (Shulla et al., 2020). The use of SSI in learning has advantages, including providing opportunities for students to convey scientific knowledge, encouraging students to view science as necessary in society, and evaluating how learners view SSI problems (Rundgren et al., 2016).

The benefits of SSI-based learning include increasing science awareness in learners by applying scientific knowledge in everyday life, raising social awareness through reflection reasoning activities, increasing the ability to argue against social phenomena that occur, training critical thinking skills about controversial scientific issues, improving decision-making skills on scientific, social problems at the local and global levels, understanding the nature of science and gaining experience to discuss controversial social scientific issues (Lee et al., 2013). SSI-based learning provides a broad context that can support learners in exploring science content, understanding science issues, linking science to life, and increasing interest and motivation in science among students (Zeidler, 2014).

1.1 Research Problem and Purpose

The socioscientific issue-based science learning profile in Banyumas Regency Senior High School (SMA) has never been mapped. However, the learning outcomes of the Merdeka Curriculum Science contain student competencies to have the ability to be responsive to global issues and play an active role in providing problem-solving for these issues, directed at achieving sustainable development goals (SDGs) (Wahyudin et al., 2024). The research aimed to obtain a profile of the implementation of SSI-based science learning in both public and private high schools in the Banyumas district. The results of the research are expected to be a reflection of the science learning process that has been carried out in schools to achieve sustainable learning goals.

2. Method

The research is descriptive research using the survey method. The study was conducted at senior high schools (SMA) in Banyumas Regency. The research was conducted by observing socioscientific-based science learning (Biology / Physics / Chemistry) implemented by science teachers. SSI-based science learning can be measured using several indicators, including the content of science materials, the use of Socioscientific issues in learning, learning methods, learning media, student attitudes in the classroom, and learning preparation by teachers.

2.1 Research Design

The research procedure is explained through the research flow diagram in Figure 1.

The research procedure begins with determining the population and research samples involving high schools in the Banyumas district, with sampling techniques using simple random sampling. The next step is to prepare research instruments consisting of questionnaires, interviews, and observation sheets. The research was conducted to obtain data on the profile of SSI-based science learning conducted by survey, interview, observation, and documentation methods. The data obtained is then analyzed using triangulation techniques, including data reduction, data presentation, and conclusion drawing using percentage techniques. The analysis results are then used to draw conclusions and disseminate them to other parties through publication activities.

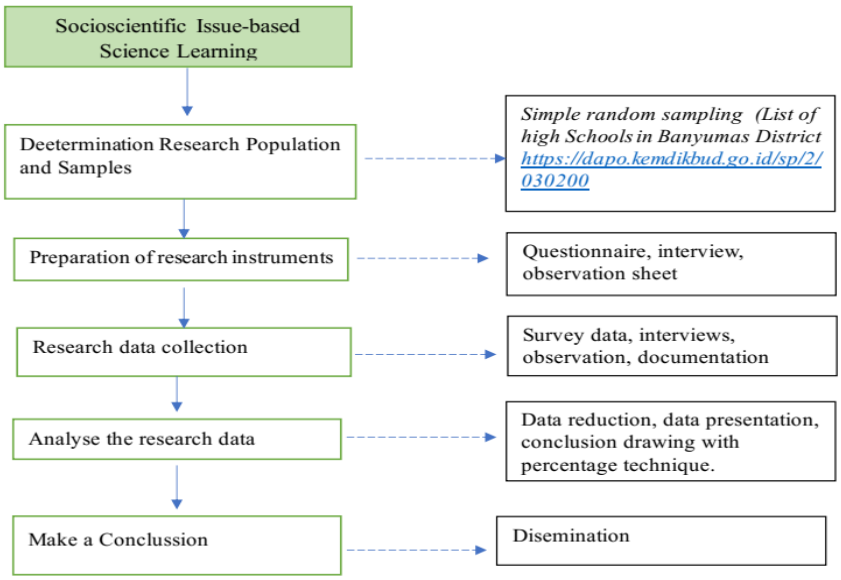

Figure 1. The Research Procedure

2.2.1 Population and Sample

The research population was 39 senior high schools in Banyumas Regency, consisting of 14 public high schools and 25 private high schools (The list of public high schools in Banyumas Regency refers to "Dapodik" data from https://dapo.kemdikbud.go.id/sp/2/030200). The research sampling used a simple random sampling technique. The sample size for descriptive research is at least 10% of the population, but for relatively small populations, at least 20% should be used (Gay et al., 2009). Thus, this study used a sample size of 20%. The schools used for the sample of public high schools include four public high schools in Banyumas Regency, including SMA N 3 Purwokerto, SMA N 1 Patikraja, SMA N 1 Jatilawang, and SMA N 1 Wangon. Schools used for the sample of private senior high schools include: SMA Muhammadiyah 1 Purwokerto, SMA IT Al Irsyad Purwokerto, SMAMuhammadiyah Sokaraja, SMA Kristen Purwokerto, and SMA Jendral Soedirman Purwokerto. Respondents involved in this study consisted of 27 teachers and 234 students.

2.2.2 Research Instrument and Data Collection

The research used questionnaires, observation sheets, and interview sheets as data collection instruments. The data collection method used surveys, interviews, and observations.

The survey was conducted by giving questionnaires to science teachers and students related to SSI-based science learning at school. Filling in the questionnaire for the teacher is done manually by giving the questionnaire directly to be filled in, so that all questionnaires given can be collected again. Questionnaire filling on students is done in class when students finish participating in science learning, and questionnaires are collected collectively with the teacher. Thus, all questionnaires given to teachers and students can be collected again, and no one is left behind.

The interview is a stage of collecting information for research by conducting a question-and-answer interaction process between researchers and informants. Interview activities in the study were carried out after the informant completed the questionnaire filling process. Observation is observing or testing particular objects to obtain facts, data, and values from these objects. Observation activities are carried out by observing the teacher's science learning process in the classroom, including the content of science material, the use of Socioscientific issues in learning, learning methods, learning media, student attitudes in the school, and learning preparation by the teacher.

2.2.3 Data Analysis Technique

The research data analysis was carried out using the triangulation method, which was carried out in three ways: data reduction, data presentation, and verification/conclusion. Data reduction is carried out during the data collection process because the data obtained from the field is very much, so it is necessary to summarise and collect the main parts of the data. For the analysis of the results of filling out the questionnaire, starting with entering the data in the table, summing up the data on each aspect of SSI, comparing the data with the maximum score, and calculating the

percentage of achievement of the SSI aspects. All questionnaire data were calculated using Microsoft Excel. If there is invalid data, the questionnaire filled out by respondents will be repeated in class through teacher assistance so that respondents understand correctly how to fill out the research questionnaire.

Data is presented in graphs, brief descriptions, or relationships between categories. The presentation aims to help readers understand the data or information collected during the incident, draw conclusions, and follow up. The results of the data conclusions are then verified so that they can be accounted for.

The data analysis used the percentage technique shown in Formula (Tersiana, 2018).

$$P= (\sum X \times 100)/N \quad (1)$$

Description:

P = percentage

Σx = number of scores for each aspect

N = the sum of the multiplication of (maximum score x number of respondents x number of each aspect selected)

The data that has been analyzed is then qualified based on the level of achievement according to Table 1.

Table 1. Achievement Level Qualification

No	Achievement level	Qualification
	76%-100%	Excellent
	51% - 75%	Good
	36% - 50%	Not Good
	<35%	Not excellent

3. Results

Effective science learning can help build strong communities and increase awareness of their present and future (Nuangchalerm, 2010). SSI represents significant social issues related to science in social aspects. In SSI-based learning in schools, teachers need to involve the deliberate use of science-related social topics to provide opportunities for students to think critically about the decisions that will be made to solve problems in life (Rahayu, 2019). SSI tasks ensure that students think about the consequences of science on people's lives, thus improving students' decision-making and inquiry skills (Pike, 2007). Through Socioscientific issues brought to the classroom, students learn to be active, informed participants in society and learn coping strategies for a changing world (Reis & Galvão, 2009). The presentation of the SSI-based science learning profile in senior high schools in Banyumas Regency is presented in Table 2.

Table 2. Profile of SSI-based Science Learning in the High School of Banyumas Regency

Implementation in public senior high schools (%)	Implementation in private senior high schools (%)	Average implementation of SSI in senior high schools in Banyumas District (%)
84 (Excellent)	85 (Excellent)	84,5 (Excellent)

Table 2 shows that the profile of SSI-based science learning in Banyumas Regency high schools is in the excellent category, with an average percentage of 84.5%. In public senior high schools, the implementation of SSI-based science learning shows a lower percentage than in private senior high schools. However, both schools show excellent implementation of SSI-based science learning.

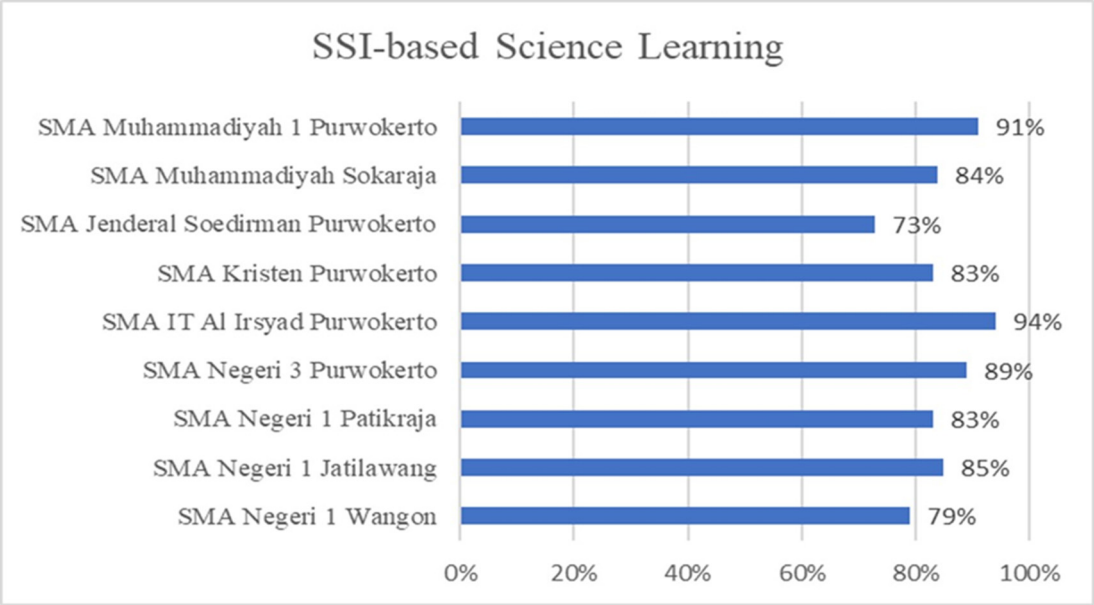

Figure 1. The SSI-based Science Learning Profile in Banyumas Regency High Schools

Figure 1 shows that all senior high schools in Banyumas Regency have implemented SSI-based science learning, as indicated by the percentage value obtained by these schools above 51%. The graph also shows that 89% of schools implement the SSI-based science learning process excellently, and only 11% have implementation still in the good category.

Table 3. SSI-based Science Learning Measurement Indicators

Element (Presley et al., 2013)	Indicators	Value for the implementation of indicators		Average implementation of SSI in senior high schools in Banyumas District (%)	Qualification
		In Public High Schools (%)	In Private High Schools (%)		
Design	Using Socioscientific issues in teaching	92	87	89.5	Excellent
	Socioscientific issues as orientation/stimulus material	85	88	86.5	Excellent
	Provide opportunities for students to solve problems Socioscientific issues	81	92	86.5	Excellent
	Provide opportunities for students to present creative work/ideas/ideas to solve Socioscientific problems Socioscientific issues	88	85	86.5	Excellent
	Use media to facilitate the SSI issues that students must solved by students	88	82	85	Excellent
	Utilise technology to facilitate students' learning experience	85	87	86	Excellent

Table 3. SSI-based Science Learning Measurement Indicators(Continued)

Element (Presley et al., 2013)	Indicators	Value for the implementation of indicators		Average implementation of SSI in senior high schools in Banyumas District (%)	Qualification
		In Public High Schools (%)	In Private High Schools (%)		
Average Design Element Aspect				86.7	Excellent
Experience student	Formulate ideas and make observations to solve social scientific problems. Socioscientific problems	85	82	83.5	Excellent
	Make a hypothesis and try a practice related to SSI problems.	79	76	77.5	Good
	Analyze the data obtained and conclude. Find a solution	88	85	86.5	Excellent
	Relate the solution given to people's lives	85	85	85	Excellent
Average Experience Aspect Students				83.1	Excellent
Teacher attributes	Knows about Socioscientific issues that can be related to the material to be discussed in the meeting	80	84	82	Excellent
	Aware of the social considerations associated with the Socioscientific issues that will be discussed	82	80	81	Excellent
	Opportunities to collaborate with students to solve problems	84	90	87	Excellent
	Ready to risk the impact of learning SSI	82	87	84.5	Excellent
Average Teacher Attribute Aspect				83.6	Excellent

Table 3 shows that the learning aspects of SSI consist of: aspects of design elements, aspects of student experience, and aspects of teacher attributes. Each aspect of SSI learning shows an excellent category with a more than 80% percentage achievement. The highest achievement is in the design element aspect, which shows that 89.5% of teachers have used SSI in learning, which is supported by teachers who are ready to risk the impact of learning SSI. However, the fact is that in the SSI-based learning process, students have difficulty making hypotheses and practising ideas related to SSI problems.

4. Discussion

SSI is a learning approach that presents science material in the context of social issues by involving moral or ethical components (Callahan, 2009). SSI has the content of environmental issues that develop in society in terms of concepts and procedures related to science and influenced by social, cultural, economic, and political aspects (Tal, Kali, Magid, & Madhok, 2011). SSI-based learning is a branch of science, technology, and society. SSI-based learning has a problem-based approach that can be presented through the relationship of science with the real world (Zeidler, Sadler, Simmons, & Howes, 2005).

Table 2 shows that the SSI-based science learning profile in Banyumas Regency high schools is in the excellent category, with a percentage value of 84.5%. Figure 2 shows that teachers in senior high schools in Banyumas Regency have integrated SSI into science learning with good performance. Teachers can do SSI-based learning in

several ways, such as facilitating students to be involved in formulating ideas for solving socioscientific problems by making hypotheses about problem solutions, practising solutions, analysing the data obtained, and making conclusions to determine the effectiveness of the proposed solutions. Applying SSI in learning will lead students to develop solutions from various aspects of life, including science, culture, morals, and other cases (Li & Guo, 2021). Thus, SSI-based learning can develop students' ability to reason, argue, and make decisions (Presley et al., 2013).

The aspects of SSI-based science learning consist of design elements, student experience, and teacher attributes. Table 3 shows that each aspect of SSI learning has an excellent category with more than 80% of achievement.

1) Design elements

The design elements aspect has an average percentage of 86.7% (excellent), which means that science teachers in Banyumas Regency High Schools have implemented SSI-based science learning very well in the classroom learning process. Based on the results of observations and interviews, teachers use SSI in learning as orientation/stimulus materials, such as presenting environmental change issues in Biology subjects, global warming and climate change in Physics subjects, and the use of hazardous chemicals on the environment in Chemistry subjects. The teacher presents SSI by showing videos and pictures or inviting students directly to the environment around the school. The criteria for SSI that can be presented in SSI-based learning include: 1) based on scientific knowledge, 2) at the centre of the media spotlight, 3) generates opinions, 4) is related to local, national and global dimensions, 5) must comply with ethical values, 6) requires an understanding of the opportunities and risks that may arise (Setyaningsih et al., 2019).

SSI stimulates students to develop high-order thinking skills (HOTS) such as reasoning, argumentation, and decision-making (Rahayu, 2019). Learning observations show that teachers provide opportunities for students to develop HOTS skills through student worksheets.

2) Student experience

The aspect of student experience has an average percentage of 83.1% (excellent), which means that teachers have facilitated students to engage in SSI-based science learning through scientific activities such as: making observations to formulate problems, making hypotheses, practicing solutions, analysing data, making conclusions related to solutions, and linking solutions to people's lives. The results of learning observations show that teachers utilise student worksheets to present SSI that students, such as issues about environmental change, must solve. Then, students formulate problems based on SSI. Students formulate relevant hypotheses and engage in the process of finding solutions that support problem-solving. The results of the search for solutions are then analysed to support conclusions. SSI integrated in learning can help students contribute to decision making on local and global issues by linking science to life, providing a context that supports exploring science content, and encouraging students to use science in science problem solving (Lee et al., 2013).

The use of SSI in learning can provide opportunities for students to convey scientific knowledge, encourage students to view science as important, make students more aware of SSI in society, help students improve skills in society, and evaluate how students view SSI that affects people's lives (Rundgren et al., 2016). SSI-based learning also effectively improves students' science literacy (Hofstein, Eilks, and Bybee, 2011; Akbulut & Demir, 2020).

3) Teacher attributes

The aspect of teacher attributes has an average percentage of 83.6% (very high), which means that teachers are ready to implement the SSI-based science learning process because they realise that SSI can be related to the material discussed in class meetings. In SSI-based science learning, teachers must know pedagogy and science content (Presley et al, 2013). The results of interviews with teachers stated that most teachers admitted that they had mastered the fields related to the SSI presented. In contrast, the rest did not dare to mention that they had mastered the field. Some factors that affect teachers' ability to raise SSI issues in the classroom learning process include: 1) lack of resources, such as limited teaching materials and relatively short learning time; 2) teachers are not confident; 3) teachers are not sure they can handle the SSI discussion process in class, and 4) the difficulty of assessing SSI-based learning outcomes (Gustiawan et al., 2023; Tideman & Nielsen, 2016).

Teachers are said to be successful in SSI-based learning if they can help students understand the scientific and social aspects of the issues presented, encourage students in discussion activities, and consider students' arguments from various points of view (Presley et al., 2013). The purpose of using social scientific issues in science learning is to facilitate students ' achievement of decision-making skills, which are the key to success in producing solutions to everyday life problems (Kinskey & Zeidler, 2021; Saija et al., 2022). Thus, implementing an SSI-based learning process is relevant to the objectives of ESD because SSI-based learning within the ESD framework emphasises the importance of problem-solving and collaboration skills, which encourage learners to think critically and analytically

and make decisions to create innovative solutions that support sustainable development.

5. Conclusion

The profile of SSI-based science learning in high schools in the Banyumas district, both in public and private high schools, is in the excellent category with a percentage value of 84.5%, which means that high school teachers in the Banyumas district have integrated SSI well into classroom learning activities. Aspects of design elements in SSI learning have an average percentage of 86.7% (excellent), aspects of student experience have an average percentage of 83.1% (excellent), and aspects of teacher attributes have an average percentage of 83.6% (excellent). Teachers use SSI in learning as orientation/stimulus materials, such as presenting environmental change issues in Biology subjects, global warming and climate change in Physics subjects, and the use of hazardous chemicals on the environment in Chemistry subjects. Teachers have facilitated students to engage in SSI-based science learning through scientific activities such as: making observations to formulate problems, making hypotheses, practicing solutions, analyzing data, making conclusions related to solutions, and linking solutions to people's lives. Most teachers admit that they have mastered the field related to the SSI presented, but the rest do not dare to mention that they have mastered the field, so it is necessary to strengthen the application of SSI-based science learning in schools. The well-implemented SSI-based learning process in schools is relevant to the objectives of the ESD programme because SSI-based learning within the ESD framework also emphasises the importance of problem-solving and collaboration skills used to encourage learners to think critically, analytically, and make decisions to create innovative solutions. Thus, the research results can be further utilised as a foundation for developing ESD programmes in schools, such as strengthening the pedagogical abilities of science teachers through the development of SSI-based science learning models.

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Authors contributions

Mufida Nofiana is responsible for research design and data collection. Listika Yusi Risnani was responsible for data analysis. Mufida Nofiana drafted the manuscript, Listika Yusi Risnani and Dewi Susylowati were responsible for revising the manuscript. All authors read and approved the final manuscript.

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Competing interests

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.