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solution to global environmental
problems**

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Learning based on education for sustainable development as a solution to global environmental problems

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Abstract

Environmental problems were still a significant global issue and challenge that was not only limited to the national or regional level. This problem was closely related to economic and social development, which was often triggered by human activities that were not environmentally friendly. In addressing this problem, the concept of sustainable development was coined with three main dimensions: economic, social, and environmental. Education played an important role in supporting sustainable development through the application of education for sustainable development in learning. This research aimed to describe the implementation of education for sustainable development-based learning in schools as a solution to global environmental problems. The method used in this research was a literature study, which included six stages: determining the topic, searching for related literature, developing arguments, conducting a survey of relevant literature, criticizing the literature, and writing a review. The research results showed that education for sustainable development-based learning in schools could be implemented using appropriate learning models and supported by various education for sustainable development-based learning resources. This implementation proved effective in increasing students' awareness and knowledge of environmental issues and encouraging more environmentally friendly actions.

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1. Introduction

Environmental problems include aspects such as climate change, air and water pollution, deforestation, loss of biodiversity and land degradation. All of these problems are closely related to economic and social development which is often triggered by human activities that are not environmentally friendly. Activities such as excessive use of fossil fuels, deforestation for agricultural land and settlements, as well as pollution from industry and transportation, are some clear examples that contribute to environmental damage (Hamidah & Surtikanti, 2023).

To overcome this problem, the concept of sustainable development was coined. Sustainable development is a development approach that seeks to meet the needs of the present without compromising the ability of future generations to meet their own needs. This concept is based on three main dimensions, namely economic, social and environmental. The economic dimension emphasizes inclusive and sustainable economic growth, the social dimension emphasizes social welfare and reducing inequality, while the environmental dimension emphasizes preserving natural resources and environmental protection (Haryanti & Kaswinarni, 2021; Rahman et al., 2019).

Sustainable development in the field of education is often called Education for Sustainable Development (ESD). ESD is a dynamic concept in education that prioritizes noble values to achieve a sustainable future. This concept focuses on three main perspectives, namely socio-cultural, environmental and economic. ESD aims to integrate the principles, values and practices of sustainable development into all aspects of education and learning. Thus, ESD does not only focus on knowledge

about environmental issues, but also on developing critical thinking skills, problem solving, and responsible decision making (Firmaningsih & Wasikin, 2021).

Indonesia is one of the developing countries that continues to strive to accelerate development, including in the fields of economy, infrastructure and transportation, to prepare itself to face the challenges of the industrial revolution 4.0 (Karmana, 2022). However, these activities have a significant impact on the environment. Environmental issues are one of the global megatrends that affect various sectors, including education in Indonesia. Therefore, wise and sustainability-oriented education is very necessary. It is important to apply this sustainability mindset to students to help them choose and sort things that will have an impact on future conditions (Nofriyandi et al., 2021). With this background, this research aims to describe the implementation of ESD-based learning in schools as a solution to global environmental problems. Through this research, it is hoped that a deeper understanding can be gained regarding how ESD can be applied in the context of formal education and how this application can contribute to increasing students' awareness and knowledge of environmental issues and encouraging more environmentally friendly actions.

2. Method

This study employed qualitative research with a descriptive analysis method and a literature review approach. The literature review method involved collecting data by understanding and studying theories from various literature related to the research (Ridwan et al., 2021). This literature review included reviews and analyses of various previously published works. The process of compiling the literature review itself included six important stages that were followed sequentially: determining the topic, searching for related literature, developing arguments, conducting a survey of related literature, criticizing the literature, and writing the review (Mahanum, 2021). The data sources for this research were previous studies that had been published in journals. The data obtained were then analyzed.

The steps of this research began with data collection, data analysis, data interpretation, and reporting of research results. Data were collected from various literature sources such as journal articles, books, research reports, and other academic sources. The researcher used academic databases such as Google Scholar and ScienceDirect to search for relevant literature. The collected data were analyzed using content analysis methods. The researcher identified the main themes, categorized the information, and evaluated the findings from various literature sources. The results of the data analysis were interpreted to answer the research questions and achieve the research objectives. The researcher linked the findings from the literature to the main arguments developed in the previous stages. Finally, the research results were reported in the form of a comprehensive literature review. This report included a summary of findings, critical analysis of the literature, and recommendations for the implementation of ESD-based learning in schools. To ensure the validity and reliability of the research, the researcher ensured several things: selecting literature from credible and reliable sources; using systematic and transparent analysis methods; performing data triangulation by comparing findings from various sources; and involving co-researchers in the analysis process to reduce bias and enhance objectivity.

3. Results and Discussion

3.1 Results

Education today must be able to create individuals who are oriented towards sustainability, acting with consideration for their impact on the future of the planet to ensure the well-being of future generations. It is undeniable that the pursuit of economic development often results in significant damage and serious threats to both humans and the environment. In response to these challenges, sustainable development has been formulated as a global paradigm by the United Nations (UN). Sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Maulana et al., 2024; Vioreza et.al., 2023).

Achieving sustainability in human life requires various processes, methods, and efforts. One way to achieve this is through sustainable development. Among the most crucial aspects of sustainable development is the field of education, known as Education for Sustainable Development (ESD).

Indonesia is one of the countries committed to integrating the values of sustainable development into its education system. This commitment is outlined in the 2020-2024 Strategic Master Plan of the Southeast Asian Ministers of Education Organization (SEAMEO) Center Indonesia. In point seven about the adoption of the 21st-century curriculum, it is targeted that by 2030, all learners must possess knowledge and skills that support sustainable development, including Education for Sustainable Development (ESD). The indicators of achieving this target specify that all member countries must integrate 5C, ESD, and GCED into their national curricula (Southeast Asian Ministers of Education Organization, 2020). ESD-based learning is also reflected in the roadmap for Indonesia's education in 2025-2045 published by Bappenas.

ESD is believed to be capable of forming individuals who are knowledgeable, skilled, and possess values and attitudes that can be empowered to contribute to sustainable development (Purwadi & Hamdu, 2021; Vioeza et.al., 2023). The core competencies of ESD that should be developed in learners include knowledge, skills, attitudes, values, motivation, and commitment (Lee, 2012). The outcomes of ESD learning are categorized into three domains: cognitive, socio-emotional, and behavioral (UNESCO, 2017). The domains of ESD learning outcomes can be seen in Table 1.

Table 1.

Domains of ESD Learning Outcomes

Domain	Descriptions
Cognitive	This domain consists of the knowledge and thinking skills needed to understand SDGs
Socio-emotional	This domain includes the social skills needed to collaborate and cooperate to promote SDGs, as well as emotional skills, attitudes, values, and motivation to develop sustainability
Behavioral	This domain involves the attitudes and actions to be responsible in sustainable development

Vilmala et al. (2022) categorized eight sustainability competencies into three domains of learning outcomes, which can be seen in Table 2.

Table 2

Categorization of Sustainability Competencies into Learning Outcome Domains

	Cognitive Domain	Socio-emotional Domain	Behavioral Domain
Sustainability Competency	Systems Thinking Competency Anticipatory Competency Normative Competency Critical Thinking Competency	Collaborative Competency elf-awareness Competency	Strategic Competency Integrated Problem-Solving Competency

The implementation of ESD learning can be integrated into learning models. A learning model is a design or pattern that can be utilized to develop curricula (long-term learning plans), design learning materials, and direct the learning process in the classroom or other environments (Maulana, 2023; Khoerunnisa & Aqwal, 2020). These learning models include problem-based learning (PBL) (Purnamasari et al., 2022; Firmaningsih & Wasikin, 2021; Kurniahtunnisa et al., 2023; Zulfah, Purnamasari, & Abdurrahman, 2024; Hasna, 2024), project-based learning (PjBL) (Latifah, Hayat, & Khoiri, 2023; Purnamasari et al., 2022; Nihayati, 2024; Laela, Khoiri, & Sugiyanto, 2024), STEM (Widarti & Roshayanti, 2021; Widarti, Khoiri, & Roshayanti, 2023; Riyanto, Nuroso, & Roshayanti, 2024; Muntamah, Roshayanti, & Hayat, 2024; Kurniawan, Abdurrahman, & Rosidin, 2024), flipped classroom (Clarisa et al., 2020; Jamaludin, 2022), and predict, observe, and explain (POE) (Fatimah et al., 2023).

ESD learning can be implemented through various learning resources. Learning resources are various or all sources, whether in the form of data, people, methods, media, or places where learning occurs, used by learners to facilitate learning (Samsinar, 2020; Anilia, Heryanto, & Sunedi, 2023; Hilyati, et.al., 2023). Learning resources used in education include learning modules (Jamaludin, 2022;

Fatimah et al., 2023; Mahdiann et al., 2022; Purnamasari et al., 2022), PPT (Purnamasari et al., 2022), videos (Purnamasari et al., 2022; Firmaningsih & Wasikin, 2021), worksheets (Purnamasari et al., 2022; Fauziah & Hamdu, 2022; Wahyuni, Khoiri, & Novita, 2024), games on Android-based devices (Purnamasari et al., 2022; Fibonacci, Azizati, & Wahyudi, 2020), textbooks (Purnamasari et al., 2022), interactive electronic textbooks (Sihombing, Muslim, & Agustin, 2024), e-encyclopedias (Azizah, Lathifah, & Hidayat, 2021), and virtual field trips (Adwiah et al., 2023).

The Problem-Based Learning (PBL) model is an innovative approach that requires learners to be actively involved in the learning process, allowing them to apply the knowledge gained to real-life situations (Hasna, 2024). The use of this model can also stimulate learners' thinking by breaking down problems as a way to solve those problems or issues. The implementation of the PBL model has successfully improved learners' skills in interpreting problems. However, combining PBL with Education for Sustainable Development (ESD) can broaden the scope of discussion, encompassing various social, economic, and environmental issues. The stages of the learning flow using the ESD-based PBL model consist of five phases (Hasna, 2024; Zulfah, Purnamasari, & Abdurrahman, 2024):

- Phase 1: Orienting learners to the problem
- Phase 2: Organizing learners for learning
- Phase 3: Guiding independent or group investigations
- Phase 4: Developing and presenting artifacts and exhibits
- Phase 5: Analyzing and evaluating the problem-solving process

In Firmaningsih & Wasikin's (2021) study, the implementation of PBL was assisted by videos. The learning videos in this study contained ESD (Education for Sustainable Development) content, which would later present a problem to be tested on the learners.

Project-Based Learning (PjBL) is a learning approach that encourages learners to actively explore knowledge, solve problems, and develop skills through engaging and meaningful real-world projects. The implementation of the ESD-based PjBL model involves several stages: (1) project planning, (2) project launch, (3) guided inquiry and product creation, and (4) project conclusion (Nihayati, 2024).

STEAM learning is an educational approach that emphasizes the connection between Science, Technology, Engineering, Art, and Mathematics (STEAM) knowledge and skills to address problems (Riyanto, Nuroso, & Roshayanti, 2024). The STEAM approach helps students develop problem-solving skills, critical thinking, and collaboration to understand various phenomena in their environment. This encourages curiosity, an understanding of the causes and impacts of a phenomenon, and efforts to find solutions to address it (Muntamah, Roshayanti, & Hayat, 2024). ESD-oriented STEAM learning can be applied in project-based learning (Riyanto, Nuroso, & Roshayanti, 2024).

One technology-supported learning method is the Flipped Classroom. ESD-based contextual learning can help students develop problem-solving skills, which in turn can enhance their interest and academic performance. By integrating the context of ESD into the Flipped Classroom model, it is expected that students' cognitive abilities will improve, while also fostering their awareness of sustainability values. The steps in Flipped Classroom learning consist of the preliminary stage (brainstorming), the learning culture stage, presenting conceptual content, analyzing and evaluating the learning process, and the conclusion (Clarisa et al., 2020). In Jamaludin's (2022) study, the implementation of the Flipped Classroom was supported by the use of e-modules. The e-modules in this learning method facilitate students' independent learning.

3.2 Discussion

Education for Sustainable Development (ESD) plays a vital role in creating individuals who not only possess knowledge but also have the skills and attitudes to contribute to sustainable development. Global commitments, including those undertaken by Indonesia, to integrate ESD into the national curriculum require an evaluation of its effectiveness in changing students' perspectives and behaviors towards sustainability issues (Taylor, J. 2014; Sinakou, E., 2019). Learning models such as Problem-Based Learning (PBL), Project-Based Learning (PjBL), STEAM, and the Flipped Classroom play crucial roles in supporting the achievement of ESD competencies. PBL and PjBL, for instance, encourage students to actively engage in solving real-world problems related to social, economic, and environmental issues,

while STEAM integrates various disciplines to develop critical thinking and collaboration skills in facing sustainability challenges. The Flipped Classroom provides students with opportunities to access material independently, allowing more time for discussions and the application of concepts in real-world contexts, as well as the development of practical skills in addressing sustainability issues.

Moreover, the use of learning resources such as videos, electronic modules, and technology-based applications further enriches the ESD learning experience, enabling students to learn in a more interactive and contextual manner (Vioreza, 2022; Supriani, Y. 2016). Videos and digital learning modules, as well as Android-based game applications, provide opportunities for students to understand sustainability issues practically and deeply (Wibowo, H. S., 2023; Vioreza, 2023). However, challenges in the implementation of ESD, from curriculum aspects, teacher training, and community involvement, remain. As highlighted by Tilbury (2011), a more inclusive curriculum adaptation and empowering teachers through more in-depth training are essential to realize sustainability-based education. Additionally, community involvement is a crucial aspect of the sustainable education process.

As a step to strengthen the implementation of ESD in Indonesia, it is important to develop a more integrative curriculum, provide in-depth teacher training on ESD principles, and maximize the use of technology to support sustainability-based learning. With the right approach, ESD-based education can have a positive impact in preparing future generations to face increasingly complex global challenges (UNESCO, 2017).

4. Conclusion

This research demonstrates that the implementation of Education for Sustainable Development (ESD) has significant potential as a solution to global environmental problems. Through the integration of sustainability concepts into the education curriculum, students not only gain knowledge about environmental issues but also develop the attitudes and skills necessary to take positive action in their daily lives. The study found that comprehensively implemented ESD teaching methods can increase students' environmental awareness, enhance their critical and analytical abilities in addressing environmental challenges, and encourage their active participation in environmental conservation activities. Furthermore, ESD helps shape a more responsible and committed generation towards sustainability, ultimately contributing to long-term solutions to various global environmental issues. Thus, the integration of ESD into the education system is a strategic step that needs to be promoted and prioritized by policymakers and education practitioners worldwide. Through education focused on sustainable development, we can create a society that is more aware and concerned about the environment, capable of facing global challenges with innovative and sustainable solutions.

This research highlights the significant potential of Education for Sustainable Development (ESD) as a strategic solution to global environmental challenges. By integrating sustainability concepts into the education curriculum, students are equipped with the knowledge, attitudes, and skills necessary to take positive action in their daily lives. Comprehensive ESD teaching methods have been shown to increase environmental awareness, enhance critical and analytical thinking in addressing ecological issues, and encourage active participation in conservation activities. To optimize the impact of ESD, several key strategies are recommended. Policymakers are urged to prioritize ESD integration into education systems through clear guidelines and standards. Teacher training programs should focus on equipping educators with the necessary skills and resources to effectively deliver ESD content. The development of accessible ESD learning materials, such as textbooks and multimedia resources, can support educators and students alike. Collaboration with local communities and organizations is essential to provide students with practical experiences, such as tree planting and recycling projects, that bring ESD principles to life. Regular monitoring and evaluation of ESD initiatives are necessary to ensure their effectiveness and sustainability. Additionally, fostering international collaboration can promote the exchange of best practices and innovative approaches to ESD implementation. By embedding ESD into education systems, societies can cultivate a generation that is environmentally conscious, skilled in sustainable practices, and prepared to address global environmental challenges with innovative and sustainable solutions.

Limitations

Write down the limitations of the research you conducted. Explain what was done for further research.

Acknowledgments

One limitation of this research lies in its reliance on a literature review method, which restricts the ability to validate findings with empirical evidence. While the study effectively synthesizes information from existing literature, it lacks direct observations or practical data from real-world ESD implementations in schools. This approach makes it challenging to account for context-specific variables such as cultural differences, resource availability, or institutional support, which can significantly impact the success of ESD programs. Additionally, the study does not explore the long-term effects of ESD-based learning on students' behavior and environmental attitudes, leaving the sustainability of its positive outcomes uncertain. Addressing these gaps in future research through field studies and longitudinal analyses could provide a more comprehensive and actionable understanding of ESD's potential in addressing global environmental problems.

Author Contribution

Author 1: Conceptualization, Writing - Original Draft, Editing and Visualization;

Author 2: Writing - Review & Editing, Formal analysis, and Methodology;

Author 3: Validation and Supervision.

Conflict of Interest

The authors declare no conflict of interest.

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