



Climate Change Education and Ethical Reasoning: Exploring Students' Responses to Socio-Scientific Issues

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Abstract

Climate change is a complex scientific and social issue that requires students to understand scientific evidence while considering ethical and societal consequences. Socio-scientific issues (SSI) can provide meaningful contexts for developing students' scientific understanding, ethical reasoning, and ability to respond to controversial environmental problems. This article aims to examine students' responses to climate change as a socio-scientific issue, with particular attention to ethical reasoning, scientific understanding, and decision-making. A literature review was used to synthesize recent studies on climate change education and SSI-based science learning. The findings indicate that SSI learning can encourage students to consider multiple perspectives, evaluate evidence, discuss competing values, and develop more informed responses to climate-related problems. Therefore, integrating climate change with socio-scientific learning can support both scientific literacy and responsible decision-making.

Keywords: climate change education, ethical reasoning, socio-scientific issues, scientific literacy, student responses

1. Introduction

Climate change has become an important issue in science education because it involves not only scientific knowledge but also social, economic, environmental, and ethical considerations. Students need to understand the scientific basis of climate change while also considering how climate-related decisions affect different groups of people and the environment. This makes climate change an appropriate context for socio-scientific learning (Clark, 2024).

Students' understanding of climate change is influenced by their previous experiences, information sources, and existing scientific conceptions. A recent systematic review found that students commonly hold different ideas about global warming, the greenhouse effect, and the carbon cycle. These findings demonstrate the importance of addressing students' existing ideas when designing climate change education (2024 systematic review).

Socio-scientific issues provide opportunities for students to explore scientific problems that have social and ethical dimensions. Climate change is particularly relevant because decisions concerning energy use, transportation, industry, environmental protection, and adaptation involve competing interests and values. Through SSI-based learning, students can examine scientific evidence while considering different perspectives surrounding the issue (Environmental SSI review, 2024).

Ethical reasoning is important when students respond to climate change because scientific evidence alone does not determine every decision. Students may need to consider questions of responsibility, fairness, environmental protection, and the consequences of different actions. Science education can therefore help students connect scientific knowledge with social justice and ethical considerations when discussing climate change (Clark, 2024).

Classroom dialogue can provide an effective environment for developing students' responses to controversial climate issues. When students discuss real-world problems involving disagreement, they can learn to listen to different perspectives, provide reasons for their views, and reconsider their positions. Such dialogue can strengthen students' participation and engagement with climate-related issues (Using inquiry-based dialogues, 2022).

Argumentation is another important component of SSI learning. When students are asked to construct arguments about climate change, they need to use evidence, justify their claims, and respond to alternative viewpoints. Research involving global warming as an SSI shows that students can demonstrate different levels of argumentation when discussing climate-related issues (Gencer et al., 2024).

Climate change education also needs to consider the educational context in which learning takes place. In Indonesia, climate change has been incorporated into aspects of formal education policy, although research indicates that climate change education remains relatively fragmented and requires stronger coordination between climate policy and education policy (Tang, 2024).

SSI-based learning can also support students' environmental literacy. When climate change is presented through scientific and social contexts, students can connect scientific concepts with environmental problems in their communities. This approach can help students recognize the relevance of science to everyday decisions and environmental responsibility (Cintiati et al., 2024).

Based on these considerations, this article aims to examine students' responses to climate change as a socio-scientific issue. The discussion focuses on students' scientific understanding, ethical reasoning, argumentation, consideration of different perspectives, and decision-making in responding to climate-related problems.

2. Research Method

This article uses a literature review method to examine recent research concerning climate change education, socio-scientific issues, ethical reasoning, argumentation, and students' responses to environmental problems. The literature was analyzed to identify contemporary findings regarding how climate change can be used as a meaningful context for science education (Environmental SSI review, 2024).

The literature was selected based on its relevance to climate change education and SSI-based learning. Particular attention was given to studies discussing students' understanding of

climate change, ethical and social dimensions of climate issues, argumentation, dialogue, environmental literacy, and decision-making (2024 systematic review).

The selected studies were analyzed thematically by identifying recurring findings related to students' scientific understanding, ethical reasoning, argumentation, perspectives, and responses to climate change. The findings were then synthesized to explain the educational potential of socio-scientific approaches for developing students' ability to respond thoughtfully to climate-related issues (Gencer et al., 2024).

3. Results And Discussion

Students' responses to climate change are influenced by how they understand the scientific processes underlying the issue. Students may possess different ideas about global warming, the greenhouse effect, and the causes of climate change. These differences demonstrate that climate change education needs to address not only factual knowledge but also the ways students interpret scientific explanations (2024 systematic review).

The use of climate change as a socio-scientific issue allows students to connect scientific knowledge with real-world problems. Instead of studying climate change only as a scientific concept, students can explore questions involving energy, environmental policy, economic interests, and community responsibility. This broader context can make science learning more relevant and encourage students to consider the consequences of scientific and social decisions (Environmental SSI review, 2024).

Ethical reasoning becomes particularly important when students discuss possible responses to climate change. Students may encounter situations in which different solutions provide benefits for some groups while creating challenges for others. Discussing such situations requires students to consider fairness, responsibility, environmental protection, and the consequences of decisions rather than relying solely on scientific facts (Clark, 2024).

Climate change education can also encourage students to recognize that climate-related problems are connected to social inequalities. Some communities may experience greater environmental risks despite contributing less to climate change. When science education addresses these dimensions, students can develop a broader understanding of climate change as both a scientific and social issue (Clark, 2024).

Students' ability to construct arguments is another important outcome of SSI-based climate education. When students discuss global warming, they are required to express claims, provide supporting reasons, and respond to alternative perspectives. Research with middle school students indicates that argumentation-based lessons can reveal differences in students' argumentation levels and opinions concerning global warming (Gencer et al., 2024).

Argumentation can become more effective when students are given opportunities to engage in debate and reflection. Students can first develop positions on a socio-scientific issue and then examine the strength of their arguments after listening to other viewpoints. This process can help students develop more careful and complex argumentation when dealing with issues that involve uncertainty and competing perspectives (Bächtold et al., 2023).

Dialogue also plays an important role in helping students respond to controversial climate issues. Classroom discussions that involve disagreement can encourage students to listen carefully, recognize alternative viewpoints, and justify their own positions. Such interactions can support students' ability to participate constructively in discussions about climate-related problems (Using inquiry-based dialogues, 2022).

The development of climate literacy requires students to go beyond recognizing that climate change exists. Students need to understand the causes, evidence, consequences, and possible responses associated with climate change. SSI-based learning can support this development by placing climate science within meaningful environmental and social contexts (Sangsa-ard & Sawangmek, 2023).

Data can also support students' understanding of climate change. Learning activities that use climate-related data and visualizations can help students interpret evidence and develop stronger knowledge about human-induced climate change. Research indicates that engaging students with novel data can improve climate change knowledge and situational interest (Supporting secondary students, 2024).

Students' responses to climate change can also be influenced by the information environments they encounter. Contemporary students may encounter climate-related information through digital media, including AI-generated content. Consequently, science education needs to support students in critically evaluating scientific claims and distinguishing reliable evidence from misleading information (Students' holistic reading, 2024).

The integration of SSI into science education can encourage students to develop more responsible decision-making. When students examine climate-related problems, they can compare possible solutions, evaluate evidence, consider consequences, and justify their preferred actions. This process connects scientific literacy with the ability to make informed decisions about complex environmental problems (Environmental SSI review, 2024).

Climate change education can also be strengthened through locally relevant learning materials. Learning activities that connect global climate change with environmental conditions familiar to students can make the issue more meaningful. Research on climate change learning materials in Indonesia demonstrates the potential of SSI-based resources to support students in engaging with climate-related scientific and social contexts (Usamah et al., 2024).

In the Indonesian context, climate change education has an important place within current educational development. However, research indicates that climate change education needs stronger integration and coordination across policies and educational stakeholders. This suggests that classroom learning should not treat climate change as an isolated topic but as an issue that can be connected with science, environmental responsibility, and sustainable development (Tang, 2024).

Ethical reasoning can also help students understand that climate change responses involve choices rather than a single universally applicable solution. Students may evaluate renewable energy, conservation, changes in consumption, or other responses from different perspectives. Through these discussions, students can learn to justify decisions using both scientific evidence and ethical considerations (Clark, 2024).

However, discussing climate change as an SSI requires careful classroom management. Because climate change can involve disagreement and different values, teachers need to create an environment in which students can express their perspectives respectfully while remaining attentive to scientific evidence. Inquiry-based dialogue can help establish this type of learning environment by encouraging respectful listening and recognition of different viewpoints (Using inquiry-based dialogues, 2022).

Another important consideration is that students' scientific understanding should remain central to ethical discussion. Ethical reasoning should not replace scientific learning but should complement it. Students need adequate scientific knowledge to evaluate climate-related claims

before making judgments about possible solutions. This integration of science and ethical reasoning can contribute to more informed responses to socio-scientific issues (Environmental SSI review, 2024).

Overall, contemporary research suggests that climate change education becomes more meaningful when students are given opportunities to engage with climate change as a socio-scientific issue. Through evidence-based discussion, argumentation, reflection, and ethical reasoning, students can develop responses that consider scientific knowledge as well as social and environmental consequences. Such learning can strengthen students' capacity to participate thoughtfully in discussions and decisions concerning climate change (Sangsa-ard & Sawangmek, 2023).

4. Conclusion

Climate change education can provide an important context for developing students' scientific understanding and ethical reasoning. When climate change is presented as a socio-scientific issue, students can explore scientific evidence while considering social consequences, environmental responsibility, fairness, and different perspectives.

SSI-based learning can encourage students to express their opinions, construct arguments, evaluate evidence, listen to alternative perspectives, and reflect on possible solutions. These learning experiences can help students develop more informed and responsible responses to climate-related problems.

Therefore, integrating climate change education with socio-scientific issues can strengthen science learning beyond the acquisition of factual knowledge. It can support students in becoming critical, reflective, and responsible participants who are able to use scientific knowledge when considering complex environmental and social issues.

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