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Generation Z Education Based on Green Technology in Climate Mitigation

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Abstract

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Climate change increases the frequency of hydrometeorological disasters, such as floods, droughts, and storms, which adversely affect the environment and health, as well as increasing morbidity and mortality rates. Green technology is present as a strategic solution through innovations in waste management, renewable energy, environmentally friendly buildings, and carbon capture technology. However, the main challenge is the low environmental literacy and green technology in Generation Z, even though they are a strategic group that will be the decision-makers in the future. This article aims to explain the role of green technology in climate change mitigation, describe education strategies for generation Z based on Education for Sustainable Development, and document community service practices as a means of knowledge transfer. The method used is Systematic Literature Review. The results of the study show that the application of green technology not only contributes to climate mitigation, but can also be an effective educational instrument through interactive digital media such as webinars, videos, infographics, and gamification. Furthermore, the implementation of Education for Sustainable Development encourages the involvement of Generation Z as agents of change who are able to instill sustainability values and put them into practice.

1. Introduction

Climate change has become the most pressing global issue of the 21st century. The real impact of climate change includes the increasing intensity of hydrometeorological disasters such as floods, landslides, tropical storms, and prolonged droughts. This phenomenon not only damages the quality of the environment, but also threatens public health with increasing morbidity and mortality rates due to environmental-based diseases. International organizations such as the United Nations have affirmed the urgency of climate action through the Sustainable Development Goals (SDG 13: Climate Action), which emphasize the importance of climate change mitigation and adaptation through a cross-sectoral and multi-actor approach. Indonesia, as an archipelagic country with high vulnerability to climate disasters, has a great responsibility to strengthen adaptation strategies, especially through green technology innovation and public education (Gaborit, 2022).

In this context, Generation Z occupies a strategic position. As a group that is currently pursuing higher education and will be decision-makers in the future, Generation Z has great potential to become agents of change in sustainability issues. However, a number of studies show that this generation still has a low understanding of green technology and practical skills in implementing a sustainable lifestyle. For example, the research of Wijaya and Kokchang (2023) found that although Generation Z shows interest in renewable energies such as solar panels, the level of real adoption in daily behavior is still limited. This shows that there is a gap between

sustainability awareness and practice that needs to be bridged through education and empowerment.

Green technology offers concrete solutions in mitigating climate change while improving environmental quality (Nainggolan et al., 2023). These innovations include integrated waste management based on the concept of zero waste, the application of waste to energy (WTE) and wastewater treatment plants (WTP), the use of renewable energy such as biomass, solar, and wind, the construction of green buildings in tropical areas, and carbon capture technology (CO_2 capture). However, as noted by Huang et al. (2023), the use of green technology does not only depend on technical or industrial aspects, but also on social, cultural, and behavioral factors of society. Thus, the success of the implementation of green technology is highly determined by the level of environmental literacy and the involvement of the younger generation in the interactive educational process.

In line with that, education efforts based on Education for Sustainable Development (ESD) are very important. Through ESD, Generation Z is not only taught the concept of sustainability theoretically, but also directed to develop critical thinking skills, collaboration, and practical application of green technology in daily life. Putri and Yanzi (2020) shows that creative communication strategies, such as the use of digital media and educational games, can increase the awareness of the younger generation on sustainability issues, especially in the urban context of Indonesia. This emphasizes that the educational approach must be adapted to the characteristics of Generation Z who are close to digital technology and interactive media.

This article is here to answer the research gap that has so far focused more on the technical aspects of green technology, while studies that link it to Generation Z education are still limited. By integrating a community service approach, this article aims to explain the role of green technology in mitigating climate change and hydrometeorological disasters, while also describing how Generation Z can be empowered through environment-based education. Furthermore, this article will outline ESD-based instructional concepts as best practices in the implementation of community service that support the achievement of the SDGs, specifically SDG 13 (Climate Action).

2. Literature Review

The study of green technology in the context of education and the younger generation has been growing in the last decade, especially as the urgency of climate change mitigation increases. In Indonesia, research on green technology has highlighted many technical aspects, such as the implementation of renewable energy, waste management, and sustainable architectural innovation. However, educational aspects that link green technology to Generation Z as a strategic group are still relatively minimally explored (Arifin et al., 2023). In fact, environmentally-based education has an important role in shaping pro-environmental behavior early on and ensuring long-term sustainability.

The study conducted by Masturin (2022) emphasizes the importance of the need for curriculum development that is relevant to generation Z. The research shows that this generation is more responsive to learning models that are interactive,

contextual, and based on digital technology. This is in line with the character of Generation Z who grew up in the era of digitalization, so that traditional educational methods are considered less effective in instilling sustainability values. An approach that emphasizes hands-on experience, simulation, and interactive visual media is believed to be better able to improve their understanding of environmental issues.

In addition, the research of Huang et al. (2023) underlines the role of digitalization and user-generated content in influencing people's green behavior. In the context of Generation Z, social media, e-commerce, and digital platforms are important means to communicate sustainability issues. Thus, counseling or education about green technology can be more effective if it uses media that are close to the daily lives of this generation, such as educational videos, interactive webinars, to application-based graphic design such as Canva. This shows that there is a great opportunity to optimize the edutainment approach in increasing environmental awareness.

Furthermore, the study by Ren and Zhao (2023) provides a new perspective on the use of creative communication strategies in increasing sustainability awareness. Through the design of digital games on sustainable plantations, the research proves that game-based media can increase the knowledge of the younger generation about environmental impacts, while motivating them to behave more pro-environmentally. This is relevant to the idea that Generation Z tends to be more involved if education is carried out through a fun, participatory, and technology-based approach.

Based on the literature, it can be seen that although there is quite a lot of research related to green technology in Indonesia, the focus on interactive educational approaches for Generation Z is still a significant research gap. Thus, the development of innovative digital-based counseling methods not only has the potential to increase the understanding of the younger generation, but can also strengthen the linkage between green technology and hydrometeorological disaster mitigation in the context of Indonesian higher education.

3. Methods

This study uses the Systematic Literature Review (SLR) approach to identify, evaluate, and synthesize various literature relevant to the topics of green technology, generation Z, and environmental education in Indonesia. This method was chosen because it is able to provide a comprehensive overview of the latest research developments, as well as find research gaps that can be used as a foothold for further study. The first stage in this SLR is to formulate research questions. The main focus of the study is directed at three things, namely the role of green technology in mitigating climate change and hydrometeorological disasters, Generation Z empowerment strategies through green technology-based education, and the effectiveness of interactive counseling models based on digital technology in improving environmental literacy. With this research question, the direction of literature search becomes more directed and systematic.

The next step is to develop a literature search strategy. The search was conducted on trusted academic databases, especially Google Scholar, Elsevier, and

Researchgate, with a limit of the last five years of publication so that the findings obtained are relevant to the current context. Several keywords are used in the search, including green technology, Generation Z, climate change education, sustainability in Indonesia, and environmental education. Articles that emerged from the search results were then selected based on their relevance to the topic, the use of Indonesian or English, and their relevance to the dimension of education and the younger generation. To maintain accuracy, this study applies inclusion and exclusion criteria. The articles included are publications that directly discuss green technology, sustainability, generation Z, environmental education, or climate change mitigation in Indonesia.

From the initial search results, around 45 articles were collected. After a screening process with the criteria that have been set, the number of relevant articles narrowed to 13. Of these, four main articles were chosen as the basis of the analysis because they explicitly link the issue of green technology, generation Z, and environmental education aspects. The rest of the article is used as an additional reference to strengthen the argument. The synthesis process was carried out by grouping the findings into three major themes, namely the role of green technology in climate change mitigation, pro-environmental behavior characteristics of generation Z, and educational strategies based on digital and interactive media.

The validity of the study results is maintained by selecting articles from indexed journals, international proceedings, and reputable academic publications. Each article is analyzed not only in terms of content, but also in terms of research methodology, the suitability of the context with the Indonesian situation, and the

real contribution to the field of study. With this approach, the results of SLR are expected to be able to provide a deep understanding of the latest research trends as well as the research gaps that are still open.

The main reason for choosing the SLR method is because the theme of this research is relatively new in the Indonesian context, especially the relationship between green technology, hydrometeorological disaster mitigation, and Generation Z education through community service. Through SLR, researchers can identify effective strategies that have been applied in various previous studies, as well as examine opportunities for the development of innovative educational methods that are more in line with the characteristics of the younger generation. Thus, the results of this study can be a strong conceptual foundation in designing a green technology-based community service model that supports the achievement of the Sustainable Development Goals (SDGs), especially SDG 13 on climate action.

4. Results and Discussion

4.1. The Role of Green Technology in Climate Change Mitigation and Hydrometeorological Disasters

Climate change has increased the frequency and intensity of hydrometeorological disasters, including floods, landslides, storms, and droughts. Indonesia, with its geographical conditions as a tropical archipelagic country, is a region that is very vulnerable to these disasters. Green technology is present as one of the solutions that can reduce risks while minimizing the impact of climate change. The concept of green technology not only includes technical innovation, but also

includes changes in social systems, community behavior, and integration with sustainable development policies (Guo et al., 2020).

In the context of climate change mitigation, green technology plays a role in three main aspects. First, through integrated waste management based on the principle of zero waste and the conversion of waste into energy or value-added products (waste to energy and waste to product). The implementation of this model has been proven to reduce urban waste piles which are one of the contributors to greenhouse gases. In addition, the implementation of wastewater treatment plants (WTP) also helps reduce water pollution and maintain the health of aquatic ecosystems.

Second, the use of renewable energy such as biomass, solar power, and wind is an important alternative to replace fossil energy which contributes greatly to carbon emissions. A study conducted by Wijaya and Kokchang (2023) shows that generation Z in Indonesia is starting to show interest in the use of solar energy, especially in the form of photovoltaic panels. However, challenges still lie in the low actual adoption due to limited access, costs, and lack of socialization about the long-term benefits of renewable energy. This shows that the successful implementation of renewable energy does not only depend on technology, but also on educational factors and public awareness.

Third, the concept of green buildings for tropical areas is also an important innovation in reducing carbon footprints while improving the quality of life of urban communities. Eco-friendly architecture that utilizes natural lighting, cross-ventilation, and sustainable materials not only reduces energy consumption, but also

reduces indoor air pollution. Green buildings contribute to reducing climate-related health risks, such as respiratory diseases due to poor air quality, and can serve as a model for sustainable urban development in Indonesia (Molina, 2021).

Furthermore, carbon capture and storage technology is a promising mitigation strategy on an industrial scale. Although its implementation is still limited in Indonesia, the global policy direction is increasingly encouraging the development of this technology as part of the commitment towards net zero emissions. Nainggolan et al. (2023) emphasized that the successful adoption of green technology depends on the synergy between technical aspects, policies, and changes in consumer behavior. This means that innovative technology must be accompanied by educational and regulatory campaigns that encourage people to change their consumption patterns to be more sustainable.

In addition to its direct contribution to reducing carbon emissions and environmental degradation, green technology also has an indirect impact on public health. With reduced air, water, and soil pollution, the risk of environment-based diseases can be suppressed. Research by Ren and Zhao (2023) shows that creative media-based education is able to increase the awareness of the younger generation about the environmental impact of human activities, thereby encouraging the creation of more responsible behavior towards the environment. This proves that the role of green technology in climate change mitigation cannot be separated from environmental education and communication strategies.

Thus, it can be concluded that the role of green technology in mitigating climate change and hydrometeorological disasters is multidimensional. Technical

innovations such as renewable energy, green buildings, and integrated waste management have a direct impact on reducing emissions and disaster risk. Meanwhile, education, communication, and engagement strategies for the younger generation ensure the long-term sustainability of the application of these technologies. Therefore, the synergy between technology development, government policies, and community participation, especially generation Z, is the key to the success of climate change mitigation in Indonesia.

4.2. Education for Generation Z Based on Education for Sustainable Development (ESD)

Generation Z is known as a digital native group that grew up in the era of information technology. These characteristics make them familiar with social media, digital applications, and technology-based interactions. However, despite having extensive access to information, research shows that Generation Z's understanding of environmental issues and green technology is still relatively low (Gomes et al., 2023). This is a challenge as well as an opportunity for the world of education to design an education program based on Education for Sustainable Development (ESD) that is relevant to the learning style of this generation.

The concept of ESD emphasizes the integration of knowledge, skills, values, and actions that support sustainability in daily life. In the context of Generation Z, ESD must not only be conveyed through conventional methods, but also through creative approaches that utilize digital technology. The study by Masturin (2022) confirms that Generation Z is more responsive to interactive and experience-based learning. Thus, learning media such as digital simulations, educational videos,

webinars, and visual design platforms such as Canva can be an effective means of improving their environmental literacy.

Technology-based educational approaches have an important role to play in bridging the gap between theoretical knowledge and real practice. For example, an interactive webinar program on waste management can introduce the concept of zero waste while providing practical guidance that can be directly applied at home or campus. Huang et al. (2023) show that digitalization is able to influence the consumption behavior of the younger generation, including in the adoption of environmentally friendly products. This proves that environmental education packaged in a digital format is not only able to increase understanding, but also encourage behavior change.

In addition, edutainment-based creative communication strategies have proven to be effective in increasing the involvement of the younger generation. Ren and Zhao (2023) prove that digital game design can improve Generation Z's understanding of the sustainability of oil palm plantations. These findings suggest that game-based media, interactive infographics, and gamification platforms have the potential to be more relevant environmental education tools than traditional methods. Through this approach, Generation Z is not only a recipient of information, but also an active actor involved in the learning process.

The implementation of ESD is also important to build sustainable pro-environmental behavior (Rahma, 2022). By combining cognitive, affective, and psychomotor aspects, Generation Z is directed to not only understand the importance of green technology, but also to apply it in daily life. For example,

through community projects involving students in campus waste management, installation of miniature solar panels, or the creation of energy-efficient building designs. These kinds of programs provide real-life experiences that reinforce their commitment to sustainability.

On the other hand, strengthening ESD in higher education can also support the implementation of green technology-based community service (Czok, et al., 2023). Generation Z students who are involved in interactive counseling activities to the surrounding community can act as agents of change who transfer knowledge while building collective awareness. This not only increases student capacity, but also strengthens community involvement in adopting environmentally friendly practices. Thus, it can be concluded that the implementation of ESD based on digital technology is a strategic approach to improve the understanding and skills of Generation Z regarding green technology. Through creative, participatory, and interactive media, this generation can be empowered as agents of change who play an important role in mitigating climate change and achieving the Sustainable Development Goals. Synergy between universities, the community, and the government in implementing ESD programs will ensure that Generation Z not only inherits knowledge, but also practical abilities to realize a more sustainable future.

5. Conclusion

Climate change and increasing hydrometeorological disasters demand the presence of innovative solutions that are not only technical, but also involve social and educational aspects. Green technology has proven to be a multidimensional

approach that is able to contribute to climate change mitigation through integrated waste management, renewable energy, green buildings, and carbon capture technology. However, the success of green technology implementation is not solely determined by technical innovation, but also by public awareness, skills, and participation in implementing it. In the Indonesian context, generation Z is a strategic group that will be decision-makers in the future. Unfortunately, their environmental literacy and skills in utilizing green technology are still relatively low. This requires an education strategy based on Education for Sustainable Development (ESD) that is relevant to the characteristics of this generation. Through digital media such as webinars, educational videos, interactive infographics, and gamification-based games, Generation Z can be invited to understand and practice environmentally friendly behavior in a more fun and participatory way.

The results of the discussion show that the combination of green technology development with ESD-based education strategies is able to strengthen the role of generation Z as agents of change. Through interactive and applicative learning experiences, they can internalize sustainability values while spreading them to the wider community through community service programs. Thus, environmental education that is oriented to real practices not only increases the awareness of the younger generation, but also strengthens the community's carrying capacity in facing the challenges of climate change. Therefore, this article emphasizes the importance of synergy between green technology innovations, higher education programs, and the involvement of Generation Z in realizing sustainable development goals, especially SDG 13: Climate Action. These efforts are not only relevant to confront

the climate crisis, but also the foundation for the construction of a more sustainable civilization in the future.

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