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ESD Integration in Science Learning: Prospective Teachers Analysis of Climate Change

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Abstract

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Education for Sustainable Development (ESD) is an educational approach designed to equip learners with the knowledge, skills, and values needed to support sustainable development across social, economic, and environmental dimensions. ESD emphasizes the principle of "Think globally, act locally," encouraging learners to take concrete actions in addressing global challenges such as climate change while considering local contexts. This study aims to analyze the level of knowledge, attitudes, and pro-environmental behaviors of pre-service science teachers in relation to climate change issues. The research employed a descriptive qualitative method, with data collected through literature review, interviews, and document analysis. The findings indicate that pre-service science teachers demonstrate a basic understanding of environmental issues and climate change, yet a noticeable gap remains between their cognitive knowledge and their actual practices in daily life. These results highlight the necessity of strengthening the integration of ESD within teacher education curricula, both through pre-service and in-service training, in order to prepare agents of change capable of embedding sustainability values effectively into science education.

1. Introduction

Education for Sustainable Development (ESD) is one of the 21st-century educational paradigms that focuses on equipping students with the knowledge, skills, values, and attitudes needed to face the challenges of sustainable development. ESD emphasizes the interconnectedness of social, economic, and environmental aspects as an inseparable whole. Through ESD, students are expected to become active agents of change in creating a more just, environmentally friendly, and sustainable society. Shahidul (2020), asserts that ESD is an important part of achieving the Sustainable Development Goals (SDGs), especially SDG 4 on quality education and SDG 13 on climate action. The underlying principle of ESD is "Think globally, act locally." This principle teaches that every individual needs to consider the global impact of their actions while adapting to the local context and needs. In an educational context, this means that learning not only provides theoretical knowledge about global issues, such as global warming or environmental degradation, but also encourages students to take real actions in their daily lives. For example, saving energy, reducing food waste, recycling used goods, and planting trees as part of mitigation and adaptation actions against climate change.

Environmental and climate change education has an increasingly urgent importance in the current era (Reid et al., 2021). Climate change has become a global issue that threatens the sustainability of life on Earth. Its impact not only includes ecological aspects, such as rising temperatures, melting ice, and natural disasters, but also affects socio-economic aspects, including food security, health, and social justice. Therefore, integrated environmental education with ESD is one of the

important means to equip the next generation to face this problem. With adequate knowledge, individuals can understand the cause and effect of human activities on the environment and design relevant adaptation and mitigation strategies.

In Indonesia, the implementation of ESD has begun through integration into the curriculum, educational policies, and learning activities. However, its application still varies between schools and regions. Some schools have developed project-based environmental learning, while others are still in the planning stage. One of the key factors for the successful implementation of ESD is the role of the teacher. Teachers do not only function as knowledge providers but also as role models and shapers of student character. Through their role, teachers can instill sustainability values in students from an early age, both through formal learning and non-formal activities (Costas Batlle, 2019). Unfortunately, research shows a gap between the cognitive knowledge and the actual practice of pre-service teachers. For example, some pre-service science teachers understand that food waste can produce methane gas, which contributes to the greenhouse effect, but in reality, they still have the habit of wasting food. This phenomenon shows that knowledge alone is not enough, but there needs to be an internalization of values and the habituation of pro-environmental behavior in daily life.

In addition, many pre-service teachers get information about climate change issues from popular media such as television, the internet, or blogs, not from academic literature or formal curriculum (Namdar, 2018). This has the potential to cause misconceptions, such as the assumption that global warming is caused by solar radiation penetrating the atmosphere, or that global warming is identical to the

ozone hole. Based on this background, this article aims to analyze the knowledge, attitudes, and pro-environmental behavior of pre-service science teachers related to climate change issues within the framework of ESD. Thus, it is hoped that this article can provide an overview of the readiness of pre-service teachers as agents of change, as well as strategic recommendations to strengthen the integration of ESD in science education. This research is also expected to contribute to strengthening the literature on the role of teachers in environmental education in Indonesia, as well as supporting the achievement of sustainable development goals.

2. Literature Review

2.1. Education for Sustainable Development (ESD)

Education for Sustainable Development (ESD) is an approach in education that integrates three main dimensions, namely social, economic, and environmental, into the learning process. The essence of ESD is to equip students with the awareness, understanding, and skills that enable them to contribute actively to the achievement of sustainable development. Ferguson et al. (2021) affirms that through ESD, individuals are expected to be able not only to understand sustainability issues but also to be moved to take real action in maintaining the balance between human needs and environmental preservation. Furthermore, Tibola da Rocha et al. (2020) places ESD as one of the important pillars in achieving the Sustainable Development Goals (SDGs), especially SDG 4 on quality education and SDG 13 which highlights climate action. This shows that education not only functions as a means of

knowledge transfer but also as a medium of social transformation towards a more sustainable society.

In practice, the implementation of ESD can be done through various learning strategies. Some of them include integrating sustainability principles into the curriculum, implementing project-based environmental learning, and organizing teacher training programs both before and during their professional life (Kricsfalusy et al., 2018). Experiences in a number of countries show the effectiveness of this approach. Research conducted in Namibia reveals that teachers who are familiar with the concept of sustainability are more prepared to guide students in understanding environmental issues comprehensively. Meanwhile, a study in Jordan shows that ESD training for educators can increase their pedagogical competence and enrich their learning strategies in facing the complexity of global development challenges . Thus, ESD not only emphasizes the cognitive aspect but also fosters pro-environmental attitudes and behavior through transformative and contextual education.

2.2. Understanding of Pre-service Science Teachers on Climate Change Issues

The understanding of pre-service science teachers on climate change issues plays a very important role because they are agents of change who will instill sustainability values in students in the future. Teachers are not only tasked with transferring knowledge but also shaping pro-environmental attitudes and behavior that can contribute to climate change mitigation. Unfortunately, a number of studies show that pre-service teachers' understanding is still limited and is often

accompanied by misconceptions. Namdar (2018), for example, revealed that the majority of pre-service teachers in Turkey still have a wrong understanding of the causes of global warming, such as linking this phenomenon to an increase in solar radiation or a hole in the ozone layer. This finding shows that the basic concepts of climate change are not yet fully understood scientifically.

In Indonesia, research by Charlson et al. (2021) shows that most pre-service teachers obtain information related to climate change from mass media, including television, newspapers, and the internet, not from more valid academic literature. This creates a gap between cognitive knowledge and actual application in daily life; for example, they understand the danger of food waste on greenhouse gas emissions, but they still throw away leftover food. Furthermore, Manasia et al. (2019) showed that although pre-service science teachers have a positive perception of Education for Sustainable Development (ESD), they still face obstacles in integrating sustainability principles into learning. This condition emphasizes the importance of providing special training, pedagogical guidance, and contextual teaching materials to strengthen their competence in teaching climate change issues more effectively.

3. Methods

This study uses a qualitative approach with a literature review method. This method was chosen because the focus of the research is to analyze and synthesize various previous research results related to the implementation of Education for Sustainable Development (ESD) and the understanding of pre-service science teachers on climate change issues. Through a literature review, this research not only

collects relevant information but also conducts a critical review of various research results to identify knowledge gaps, similarities in findings, and implications for the world of education. The data collection process was carried out by searching for scientific articles from national and international journals relevant to the research topic. The search for sources was carried out through academic databases. However, classic literature that is still relevant, such as the initial definition of ESD and sustainable development theory, is also used as a conceptual basis.

Data analysis was performed using thematic analysis techniques. Each selected article was read thoroughly to identify the main themes related to the research topic. The emerging themes were then grouped into several categories, such as: the concept and goals of ESD, the role of teachers in ESD, the level of understanding of pre-service science teachers on climate change, common misconceptions, and the gap between cognitive knowledge and actual behavior. Furthermore, the results of the analysis were compared and synthesized to obtain a more comprehensive understanding of the role of pre-service science teachers in the integration of ESD.

This literature review approach allows the research to obtain a broad and in-depth picture of the phenomenon under study without having to collect field data. The advantage of this method is that it is able to integrate findings from various country contexts and different situations, thus providing a richer perspective. However, the limitation is that this research is highly dependent on the quality and availability of existing literature and cannot capture the latest dynamics that may not yet have been published. With this method, the research is expected to contribute to

mapping the literature related to ESD and the understanding of pre-service science teachers on climate change issues. The results of the literature review are also expected to provide practical recommendations for the development of curriculum, teacher training, and educational policies in Indonesia to be more responsive to sustainability challenges.

4. Results and Discussion

Based on the results of the literature review, the implementation of Education for Sustainable Development (ESD) in science education shows a significant development in various countries, although its implementation still faces challenges. ESD as an educational approach emphasizes the integration of social, economic, and environmental aspects into learning. In the context of science education, ESD functions to broaden students' understanding of the relationship between science and the sustainability of life. Ferguson et al. (2021) research confirms that ESD aims to provide awareness and ability to students to be able to contribute to sustainable development, both now and in the future.

The results of international studies show that teachers play a central role in the success of ESD implementation. Sinakou et al. (2019) in his research in Namibia found that teacher training in ESD is very important to equip them with relevant skills and knowledge. A similar thing was found in Jordan by Nguyen and Ng (2020), where collaborative training allowed teachers not only to receive knowledge but also to transfer experiences to colleagues in their schools. This collaborative model has

been proven to increase the flexibility of teachers in dealing with complex environmental issues.

In addition, the implementation of ESD in Indonesia often depends on school or teacher initiatives (Ssossé et al., 2021). Some schools have successfully developed environment-based programs such as eco-schools, greening activities, and waste management. However, such practices are not yet evenly distributed in all regions. The obstacles that arise include a lack of policy support, limited resources, and low awareness of the surrounding community. Therefore, the integration of ESD in science education needs to be strengthened through a more systematic and sustainable national policy. The literature also highlights the importance of a paradigm shift in science learning. ESD encourages project-based learning and contextual learning that links global issues with local actions. For example, students are invited to research the impact of plastic waste in their environment, then link it to the problem of global marine pollution.

This strategy not only enhances the comprehension of scientific concepts but also fosters the development of attitudes and practical skills necessary to translate knowledge into meaningful action. By connecting theoretical understanding with real-world applications, learners are encouraged to move beyond memorization and engage in critical thinking, problem-solving, and decision-making processes that directly address environmental and sustainability challenges. Such an approach equips individuals with the capacity to not only recognize the urgency of global issues like climate change but also to actively participate in solutions through everyday practices and long-term initiatives. Ultimately, it ensures that education serves as a

transformative tool, preparing students to become responsible citizens who are capable of contributing to sustainable development in both local and global contexts. Thus, it can be concluded that although the implementation of ESD in science education has shown progress, further support is still needed in the form of teacher training, contextual curriculum development, and the involvement of the school community and the wider community. Teachers, especially pre-service science teachers, must be prepared as agents of change who can integrate sustainability principles into every aspect of science learning.

The understanding of pre-service science teachers on climate change issues is a key factor in the successful implementation of ESD. Based on the results of the literature review, their level of understanding is still diverse, ranging from quite good to still being filled with misconceptions. Research by Charlson et al. (2021) shows that most pre-service science teachers obtain information about climate change from popular media such as television, newspapers, blogs, or the internet. These less credible sources of information lead to various misunderstandings, for example, the assumption that global warming is caused by an increase in solar radiation or that global warming is identical to the ozone hole.

The gap between cognitive knowledge and actual practice is also a major problem. For example, research shows that 65% of pre-service science teachers know that food waste can produce methane gas, which contributes to the greenhouse effect. However, some of them still have the habit of leaving food or not managing organic waste correctly. This indicates that although cognitive

knowledge is owned, pro-environmental behavioral changes are not always internalized in daily life.

Higde et al. (2017) also found that although teachers consider climate change to be a serious problem, they rarely take real action to reduce it (Reid, 2019). The factors that influence this include a lack of a sense of urgency, limited practical knowledge, and a low belief that individual actions can have a significant impact. In addition, there are differences in perception based on the educational background of pre-service teachers.

Pre-service biology teachers tend to see climate change solutions through reforestation and ecosystem preservation. Meanwhile, pre-service chemistry teachers emphasize waste management and recycling, and pre-service physics teachers focus more on energy saving (Türkoğlu, 2019). These differences show that the scientific basis affects the way of viewing environmental issues. However, without cross-disciplinary integration, their approach is still partial and not holistic.The literature also highlights the importance of pro-environmental values in shaping attitudes towards climate issues. That individuals who have ecocentric values tend to be less skeptical of climate change. However, other studies show that ecocentric values alone are not enough to guarantee real behavioral change, especially when individuals face habits or personal comfort that are difficult to leave (Syed-Abdullah, 2020).

Thus, the internalization of sustainability values needs to be combined with real practice through experience-based learning and critical reflection. This discussion shows that pre-service science teachers need to strengthen their understanding, which is not only cognitive but also affective and psychomotor.

Teacher education must encourage them to develop a reflective attitude, build critical awareness of the impact of personal behavior, and commit to real action. Pre-service training based on field experience, such as environmental projects, local research, and community collaboration, is very important to foster practical skills and internalize sustainability values. Thus, the understanding of pre-service science teachers on climate change issues not only functions as a provision of knowledge but also as a foundation for developing contextual and transformative learning strategies. The integration of ESD into the teacher education curriculum will be a strategic step to ensure that they are ready to become agents of change in facing the global challenges of climate change.

5. Conclusion

Education for Sustainable Development (ESD) is an important approach in equipping the younger generation to face global challenges, especially climate change issues. Based on the results of the literature review, ESD has great potential in increasing the knowledge, attitudes, and skills of students to be able to contribute to sustainable development. However, its implementation in science education still faces various obstacles, especially in the aspect of integrating concepts into the curriculum and the limitations of teacher training. Pre-service science teachers have a strategic role as agents of change who will determine the direction of sustainable learning in schools. The literature findings show that although they already have a fairly good basic understanding of environmental issues and climate change, there is still a gap between cognitive knowledge and actual practice.

Some misconceptions were also found, especially related to the causes and impacts of global warming, as well as limitations in applying pro-environmental behavior daily. Thus, a systematic effort is needed to strengthen the integration of ESD in the education of pre-service science teachers. This can be done through the development of a contextual curriculum, pre-service and in-service training, as well as environmental project-based learning that can connect theory with practice. Through this strategy, pre-service teachers will not only understand climate change issues academically but also be able to foster sustainability values and internalize them in real behavior. In the end, teachers empowered with an understanding of ESD will be more prepared to guide the next generation towards a sustainable society.

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