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Integration of ESD-Based Education (Education for Sustainable Development) in the Science Curriculum

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ABSTRACT

Education for Sustainable Development (ESD) plays a pivotal role in addressing global challenges such as climate change, environmental degradation, and social inequality. The integration of ESD into science curricula is essential as science education provides the foundation for understanding natural phenomena and the relationship between humans and the environment. This paper explores the significance of incorporating ESD into science education in Indonesia, highlighting its potential to raise environmental awareness and foster sustainable behaviors from an early age. Despite its global recognition, the implementation of ESD in Indonesia faces several challenges, including the preparedness of educators, limited resources, and a lack of conceptual understanding of ESD. Effective strategies such as teacher training, development of sustainability-based teaching materials, and collaboration between schools, communities, and the private sector are crucial for overcoming these obstacles. Furthermore, adopting interdisciplinary and project-based learning approaches can enhance critical thinking and problem-solving skills, which are essential for addressing sustainability issues. The successful integration of ESD in science education is expected to produce a generation of students who are not only knowledgeable about sustainability but also actively contribute to achieving the Sustainable Development Goals (SDGs) by 2030. Through this approach, ESD becomes a transformative tool that shapes students' character as responsible agents of change, fostering a sustainable future.

INTRODUCTION

Sustainable economic development is characterized by actions that prioritize the wise use of natural resources, control of air and water pollution, effective forest management, reduction of plastic use, and other efforts that support environmental sustainability. Additional strategies include the application of environmentally friendly technologies, the use of renewable energy, waste management through recycling, and the implementation of policies and regulations that support environmental protection. In addition, sustainable development also emphasizes the importance of collaboration between the private sector, government, and society to create innovations and solutions that focus on reducing negative impacts on the environment (Gill et al., 2018; Opoku, 2019; Vioreza et al., 2022). Thus, sustainable economic development integrates the principle of sustainability into every aspect, aiming to achieve long-term economic growth without sacrificing ecosystem balance and social welfare. This approach ensures that development is in line with efforts to protect and preserve the environment, thereby creating a better life for present and future generations.

As a developing country with various development activities and economic growth, Indonesia also faces various environmental problems. These challenges mainly occur in big cities, such as increasing population, air and water pollution, excessive consumption, degradation of natural resources, and increasing volume of waste (UNESCO, 2019). However, Indonesia has shown a strong commitment to addressing these issues through cooperation with UN member countries, by adopting a sustainable development approach. This approach aims to create a balance between economic growth and

environmental protection (BAPPENAS, 2021; Ekantini & Wilujeng, 2018; Info Publik, 2021). In Law No. 32 of 2009 concerning Environmental Protection and Management (PPLH) article 1 paragraph 3, sustainable development is defined as a conscious and planned effort that combines environmental, social, and economic aspects in development strategies. The aim is to maintain environmental sustainability and ensure the safety, ability, welfare, and quality of life of current and future generations. The focus of sustainable development includes environmental preservation, socio-cultural development, and economic growth, because these three aspects are interrelated with the main goal of meeting human needs without sacrificing the interests of future generations (Laurie et al., 2016; McGregor, 2020).

Various efforts can be made to utilize natural potential to support development without causing environmental damage. One strategic step that can be taken is through the education sector. Education has a crucial role in encouraging sustainable development practices by providing understanding, instilling a caring attitude, and equipping students with sustainable living skills. The significant role of education in realizing sustainable development has received increasing attention, especially since the UN designated the 2005–2014 period as the Decade of Education for Sustainable Development (DESD). This determination became the basis for the formation of an agreement forum supported by the United Nations Educational, Scientific and Cultural Organization (UNESCO) to encourage sustainable development policies through an approach known as Education for Sustainable Development (ESD).

Education for Sustainable Development (ESD) is an educational approach that aims to prepare individuals to think critically and act sustainably in facing global challenges such as climate change, environmental degradation, and social inequality (UNESCO, 2020). Integrating ESD into the science curriculum is crucial because science education has a strategic role in shaping students' understanding of natural phenomena and their impacts on human life and the environment (Tilbury, 2021). ESD-based education enables students not only to understand scientific concepts theoretically but also to apply that knowledge to solve real-world problems, especially those related to sustainability. According to a study by Leicht et al. (2021), the implementation of ESD in the school curriculum can improve students' critical thinking skills and awareness of environmental issues. In addition, the implementation of ESD can shape students' sustainable behavior from an early age, which is expected to contribute to the achievement of the 2030 Sustainable Development Goals (SDGs).

In Indonesia, the integration of ESD into the science curriculum still faces various challenges, such as the readiness of educators, limited resources, and low understanding of the concept of ESD itself. Recent research by Prasetyo and Kurniawan (2021) shows that most science teachers at the secondary school level still need additional training to understand and implement ESD effectively in learning. Meanwhile, Indonesian education policy has begun to show positive steps by integrating sustainability principles into the Merdeka Curriculum as an effort to improve the quality of environment-based education (Kemendikbud, 2022). In a global context, the integration of ESD into science education emphasizes the importance of an interdisciplinary approach that combines environmental, economic, and social aspects. This is in line with Sterling's view (2021) which states that the transformation of science education towards ESD-based education can be the foundation for forming a more resilient and sustainable society. Therefore, this article aims to explore how ESD-based education can be integrated into the science curriculum, as well as to analyze the benefits and challenges in its implementation at the primary and secondary education levels in Indonesia. This study also provides insight into practical strategies that can be taken to overcome barriers to ESD integration in schools.

RESEARCH METHODS

This study uses a literature review method, which is a research approach that involves observation, reading, collecting, and analyzing data from various sources, such as books, journals, reports, historical records, documents, and other sources relevant to the phenomenon being studied. The literature review process in this study includes identification, analysis, evaluation, summarization, and synthesis of various readings or related research sources. There are five main steps in conducting a literature review, namely: (1) identifying key terms, (2) searching for relevant literature, (3) critically evaluating and selecting literature, (4) organizing literature, and (5) writing the results of the literature

review. The sources used in this literature review include national and international journals, research reports, books, e-books, and other documents relevant to the research topic.

RESULTS AND DISCUSSION

Education for Sustainable Development (ESD) plays a key role in addressing global challenges such as climate change, environmental degradation, and social inequality (UNESCO, 2020). The integration of ESD into the science curriculum is crucial because science education provides a foundation for understanding natural phenomena and the relationship between humans and the environment. According to Tilbury (2021), this approach not only instills theoretical understanding but also hones students' skills to think critically and solve real-world problems related to sustainability. The application of ESD in science education has the potential to increase environmental awareness and sustainable behavior from an early age. A study by Leicht et al. (2021) found that the integration of ESD in schools encourages increased critical thinking skills and students' awareness of environmental issues. This is important to achieve the 2030 Sustainable Development Goals (SDGs), especially the targets for quality education (SDG 4) and climate action (SDG 13). Education for Sustainable Development (ESD) focuses on developing critical, reflective, and innovative thinking skills needed to address global challenges. Integration of ESD into the science curriculum provides opportunities for students to understand the role of science in maintaining ecosystem balance and encouraging behavioral change towards sustainability. According to Leicht et al. (2021), ESD-based education can foster an attitude of caring for the environment and problem-solving skills, which are key to the success of sustainable development. The science curriculum has a strategic role in facilitating students' understanding of the impacts of human activities on the environment, such as climate change, pollution, and ecosystem damage. Tilbury (2021) states that science can be the main platform for teaching sustainability principles through active, interdisciplinary, and contextual learning methods. This provides space for students to not only understand the theory but also apply it in real life.

Although the urgency of Education for Sustainable Development (ESD) has been recognized globally, its implementation in Indonesia still faces various challenges that require serious attention. One of the main challenges is the readiness of educators. Research by Prasetyo and Kurniawan (2021) shows that many science teachers in Indonesia do not yet have a deep understanding of the concept of ESD, making it difficult for them to integrate sustainability principles into the learning process. Additional training and professional development programs that focus on the implementation of ESD are crucial so that teachers have adequate competence. In addition, limited resources are also a significant obstacle to the implementation of ESD in Indonesia. The lack of specific ESD-based learning materials and limited educational infrastructure make efforts to integrate the concept of sustainability less than optimal. Teachers need guidance, learning modules, and supporting resources that can facilitate the implementation of ESD in science classes (Kemendikbud, 2022).

Another challenge is the low conceptual understanding of ESD, both among teachers and policy makers. Partial understanding often hinders efforts to systematically integrate ESD into the curriculum. According to Sterling (2021), a transformative approach in education is needed to form a holistic understanding of sustainability. This transformative education involves an interdisciplinary, reflective, and participatory approach, so that students and educators can understand the relationship between science, the environment, and sustainability as a whole. In addition, synergy between the government, educational institutions, and the community is an important factor in overcoming this obstacle. With the provision of adequate resources, strengthening the capacity of educators, and developing policies that support ESD, the implementation of ESD in science education in Indonesia can run more effectively and contribute significantly to achieving the 2030 sustainable development goals (SDGs), especially in the fields of quality education and climate action.

Various practical strategies can be implemented to integrate Education for Sustainable Development (ESD) into the science curriculum in Indonesia to create more contextual and relevant learning to global sustainability challenges. Teacher training is a crucial first step, where training programs and workshops can focus on improving teachers' understanding of the concept of ESD and the application of interdisciplinary approaches in science teaching (Prasetyo & Kurniawan, 2021). With the right training, teachers will have the skills to link science theory to environmental and social issues around students. In addition, the development of sustainability-based teaching materials also needs to

be carried out by compiling modules and learning materials that integrate science concepts with environmental, social, and economic phenomena. This module not only provides theoretical understanding but also directs students to critical reflection and practical solutions related to sustainability issues (Tilbury, 2021).

Furthermore, collaboration between schools and communities can be an effective strategy to enrich ESD implementation. Involving the private sector, government, and local communities in environmental education programs in schools can create experiential learning and provide students with the opportunity to see firsthand how sustainability principles are applied in real life. This collaboration can also open access to additional resources and best practices that support ESD integration in schools. Meanwhile, a practical and interdisciplinary approach in the learning process, such as the application of the project-based learning (PBL) method, can be an effective solution to encourage students to think critically and collaboratively. Through PBL, students are given the opportunity to solve real problems related to sustainability with a project-based approach, which allows them to apply scientific theories in practical situations and find innovative solutions (Leicht et al., 2021). With these strategies, the integration of ESD in the science curriculum can be more structured, relevant, and sustainable, supporting the formation of a young generation that is environmentally aware and plays an active role in achieving the sustainable development goals (SDGs).

The implementation of Education for Sustainable Development (ESD) in science education has a number of significant benefits, both for students and for global efforts to achieve sustainability. One of the main benefits is improving environmental understanding, where students gain a more comprehensive insight into the interrelationships between humans, the environment, and sustainable development (UNESCO, 2020). This understanding allows students to see the cause-and-effect relationships between human activities, environmental changes, and long-term consequences that affect the balance of the ecosystem. In addition, ESD also plays an important role in developing critical thinking skills. Through learning based on sustainability issues, students are trained to critically analyze environmental problems, evaluate the impacts of various actions, and find innovative and sustainable solutions (Leicht et al., 2021). These skills are very relevant in facing global challenges such as climate change, pollution, and resource crises. Furthermore, the implementation of ESD in science education encourages sustainable behavior among students. By instilling environmental awareness and care from an early age, ESD-based education forms habits and mindsets that are more responsible for the environment. Students not only become more sensitive to environmental issues around them, but also have the drive to actively contribute to sustainability efforts. This prepares the younger generation to be ready to face global challenges and play a role in achieving the Sustainable Development Goals (SDGs) 2030, especially in terms of quality education (SDG 4) and climate action (SDG 13). Thus, the implementation of ESD is not only limited to curriculum transformation, but also forms the character of students as responsible agents of change who care about the future of the earth.

CONCLUSION

The implementation of Education for Sustainable Development (ESD) in science education in Indonesia plays a very important role in shaping students' understanding of sustainability and introducing science concepts related to global challenges such as climate change and environmental degradation. Although challenges such as the readiness of educators, limited resources, and conceptual understanding of ESD are still obstacles, various practical strategies such as teacher training, development of sustainability-based teaching materials, and collaboration between schools, communities, and the private sector can be effective solutions. Through an interdisciplinary and project-based approach, ESD not only encourages theoretical understanding, but also develops critical thinking skills and sustainable behavior among students. The proper implementation of ESD is expected to produce a young generation that has a high awareness of environmental issues and is ready to contribute to achieving the Sustainable Development Goals (SDGs) 2030. Thus, ESD is not only a curricular approach, but also a tool to create sustainable social change and shape students' characters as agents of change for a better future.

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