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Understanding of Science Teacher Candidates on Climate Change and the Integration of Education for Sustainable Development (ESD)

Mutia Cahyaningrun[1]

[1] Universitas Sanata Dharma, Yogyakarta, Indonesia

Abstract

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Education for Sustainable Development (ESD) occupies an important position in efforts to address global challenges, especially climate change which has a wide impact on social, economic, and environmental life. This study aims to analyze the understanding of prospective pre-tenured science teachers about the issue of climate change and their difficulties in integrating ESD into learning. Using the Systematic Literature Review (SLR) method, the research examined various relevant international and national studies. The results of the study show that prospective science teachers are aware of the urgency of climate change, but there is still a gap between conceptual knowledge and learning practice. Some of the obstacles identified include misconceptions about climate change, limited pedagogical experience, and lack of curriculum and training support. These findings underscore the importance of more systematic educational strategies to strengthen teacher capacity, particularly through the integration of sustainability values and practice-based training. Recommendations are given to strengthen teachers' competence in dealing with sustainability issues contextually and applicatively.

1. Introduction

Education for Sustainable Development (ESD) is an educational approach that aims to equip individuals with the awareness, knowledge, and skills to contribute to realizing sustainable development. According to Fitria and Hamdu (2021), ESD emphasizes the ability to think critically, make responsible decisions, and strengthen environmental care from an early age to college. In this context, education has a central role as a means of social transformation, as it is able to shape the pro-environmental behaviors necessary to face global challenges. ESD is also relevant to global issues such as climate change, environmental degradation, deforestation, and increasing energy consumption that suppress the sustainability of the earth's ecosystem.

Climate change has become an urgent global problem, characterized by rising global average temperatures, rising concentrations of greenhouse gases such as CO_2, CH_4 , and N_2 O, and significant socio-economic impacts on people around the world. This phenomenon poses a threat to food security, human health, and ecosystem balance. Because of its global nature, climate change requires the contribution of every individual and local community through the principle of "think globally, act locally". Mitigation and adaptation efforts are not only the responsibility of governments and international organizations, but also demand the active participation of communities, including behavioral changes in daily life, such as energy efficiency, waste management, and sustainable consumption (Dellmuth & Gustafsson, 2021).

In the face of these challenges, education plays an important role in raising awareness and encouraging real action. The integration of ESD into the curriculum can be a strategic means to foster understanding and attitude of caring for the environment in students. Teachers play the role of agents of change who are expected to be able to instill sustainability values in the learning process. A number of international studies have shown the effectiveness of ESD in creating environmental awareness, for example through teacher training programs in Namibia (Anyolo et al., 2018) and Jordan (Ferguson et al., 2021) which have been proven to increase teachers' competence and innovation in teaching sustainability issues. However, the implementation of ESD is not always easy, given the complexity of the material and the limitations of teachers' experience in integrating global issues into local practice.

In the Indonesian context, the role of science teachers, especially pre-tenured science teachers, is very important because they are prospective educators who will form a new generation. A number of studies show that even though prospective teachers have awareness of the issue of climate change, there are still various misconceptions about the concept. For example, research by Winter et al. (2022) revealed that some prospective teachers in Turkey have a misunderstanding of global warming, while Agustini et al.'s (2022) research in Indonesia highlights that most pre-position science teachers obtain climate information from the mass media rather than textbooks or formal learning. This condition indicates a gap between theoretical knowledge and practical application in learning.

Furthermore, the difficulty of pre-position science teachers in integrating ESD into subjects is also a serious problem. Erlina (2021) reported that although prospective science teachers showed a fairly high level of understanding of ESD concepts (79.5%) and readiness to integrate ESD (80.5%), they still faced difficulties at the implementation stage with a percentage of obstacles of 73.5%. This shows that cognitive comprehension is not always directly proportional to practical ability, so support is needed in the form of guidelines, training, and appropriate learning strategies.

Based on these conditions, there appears to be a research gap. Many previous studies have focused on the implementation of ESD and climate education in general, but there is still limited research that specifically highlights the understanding and challenges of pre-tenured science teachers in the Indonesian context. In fact, their understanding greatly determines the success of ESD in the future, because pre-service teachers are agents of change who will internalize the value of sustainability in the learning process. Thus, this study aims to analyze the understanding of prospective science teachers on the issue of climate change, identify their difficulties in integrating ESD into learning, and provide recommendations for educational strategies that can strengthen teachers' capacity to face sustainable development challenges. It is hoped that the results of this research can contribute to the development of the teacher education curriculum and strengthen the role of education as an important instrument in dealing with the global environmental crisis.

2. Literature Review

Education for Sustainable Development (ESD) is a strategic approach in equipping students to have awareness, attitudes, and skills to face global challenges, especially related to climate change and environmental damage. According to Fitria and Hamdu (2021), ESD is oriented towards improving the quality of education by integrating environmental, social, and economic aspects. ESD emphasizes not only knowledge transfer, but also on the formation of character, values, and behaviors that support sustainability. Nugraha (2019) added that the implementation of ESD can be carried out through integrating sustainability materials into the curriculum as well as through contextual learning activities. Several studies have shown that the application of ESD through teacher training is able to improve pedagogical understanding and skills. Anyolo et al. (2018) found that teachers in Namibia who received ESD training were able to internalize sustainability issues into learning, even encouraging collaborative practices between teachers.

Similar research in Jordan by Ferguson et al. (2021) also confirms the importance of teacher debriefing, where the trained teacher then acts as a mentor to peers. This shows that teachers are key actors in realizing the effective implementation of ESD. However, a number of studies show that there are challenges in understanding the issue of climate change. Winter et al. (2022) report that most pre-tenured teachers in Turkey have a limited understanding of atmospheric issues, and there are even fundamental misconceptions such as the notion that global warming is caused by the penetration of solar radiation or is directly related to the ozone hole. Research by Agustini et al. (2022) in Indonesia

also revealed that pre-tenured science teachers still obtain a lot of information on climate change from the mass media, not from formal academic sources, thus causing limitations in conceptual understanding. This condition has an impact on their difficulty in integrating climate change issues into learning.

In addition to conceptual understanding, pro-environmental behavior is also in the spotlight. Hasnindar (2019), found that although teachers are aware of climate change as a serious issue, their actions are still limited to simple activities such as walking or recycling, without truly connecting with climate mitigation goals. Meanwhile, Erlina (2021) shows that prospective science teachers in Indonesia have a fairly good understanding of ESD concepts and readiness to integrate them into learning. However, there are still obstacles at the implementation stage that require further guidance and training. Thus, the literature shows that the implementation of ESD and understanding of climate change issues among teachers, especially pre-tenured science teachers, still face challenges. The gap between knowledge, attitudes, and real practice confirms the need for further research to understand the factors that influence the understanding of prospective teachers, as well as formulate more effective educational strategies.

3. Methods

This study uses the Systematic Literature Review (SLR) method to obtain a comprehensive overview of the understanding of prospective science teachers on Education for Sustainable Development (ESD) and climate change issues. The SLR method was chosen because it is able to provide synthesis of various previous studies

in a systematic, transparent, and replicable manner. Through this approach, the data obtained is not only sourced from one study, but compiled from various relevant research results, so that it can provide more in-depth and holistic conclusions. The SLR process is carried out through several stages. First, the determination of research questions that focus on: (1) how science teachers understand ESD and climate change issues, (2) the difficulties they face in integrating ESD into learning, and (3) recommended strategies to increase teachers' capacity in dealing with sustainability issues. This question is the basis for the search, selection, and analysis of the literature.

Second, literature searches are carried out through scientific databases such as Google Scholar with the keywords: Education for Sustainable Development, climate change education, science pre-service teachers, teacher training, and environmental education. The selected literature is limited to ensure the data used is current and relevant. In addition, the literature reviewed consists of journal articles, proceedings, and research reports that have gone through a peer review process. Third, the literature selection stage is carried out by applying inclusion and exclusion criteria. Inclusion criteria include: (1) research that focuses on science teachers or prospective teachers, (2) research that discusses ESD and/or climate change issues, and (3) publications that are available in English and Indonesian. The exclusion criteria include: (1) non-scientific articles such as opinions or news, (2) research that does not directly address teacher education, and (3) duplicate articles from other sources. From this process, a number of articles were obtained that met the criteria for further analysis.

Fourth, data analysis is carried out by reading, classifying, and synthesizing findings from each relevant study. The analysis focused on key themes such as the level of conceptual understanding, forms of misunderstanding, ESD integration practices, and challenges faced by pre-tenured teachers. The findings are then compared to identify similarities, differences, and current research trends. Using the SLR method, this study is expected to provide a clear mapping of the actual conditions of prospective science teachers' understanding of ESD and climate change issues, as well as identify research gaps that can be used as a basis for the development of future educational strategies.

4. Results and Discussion

4.1. Understanding of Science Teacher Candidates on ESD and Climate Change Issues

Prospective science teachers' understanding of Education for Sustainable Development (ESD) and climate change issues is a fundamental aspect in shaping their readiness as educators in the future. Based on the results of the literature review, most of the prospective science teachers show awareness of the importance of ESD, but their level of understanding still varies. Erlina (2021) found that 79.5% of prospective science teachers have understood the concept of ESD, even 80.5% of them expressed readiness to integrate ESD into learning. However, there are still real difficulties in implementation, which is shown by the percentage of obstacles of 73.5%. This indicates that theoretical knowledge is not always in line with practical ability.

Awareness of climate change issues is also an important highlight. Research by Agustini et al. (2022) shows that most prospective science teachers understand the linkage of human activities to climate change, including the importance of mitigation and adaptation. However, the study also highlights that the information they obtain comes mostly from mass media such as television, the internet, and newspapers, rather than from textbooks or formal academic sources. This has the potential to lead to bias and conceptual misunderstandings. For example, Winter et al. (2022) revealed that prospective pre-tenured teachers in Turkey have misconceptions, such as believing that global warming is caused by increased solar radiation or that the phenomenon is caused by the ozone hole. This kind of misunderstanding is dangerous if not straightened out, as it can lead to misconceptions carried over into classroom teaching practice.

The understanding of prospective teachers is also different based on their scientific background. Prospective biology teachers tend to associate climate change with the issue of deforestation and the importance of replanting forests as an effort to absorb greenhouse gases. Meanwhile, prospective chemistry teachers emphasize the importance of reducing food waste and recycling used items that have the potential to produce methane gas. The prospective physics teacher highlighted the use of fossil-based electrical energy as the main factor in increasing greenhouse gas emissions. This difference in viewpoints reflects the wealth of perspectives in understanding environmental issues, but at the same time shows the lack of an integrated understanding across disciplines. In fact, ESD demands a holistic

approach that combines various fields of science to produce comprehensive solutions.

In addition to the difference in perspectives, the understanding of prospective science teachers on the issue of climate change is still limited to the cognitive aspect. Some of them understand the basic concepts, but have not yet arrived at the reflective awareness that drives pro-environmental behavior. Like teachers who consider climate change a serious problem, but they rarely take concrete action to address it. Activities carried out, such as walking, cycling, or recycling, are driven more by practical daily needs than awareness of climate mitigation. This condition is in line with the findings of Hasnindar (2019), who attribute the level of understanding to individual environmental values: teachers with high ecocentric values tend to be more concerned, while those with low environmental values tend to underestimate the impact of climate change.

Limited sources of understanding are also an obstacle. Agustini et al. (2022) noted that material on climate change has only formally entered the school-based curriculum, so that access to information for pre-service teachers is highly dependent on media outside the school. This makes them less likely to get systematic learning about environmental issues. Teachers only treat environmental issues as conceptual memorization, students tend not to see them as real problems. Therefore, the quality of pre-position teachers' understanding is very important in shaping students' attitudes.

From this description, it can be concluded that the understanding of prospective science teachers on ESD and climate change issues is at a fairly good

level, but still faces challenges in the form of conceptual misunderstandings, limited formal learning resources, and lack of cross-disciplinary integration. Differences in scientific backgrounds enrich perspectives, but without adequate debriefing, it can result in fragmentation of understanding. For this reason, it is necessary to strengthen the education of pre-service teachers through practice-based training, consistent integration of environmental issues into the curriculum, and the provision of valid academic learning resources. This is important so that pre-service teachers not only understand the issue of climate change theoretically, but also are able to internalize sustainability values in contextual learning practices.

4.2. Challenges and Strategies for ESD Integration in Science Learning

The integration of Education for Sustainable Development (ESD) in science learning faces various complex challenges. Although most aspiring science teachers have a good understanding of the concept of sustainability, research shows that difficulties arise when they try to implement it into learning practices. Erlina (2021) emphasized that although 80.5% of prospective science teachers expressed readiness to integrate ESD, as many as 73.5% still experienced real obstacles in practice. These obstacles include limited pedagogical knowledge, lack of implementation guidelines, limited learning resources, and lack of direct experience in teaching sustainability issues.

One of the main challenges is the limitations of curriculum and learning materials that explicitly include ESD. Agustini et al. (2022) note that climate change material has just been formally incorporated into school-based curricula. This causes pre-position teachers to not receive systematic briefing on sustainability issues. In

addition, prospective teachers often rely on information from mass media such as television, blogs, or Wikipedia (Agustini et al., 2022), which has the potential to lead to misconceptions. As a result, when they try to integrate climate change issues into learning, the discussion is often superficial and uncontextual.

Behavioral factors are also an obstacle. Many prospective pre-tenured science teachers are aware of the importance of pro-environmental behavior, but still struggle to leave old habits such as throwing away food, using excess electricity, or not sorting waste consistently (Nielsen et al., 2021). This misalignment between knowledge and practice reflects a low commitment to internalizing sustainability values. In fact, Donmez-Turan and Kiliclar (2021) assert that a person's self-acknowledged environmental orientation is often not reflected in real behavior, especially when pro-environmental actions are considered troublesome.

However, a number of ESD integration strategies in science learning have been successfully implemented in various countries and can be an inspiration. In Namibia, teachers who receive ESD training then share their experiences with other teachers collaboratively, creating more flexible and innovative learning (Anyolo et al., 2018). This training model is effective because it emphasizes on peer mentoring and the transfer of practical experience. Meanwhile, research by Ferguson et al. (2021) in Jordan shows that trained teachers are able to become agents of renewal in their schools, so the impact is wider. This proves that strengthening teacher capacity through tiered training is very important to support ESD integration.

In the context of prospective science teachers in Indonesia, ESD integration strategies can be directed through several approaches. First, there is a need to

strengthen the teacher education curriculum by explicitly including sustainability issues in science courses. This aims to make prospective teachers accustomed to seeing the relationship between science and environmental issues. Second, the development of practice-based training, such as lesson studies or microteaching that integrates climate change materials into learning scenarios. Through practical experience, prospective teachers not only understand concepts, but are also skilled in conveying them to students. Third, the use of innovative learning media such as digital simulations, environment-based projects, and out-of-class learning can help connect theory with contextual reality.

In addition to the formal approach, ESD integration strategies can also be strengthened through habituation of pro-environmental behavior in the teacher education campus environment. Simple habits such as reducing food waste, saving energy, or waste management can be practiced consistently to form a culture of sustainability. Thus, prospective teachers not only transfer knowledge, but also become real role models for students. Boon (2016) emphasized that teacher education has an important role in preparing future citizens who are able to take mitigation and adaptation actions to climate change.

From the description above, it can be concluded that the challenges of integrating ESD in science learning include curriculum limitations, lack of academic resources, lack of practical experience, and mismatches between knowledge and behavior. However, various strategies can be applied to overcome these barriers, ranging from strengthening teacher education curriculum, practice-based training, the use of innovative media, to habituating pro-environmental behavior. With the

support of the right education policy and adequate debriefing, prospective science teachers can play an optimal role as agents of change that instill the value of sustainability in future generations.

5. Conclusion

Education for Sustainable Development (ESD) has an important role in shaping a generation that cares about the environment and is able to face global challenges, especially climate change. The results of the study show that prospective pre-tenured science teachers have a relatively good understanding of sustainability issues, but there is still a gap between conceptual knowledge and real application in learning and daily behavior. Misconceptions about climate change, curriculum limitations, and lack of practical experience are the main obstacles to integrating ESD effectively. Findings from various studies in Namibia, Jordan, and Turkey provide valuable lessons that teacher training based on practice, collaboration, and habituation can improve the ability of prospective teachers to integrate ESD.

In the Indonesian context, strengthening the teacher education curriculum, providing practice-based training such as microteaching or lesson study, and the use of innovative learning media are very necessary. In addition, habituating pro-environmental behavior in the campus environment is also an important strategy so that prospective teachers not only understand the concept of sustainability, but also emulate real practices. Thus, this study emphasizes the urgency of strengthening the capacity of prospective science teachers as agents of change who are able to instill sustainability values in students. Systematic efforts through education, training, and

habituation policies are expected to be able to bridge the gap between theory and practice, so that education can be an effective instrument in mitigating and adapting to climate change.

References

Agustini, M. P., Meilinda, M., Aisyah, N., Ismet, I., & Sriyanti, I. (2022). Pemahaman guru IPA Pra Jabatan Terhadap Mitigasi Dan Isu Perubahan Iklim. *JIPI (Jurnal IPA & Pembelajaran IPA)*, *6*(1), 11-19.

Anyolo, E. O., Kärkkäinen, S., & Keinonen, T. (2018). Implementing Education For Sustainable Development In Namibia: School Teachers¿ Perceptions And Teaching Practices. *Journal of Teacher Education for Sustainability*, *20*(1), 64-81.

Boon, H. J. (2016). Pre-service teachers and climate change: A stalemate?. *Australian Journal of Teacher Education (Online)*, *41*(4), 39-63.

Dellmuth, L. M., & Gustafsson, M. T. (2021). Global adaptation governance: how intergovernmental organizations mainstream climate change adaptation. *Climate Policy*, *21*(7), 868-883.

Donmez-Turan, A., & Kiliclar, I. E. (2021). The Analysis of Pro-Environmental Behaviour Based on Ecological Worldviews, Environmental Training/Knowledge and Goal Frames. *Journal of Cleaner Production*, *279*, 123518.

Erlina, N. (2021). Kesiapan Calon Guru IPA Dalam Pengembangan Rencana Pembelajaran Berbasis Education for Sustainable Development. *Jurnal pendidikan dan pembelajaran sains indonesia (JPPSI)*, *4*(2), 142-150.

Ferguson, T., Roofe, C., & Cook, L. D. (2021). Teachers' perspectives on sustainable development: the implications for education for sustainable development. *Environmental Education Research*, *27*(9), 1343-1359.

Fitria, A., & Hamdu, G. (2021). Pengembangan aplikasi mobile learning untuk perangkat pembelajaran berbasis education for sustainable development. *Jurnal Inovasi dan Teknologi Pembelajaran*, *8*(2), 134-145.

Hasnidar, S. H. S. (2019). Pendidikan estetika dan karakter peduli lingkungan sekolah. *Jurnal serambi ilmu*, *20*(1), 97-119.

Nielsen, K. S., Clayton, S., Stern, P. C., Dietz, T., Capstick, S., & Whitmarsh, L. (2021). How psychology can help limit climate change. *American Psychologist*, *76*(1), 130.

Winter, V., Kranz, J., & Möller, A. (2022). Climate Change Education Challenges From Two Different Perspectives Of Change Agents: Perceptions Of School Students And Pre-Service Teachers. *Sustainability*, *14*(10), 6081.