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Implementation of Science Learning Oriented to Socio-Scientific Issues on Ecology and Biodiversity Material in Indonesia to Improve Learning Outcomes and Environmental Awareness Attitudes

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Abstract: Science education at the junior high school level plays a crucial role in developing scientific thinking skills, scientific literacy, and environmental awareness. However, conventional teaching practices often result in low student understanding and limited environmental consciousness. This study aimed to examine the effect of Socio-Scientific Issues (SSI)-based science learning on the cognitive learning outcomes and environmental awareness of seventh-grade students at SMPN 7 Pangkalan Kuras, as well as the relationship between these variables. The study sample consisted of 43 students, divided into an experimental class (21 students) receiving SSI-based learning and a control class (22 students) receiving conventional instruction. Data were collected through written tests (multiple-choice questions) and environmental awareness questionnaires, then analyzed. The results showed that the average cognitive learning outcomes of the experimental class (75.45) were higher than those of the control class (63.81) and students' environmental awareness in the experimental class (75.27) was also higher than in the control class (70.12), indicating that SSI effectively enhances both conceptual understanding and environmental concern. These findings provide valuable reference for teachers in implementing contextual and meaningful learning approaches that foster students' social and ecological responsibility.

Keywords: Ecology and Biodiversity of Indonesia; Environmental Awareness; Learning Outcomes; Science Learning; Socio-Sscientific Issues

Introduction

Education is a universal activity in human life that occurs anytime and anywhere. As stated by (Mardiyah, 2017), education functions as a means to humanize humans and to shape cultured individuals. This aligns with Law No. 20 of 2003, which states that education is a conscious and planned effort to create a learning atmosphere and learning process so that students can actively develop their potential, including spiritual and religious strength, self-control, personality, intelligence, noble character, and skills needed for themselves, society, the nation, and the state. This statement implies that education is not only focused on cognitive aspects but also on character formation. In this process, teachers play a central role in creating a learning environment that can facilitate students in developing their full potential (Fikri et al., 2021)

The quality of a nation's education heavily depends on the quality of its learning processes. According to (Putri et al., 2022), effective learning requires students to be active in constructing knowledge, while teachers act as facilitators and motivators. However, based on findings by (Hastiwi et al., 2023) it is evident that many learning management practices are still suboptimal. The teaching methods used are often monotonous and fail to foster student engagement, which ultimately impacts learning outcomes. This issue poses a significant

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challenge in efforts to improve the quality of education in Indonesia.

Science education (IPA) plays a strategic role in equipping students with scientific literacy and raising awareness of the importance of environmental conservation. Ideally, science learning should not only emphasize mastery of concepts but also connect the material to real-life phenomena encountered in daily life. The main challenge today is how to create science learning that is relevant, contextual, and meaningful, thereby fostering students' environmental awareness amid global ecological crises such as biodiversity loss, pollution, and climate change.

The Merdeka Curriculum, through science learning outcomes, emphasizes the importance of student activity in discovering and applying knowledge to solve real problems ((Kemendikbud, 2024) However, observations at SMPN 7 Pangkalan Kuras show challenges in achieving these goals. About 56.7% of students have difficulty understanding ecology and Indonesian biodiversity, and 46.7% find it challenging due to the need to memorize taught concepts. The average student learning outcome only reached 68.71%, which is still below the KKM standard of 72. This indicates that the teaching methods applied have not optimally supported student understanding.

Moreover, students' awareness of the importance of environmental preservation is still relatively low. According to observations, 83.3% of students only occasionally maintain the cleanliness of the school environment, while 46.7% of students have never expressed ideas or suggestions regarding environmental conservation. The school environment often appears dirty, and activities such as greening programs have not been actively participated in by all students. This condition reflects that science learning has not fully fostered students' awareness and care for their surroundings.

Ecology and Indonesian biodiversity are important topics in science because they discuss the interactions between living beings and their environment, as well as various environmental issues. Real-world problems, such as land-use change and river pollution in Pangkalan Kuras District, as reported by (Ananda, 2025) directly affect ecosystem sustainability and community quality of life. Unfortunately, existing science learning in schools has not fully integrated these local issues, making it difficult for students to connect learned concepts with real phenomena around them.

The Socio-scientific Issues (SSI) approach emerges as a potential solution to these challenges. As (Khozin et al., 2020) state, this approach links science material to real social and environmental issues, thereby enhancing students' critical thinking, problem-solving skills, and environmental awareness. Although this approach has proven effective in various studies, its implementation in ecology and Indonesian biodiversity topics, particularly at SMPN 7 Pangkalan Kuras, has been limited. This shows that efforts to connect science learning with local environmental issues still need to be developed to make it more meaningful for students and to impact their real behavior in environmental preservation.

This study aims to fill that gap by exploring the implementation of SSI-based science learning on ecology and Indonesian biodiversity. The research focuses on strengthening students' understanding of science concepts while fostering environmental awareness through real-world contextual problems around them. This approach is expected to provide a novel contribution to developing contextual, relevant science learning that positively influences students' environmental behavior.

Method

The research design employed in this study was a posttest-only group design. This type of research is categorized as descriptive quantitative research with a pre-experimental design approach. The study was conducted at one of the public junior high schools, SMP Negeri 7 Pangkalan Kuras, in the 2024/2025 academic year. The research subjects consisted of 43 seventh-grade students.

The data collection methods used in this study included a test method, aimed at measuring students' cognitive learning outcomes, and a non-test method in the form of a questionnaire, intended to assess students' environmental care attitudes. Both the cognitive learning achievement test instrument and the environmental care attitude questionnaire had undergone validity and reliability testing. The indicators of cognitive learning outcomes are presented in Table 1.

Table 1. Cognitive Learning Outcome Indicators

Category	Number of Items
C3 (Applying)	6
C4 (Analyzing)	6
C5 (Evaluating)	5
C6 (Creating)	3

Table 1. The test instrument only covered the cognitive levels of C3–C6, as this study focused on measuring Higher Order Thinking Skills (HOTS), which emphasize the abilities to apply, analyze, evaluate, and create. The cognitive learning achievement test items were in the form of objective questions, with the data analysis technique for cognitive learning outcomes described as follows:

$$\text{Score} = \frac{Total\ Student's\ Obtained\ Score}{Maximum\ Score} \times 100 \quad (1)$$

To determine the level of students' cognitive learning outcomes, the analysis was carried out using the criteria presented in Table 2.

Table 2. Interval and Categories of Cognitive Learning Outcomes

Percentage Interval (%)	Category
82 ≤ x < 100	Very Good
71 ≤ x < 81	Good
60 ≤ x < 70	Fair
49 ≤ x < 59	Poor
≤ 49	Very Poor

(Arikunto, 2010)

The indicators of students' environmental care attitude are presented in Table 3.

Table 3 Indicators of Students' Environmental Care Attitude

Category	Number of Items
Environmental Care	6
Waste Management by Type	5
Carbon Emission Reduction	5
Energy Conservation	5
Tree Planting	5
Utilization of Recycled Materials	4

Adapted (Irfianti et al, 2016)

The data on students' environmental care attitude were collected through a questionnaire consisting of 15 items, which were adapted from the indicators of environmental care attitude. The percentage score was analyzed using the scoring data obtained from the rubric, calculated with Formula 2.

$$\text{Score} = \frac{Total\ Student's\ Obtained\ Score}{Maximum\ Score\ x\ Number\ Of\ Students} \times 100 \quad (2)$$

Table 4. Percentage Interval and Category of Environmental Care Attitude

Percentage Score (%)	Category
85 < P ≤ 100	Very High
70 < P ≤ 85	High
55 < P ≤ 70	Moderate
40 < P ≤ 55	Low
0 ≤ P ≤ 40	Very Low

(Nilam & Yenti, 2023)

Result and Discussion

The posttest of cognitive learning outcomes was conducted with the aim of obtaining sample scores from both classes, namely the experimental class, which was given treatment through the implementation of science learning oriented to socio-scientific issues (SSI), and the control class, which received conventional learning. The cognitive learning outcome test consisted of 20 objective items. This test was administered after the implementation of SSI-oriented science learning in the experimental class and scientific approach-based learning in the control class. The achievement results of the cognitive learning outcome categories for each student in the experimental and control classes were also interpreted, as shown in Figure 1.

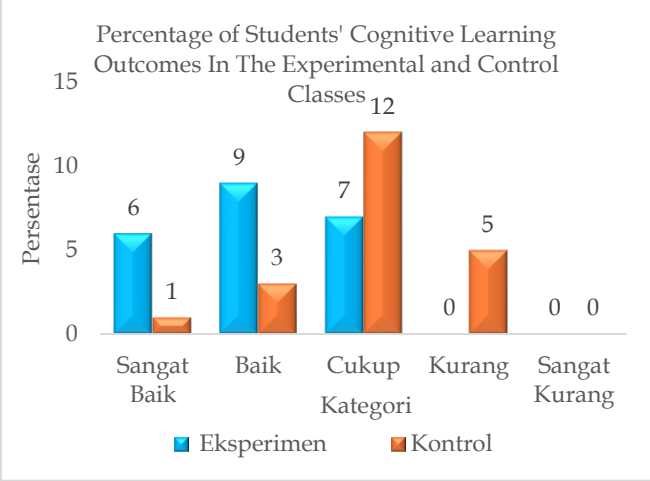

Figure 1. Percentage of Students' Cognitive Learning Outcomes In The Experimental and Control Classes

Based on Figure 1, the cognitive learning outcomes of students in the experimental class show that 27% fall into the very high category, 41% in the high category, and 32% in the moderate category, with no students in the low or very low categories. Meanwhile, in the control class, 5% of students fall into the very high category, 14% into the high category, 57% into the moderate category, and 24% into the low category, with no students in the very low category. This indicates that the implementation of socio-scientific issue (SSI)-oriented science learning can improve students' learning outcomes, as shown by the higher proportion of students in the very high and high categories in the experimental class, whereas in the control class, the majority of students were in the moderate category and some students remained in the low category.

The superiority of cognitive learning outcomes in the experimental class was attributed to the implementation of the socio-scientific issues (SSI) approach, which was able to integrate science concepts with contextual issues, thereby encouraging active student engagement, deepening conceptual understanding, and strengthening critical thinking skills. The findings of this study are in line with (Silvia et al., 2024) who stated that the use of SSI-based e-modules is effective in improving critical thinking skills.

This is also supported by (Rohmaya, 2022) who showed that the SSI approach significantly contributes to enhancing scientific literacy and science learning outcomes. Furthermore, a systematic review by (Subiantoro, 2020) emphasized the consistent effectiveness of the SSI approach in developing learning outcomes and higher-order thinking skills. In line with this, (Mudawamah, 2020) also found that the implementation of the Problem-Based Learning (PBL) model oriented toward SSI was able to strengthen students' scientific literacy. Thus, the results of this study confirm previous findings that the SSI approach is more effective than conventional learning in improving students' cognitive learning outcomes. Students' cognitive learning outcomes for each aspect studied are presented in Table 5.

Table 5. Students' Test Results on Each Indicator

Cognitive Level	Experimental Class		Control Class	
	Mean	Category	Mear	Category
C3 (Applying)	82.58	Very Good	72.22	Good
C4 (Analyzing)	74.24	Good	61.90	Fair
C5 (Evaluating)	78.18	Good	62.86	Fair
C6 (Creating)	59.09	Poor	52.38	Poor
Mean	75.45	Good	63.81	Fair

The results of the study indicate that the implementation of science learning oriented toward socio-scientific issues (SSI) significantly contributes to improving junior high school students' cognitive learning outcomes across four cognitive levels. At the C3 (Applying) level, students in the experimental class achieved an average score of 82.58%, while students in the control class only reached 72.22%. The higher average in the applying indicator for the experimental class demonstrates that SSI-based learning not only strengthens conceptual mastery but also significantly enhances students' ability to apply scientific knowledge in real-life contexts, in line with the main goals of 21st-century science education.

The cognitive level C4 (Analyzing) also showed a significant improvement. The experimental class obtained an average score of 74.24%, which was higher than the control class that only reached 61.90%. The socio-scientific issues (SSI) approach is a learning strategy for teaching science that situates scientific knowledge within social issues, thereby requiring students to engage in dialogue, discussion, and debate (Shoba et al., 2023). SSI contains elements that demand a standard of moral reasoning in order to arrive at decisions regarding possible solutions to the problems presented. According to (Hwang et al., 2023) the selected socio-scientific issues should be current, controversial, relevant to students, related to scientific content, and feasible to be openly discussed among learners.

The cognitive level C5 (Evaluating) showed the dominance of the experimental group with an average score of 78.18%, compared to the control group, which only achieved 62.86%. This achievement reflects that students in the experimental class had better abilities in assessing, comparing, and making decisions based on scientific arguments and relevant data. The ability to evaluate is closely related to higher-order thinking skills, which are fostered through relevant and authentic learning contexts. This is line with the finfings of (Shoba et al., 2023) who emphasized that SSI challenges students to make both moral and scientific judgments on complex issues, thereby enhancing their ability to make well-considered and responsible decisions. In addition, according to (Siska et al., 2020), students engaged in SSI-based learning demonstrated significant improvement in their skills to evaluate arguments and scientific evidence, as they became accustomed to reflective and analytical thinking activities when dealing with real-world issues.

The average achievement at the cognitive level C6 (Creating) in both classes is still categorized as low, with the experimental class showing a slightly higher result (59.09%) compared to the control class (52.38%). This indicates that the Socio-Scientific Issues (SSI) approach applied in the experimental class has begun to influence students' ability in the aspect of creating, although it has not yet reached an optimal level. The SSI approach places students in situations that encourage them to take on roles as decision-makers and problem solvers—two critical roles in fostering creative abilities. According to research by (Shoba et al., 2023), SSI creates learning conditions in which students are motivated to generate authentic solutions to complex socio-scientific issues that do not have a single correct answer. This fosters creativity and the synthesis of ideas. Similarly (Zhao & Wang, 2022) found that issue-based contextual learning enhances students' motivation and creativity, as they feel a sense of social responsibility in problem-solving.

The student environmental care attitude questionnaire was conducted with the aim of identifying the tendencies of environmental care attitudes among students in the experimental and control classes after the treatment was given. The instrument used was a questionnaire consisting of 30 statements. The questionnaire on students' environmental care attitudes was developed based on six indicators, namely Environmental Maintenance, Waste Management According to Type, Carbon Emission Reduction, Energy Conservation, Tree Planting, and the Utilization of Recycled Materials. The data from the environmental care attitude questionnaire for both experimental and control classes were also interpreted based on categories, as shown in Figure 2.

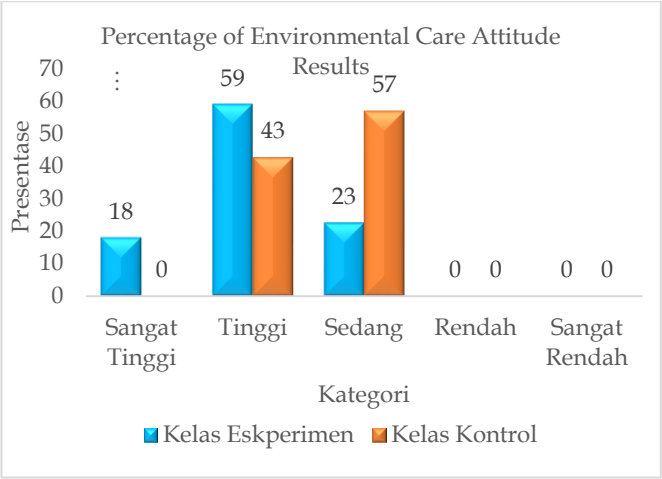

Figure 2. Percentage Distribution of Students' Environmental Care Attitudes By Category

Based on Figure 2, it can be seen that the students' environmental care attitudes in the experimental class are distributed as follows: 18% of students fall into the very high category, 59% into the high category, 23% into the moderate category, and 0% into the low and very low categories. Meanwhile, in the control class, the results show 0% of students in the very high category, 43% in the high category, 57% in the moderate category, and 0% in both the low and very low categories.

These differences indicate that science learning using the *Socio-Scientific Issues* (SSI) approach applied in the experimental class is more effective in fostering and enhancing students' environmental care attitudes. This is because the SSI approach presents real-world issues related to the environment, such as forest fires, human–wildlife conflicts, and habitat destruction. Such issues encourage students to reflect on environmental values and actively formulate solutions through meaningful discussions, analyses, and group projects (Shoba et al., 2023).

In addition to understanding science concepts, students are also engaged in affective activities such as attitude reflection, value-based decision-making, and real environmental actions, which make the learning process more personal and contextual. For instance, in the student worksheet (LKPD), students are asked to identify conservation measures that can be taken to protect elephants from extinction. Furthermore, they analyze the impact of human activities on ecosystems and the surrounding environment. These processes foster empathy, moral responsibility, and environmental awareness, which directly contribute to the improvement of students' environmental care attitudes.

According to (Mudawamah, 2020), student engagement in learning based on socio-scientific issues can strengthen moral reflection and social values, which are essential in the development of attitudes. Meanwhile, (Hodson, 2020) states that the emotional and social context in SSI can enhance students' attachment to environmental issues, thereby motivating them to engage more actively and demonstrate greater concern. The students' environmental care attitudes for each indicator examined in the experimental and control classes are presented in Table 6.

Table 6. Results of Students' Environmental Care Attitude Questionnaire on Each Indicator

Environmental Care Attitude Indicator	Experimental Class		Control Class	
	Mean	Category	Mean	Category
Environmental Care	80.87	High	75.00	High
Waste Management by Type	76.14	High	69.52	Moderate
Carbon Emission Reduction	74.09	High	71.43	High
Energy Saving	68.64	Moderate	65.48	Moderate
Tree Planting	77.95	High	71.43	High
Utilization of Recycled Materials	72.16	High	65.18	Moderate
Mean	75.27	High	70.12	Moderate

Based on Table 6, the questionnaire results show that students' environmental care attitudes in the experimental class were generally in the high category (average 75.27%), while in the control class they only reached the moderate category (average 70.12%).

This difference reflects that science learning using the Socio-Scientific Issues (SSI) approach applied in the experimental class was more effective in shaping and enhancing students' environmental care attitudes. Learning with the SSI approach presents real issues related to the environment, such as forest fires, human–wildlife conflicts, and habitat destruction, which encourage students to reflect on environmental values and actively formulate solutions through meaningful discussions, analyses, and group projects (Wardani et al., 2024a).

The results for the environmental care indicator show a significant difference between the experimental and control classes. The experimental class achieved an average score of 80.87%, which was higher than the control class with 75.00%. This indicates that the implementation of science learning oriented toward Socio-Scientific Issues (SSI) was more effective in enhancing students' environmental care on the environmental care indicator. SSI-oriented science learning fosters the development of *ecological literacy*, namely the ability to understand the relationship between human activities and natural systems, as well as the willingness to take responsible action (Siska et al., 2020). Students learn that simple behaviors such as not littering, taking care of plants, and reducing waste can have a positive impact on the environment. When

students are able to reflect on the relationship between scientific knowledge and its socio-environmental impacts, they become more aware that caring for the environment is not only an individual responsibility but also a shared responsibility within community life (Vioreza et al., 2023).

The indicator of environmental awareness in the aspect of waste management according to its type is higher in the experimental class (76.14%) compared to the control class (69.52%). This increase reflects the success of the Socio-Scientific Issues (SSI) approach in shaping students' awareness and behavior regarding the importance of sorting waste by type. Science learning oriented toward Socio-Scientific Issues trains students to make ethical decisions on complex issues, including waste management. As stated by (Hanifah et al., 2021) SI positions students as agents of change who not only understand scientific concepts but also recognize the social and environmental impacts of their actions. When students are given the space to analyze problems and formulate solutions, such as promoting the 3R movement (Reduce, Reuse, Recycle), they become more caring and actively engaged in environmentally friendly practices (Jasim et al., 2025).

The indicator of carbon emission reduction is higher in the experimental class (74.09%) compared to the control class (71.43%). Although the difference is relatively small, it still reflects that the Socio-Scientific Issues (SSI) learning approach has a more positive impact on students' awareness of reducing carbon emissions. The SSI approach also provides a strong social and moral context in science learning. Students not only understand the relationship between carbon emissions and global warming but also recognize the social and ecological impacts of human actions on the sustainability of the Earth (Wardani et al., 2024b). According to (Macalalag et al., 2024) SSI-based learning encourages students to consider the ethical and environmental consequences of their choices, ultimately influencing changes in attitudes.

The indicator of energy conservation shows a significant difference between the experimental and control classes. The experimental class achieved an average score of 68.64%, while the control class only scored 65.48%. Although both values are still in the moderate category, this score gap reflects the positive influence of SSI-based learning on students' environmental awareness, particularly in the wise use of energy. According to (Hwang et al., 2023) the SSI learning approach helps students understand the complexity of scientific issues related to energy use. Similarly, (Shoba et al., 2023) state that discussions and analyses of environmental problems through SSI can foster social awareness and responsible behavior in students. Furthermore, (Jasim et al., 2025), note that active involvement in solving environmental problems through contextual learning increases students' motivation and ecological awareness, including in the aspect of energy conservation.

The indicator of tree planting shows a significant difference between the experimental and control classes. The experimental class achieved an average of 77.95%, while the control class only scored 71.43%. This difference confirms that the Socio-Scientific Issues (SSI) approach is more effective in enhancing students' ecological awareness regarding the importance of greening and biodiversity conservation. Students' involvement in SSI-oriented learning activities also strengthens the affective and conative dimensions of environmental education. Beyond theoretical understanding, students demonstrate increased emotional sensitivity to environmental conditions and a willingness to take action. As explained by (Subiantoro, 2020), one of the strengths of the SSI approach lies in its ability to develop students' scientific character and social responsibility. In this study, one form of concrete action taken was tree-planting practices in the school environment and around students' homes. This activity serves as an applied avenue for the material studied while internalizing values of environmental concern.

The indicator of environmental awareness in the aspect of utilizing used items is higher in the experimental class (72.16%) compared to the control class (65.18%). This difference indicates that the Socio-Scientific Issues (SSI) learning approach is more effective in fostering students' awareness of the importance of reducing waste by recycling and reusing materials. The SSI approach can enhance students' awareness of environmental issues and motivate them to take socially and ecologically responsible actions, such as practicing recycling and waste reduction (Wardani et al., 2024). Moreover, students learning in an SSI context usually feel a moral responsibility toward the solutions they develop. This contrasts with conventional learning, which tends to be more theoretical. (Abrica et al., 2024) emphasize that a social-scientific issue-based approach can build emotional attachment and personal values toward the environment, forming a strong foundation for concrete actions such as repurposing used items for personal or social benefit.

Conclusion

This study demonstrates that Science learning based on Socio-Scientific Issues (SSI) is more effective than conventional learning in improving students' cognitive learning outcomes and environmental awareness. The average cognitive learning outcome of the experimental class reached 75.45% (good category), higher than the control class at 63.81% (fair category),

with notable achievements at C3, C4, and C5 levels. Students' environmental awareness in the experimental class was also higher (75.27% / high category) compared to the control class (70.12% / moderate category), with advantages across all indicators examined. Therefore, SSI-based learning is proven to enhance conceptual understanding while significantly fostering environmental concern.

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