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Integrating Climate Education in *Kurikulum Merdeka*: Multidisciplinary and Digital Approaches for Climate Literacy

Farhan Baktian Kelana[1]

[1] Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

Abstract

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Climate change represents a global challenge that requires complementary strategies of mitigation and adaptation. Mitigation focuses on efforts to reduce greenhouse gas emissions, while adaptation emphasizes adjustments to unavoidable impacts. Within this context, climate literacy emerges as a crucial long-term strategy to foster awareness and strengthen the capacity of societies, particularly younger generations, in addressing environmental dynamics. Education plays a vital role in embedding climate literacy through curriculum integration, contextual learning, and cross-disciplinary approaches. In Indonesia, the *Kurikulum Merdeka* provides flexible opportunities through local content and the *Projek Penguatan Profil Pelajar Pancasila* (P5), enabling concrete environmental actions such as school-based waste banks and greening initiatives. Moreover, advances in digital technology enrich pedagogical practices, including the use of the EzGCM climate simulation model and mobile learning enhanced by gamification. This article aims to explore the potential of multidisciplinary and technology-based climate education in fostering transformative climate literacy, using a literature review as the primary methodological framework.

1. Introduction

Climate change is a global environmental issue and one of the most pressing challenges of the 21st century. The impacts it causes are not only in the form of increased global temperatures, melting polar ice, and rising sea levels, but also extreme weather pattern changes that affect human health, food, water, and even the survival of humanity. To face these challenges, mitigation and adaptation strategies are seen as two complementary main approaches. Mitigation emphasizes efforts to reduce greenhouse gas emissions through the transition to renewable energy, increased energy efficiency, and forest conservation. Conversely, adaptation focuses on adjusting to the unavoidable impacts of climate change, for example, by developing drought-resistant plant varieties, building climate-friendly infrastructure, or designing city spatial planning that is adaptive to climate disasters (European Environment Agency; Iberdrola).

Beyond technical and policy efforts, climate literacy emerges as one of the fundamental long-term strategies (Shwom et al., 2017). Climate literacy is not merely about conveying scientific information, but about building a comprehensive understanding so that individuals and communities can respond to climate change with a critical, solution-oriented, and pro-environmental attitude. A good understanding of climate will encourage community participation in mitigation while increasing adaptive capacity. Thus, climate literacy acts as a foundation for sustainable development that must be instilled from an early age. Education has a strategic position in building climate literacy in the younger generation. Boca and Saraçlı (2019) emphasize three main pathways for climate education: providing an

environment-based education infrastructure, curriculum integration that includes climate change topics, and the application of contextual learning that connects theory with local realities. The relevance of climate education is even stronger when it is linked to the formation of pro-environmental attitudes.

According to Goldman et al. (2017), environmentally friendly behavior is formed from the interaction of cognitive, affective, and social factors that can be developed through appropriate learning design. In the Indonesian context, the *Merdeka* Curriculum opens up great opportunities to strengthen the integration of climate education. This curriculum emphasizes the flexibility and autonomy of schools in developing learning based on local contexts, one of which is through local content. Through this approach, climate change issues can be integrated with cultural practices and local knowledge, such as sustainable agricultural systems, water conservation, or indigenous forest management. In addition, the Strengthening Pancasila Student Profile Project (P5) provides a space for students to be directly involved in real actions such as waste banks, greening, and environmental campaigns.

The interdisciplinary approach also plays an important role in enriching students' understanding of climate issues. The integration of various subjects allows students to see the connection between scientific concepts, social impacts, language narratives, and artistic expressions in responding to environmental issues. For example, a science teacher discusses the greenhouse effect, a social studies teacher links it to socio-economic vulnerability, an Indonesian language teacher guides students in creating persuasive texts about the environment, and an arts and culture

teacher helps create campaign posters. This kind of collaboration not only adds to cognitive understanding but also fosters 21st-century skills such as critical thinking, collaboration, and creativity (Duncan, 2020).

This article focuses on a literature review of how the integration of climate education can be realized through the *Merdeka* Curriculum by utilizing a multidisciplinary approach and digital technology. With a literature review method, this paper seeks to provide a comprehensive overview of the potential, challenges, and implementation strategies of climate education that are relevant to the needs of the current generation. It is hoped that this article can strengthen academic discourse on the urgency of climate education and provide a practical contribution to the development of transformative climate literacy in Indonesia.

2. Literature Review

2.1. Climate Education and Environmental Literacy

Climate literacy is essentially an integral part of scientific literacy that focuses on an individual's understanding of the climate system, the impacts it causes, and various alternative solutions through adaptation and mitigation strategies. This literacy not only emphasizes the aspect of scientific knowledge but also the skills to connect that knowledge with the reality of daily life. According to Lehtonen et al. (2018), climate education is not enough just to convey scientific concepts in the form of theory, but must be designed in such a way as to be able to foster critical awareness and a sense of ecological responsibility. This means that climate education needs to provide space for students to see the direct relationship between climate change and

their local environmental conditions, so that the learning process becomes more contextual, relevant, and meaningful.

On the other hand, the educational psychology literature confirms that pro-environmental behavior is not the result of knowledge alone, but is formed through the interaction of cognitive, affective, and social factors. Goldman et al. (2017) highlight that environmentally friendly attitudes can be cultivated effectively if the learning process encourages empathy, emotional involvement, and social participation of students. Thus, climate education should integrate emotional and social aspects for more sustainable results. In this regard, the 5E learning model introduced by Narzulloevna et al. (2020) is seen as one of the effective pedagogical strategies. The model invites students to be actively involved in the learning process through the stages of Engage, Explore, Explain, Elaborate, and Evaluate. Each stage allows students to connect personal experience with scientific knowledge, while also facilitating critical reasoning on complex environmental issues. Through this approach, climate education can strengthen students' ecological understanding, awareness, and behavior holistically.

2.2. *Merdeka* Curriculum, Multidisciplinary, and Digital Technology

The *Merdeka* Curriculum in Indonesia provides great flexibility for schools to adjust learning according to the needs and characteristics of their region. One form of this flexibility is seen through the development of local content and the application of the Strengthening Pancasila Student Profile Project (P5). Through these two instruments, schools are freer to design learning activities rooted in the social, cultural, and environmental context around students. Annan-Diab and

Molinari (2017) asserts that the interdisciplinary approach is an important strategy in climate education, as it allows for the integration of various scientific perspectives. In this way, students not only gain an understanding from the scientific side but are also able to connect it with social, cultural, and economic issues that are real in their lives. This kind of integration builds a holistic understanding while strengthening critical thinking and collaborative skills.

In addition, digital technology is now increasingly enriching climate learning methods by presenting interactive and direct experience-based media. That the use of EzGCM allows students to conduct real climate simulations, making it easier for them to understand the cause-and-effect relationship in the global climate system. Meanwhile, mobile-based learning equipped with gamification, as noted by Seibert Hanson and Brown (2020), has been proven to increase concept retention by more than 20%. No less important, the multimedia learning theory developed by Rau (2017) provides a theoretical foundation for the use of a combination of text and visuals in learning. This approach helps reduce students' cognitive load while accelerating their understanding of complex concepts. Thus, from the results of the literature review, it can be seen that the integration of climate education through the *Merdeka* Curriculum has the potential to form a generation that not only understands the issue of climate change but also has the skills, motivation, and concern to actively contribute to sustainability efforts.

3. Methods

This study uses a literature review method with the main goal of identifying, analyzing, and synthesizing various academic studies related to climate education, the *Merdeka* Curriculum, and the integration of digital technology in learning. The choice of this method is based on the consideration that a literature review is the most appropriate way to explore previous thoughts, theories, and research results to formulate a more comprehensive and relevant conceptual framework for the Indonesian education context. Through a literature review, researchers can obtain a broad overview of the development of climate literacy theory, innovative pedagogical models, and opportunities for the use of digital technology in supporting learning. The research process was carried out by searching various literature sources, both in the form of scientific articles, international research reports, and national regulations directly related to climate education.

The main sources include reputable international journals that discuss topics of climate literacy, interdisciplinary pedagogical approaches, and the application of technology in education. In addition, national education policies such as the *Merdeka* Curriculum and Permendikbud No. 79 of 2014 are also used as important references to understand the regulatory framework that applies in Indonesia. Literature data was obtained through academic databases such as Google Scholar, and other credible online sources. The literature analysis was conducted in stages through three main processes. First, the identification stage, which is the selection of articles, books, and official documents that match keywords such as climate literacy, climate

change education, multidisciplinary learning, digital technology in education, and the *Merdeka* Curriculum.

Second, the thematic analysis stage, where the collected information is grouped based on major themes such as climate literacy, pedagogical innovation, curriculum integration, and the use of digital technology. Third, the synthesis stage, which is arranging the relationships between concepts, comparing existing findings, and finding a gap (research gap) that can be the focus of further study. Thus, this literature review method not only serves to map the results of previous research but also to highlight opportunities for the practical implementation of climate education in Indonesian schools. This approach is ultimately expected to be able to strengthen the conceptual framework and offer a direction for the development of meaningful climate education in the context of the *Merdeka* Curriculum, so that it can support the formation of climate literacy in the younger generation.

4. Results and Discussion

Climate education in the context of the *Merdeka* Curriculum offers great potential for building climate literacy in the young generation of Indonesia. The results of the literature review show that the integration of mitigation and adaptation strategies with a multidisciplinary approach, project-based learning, and the use of digital technology can produce a more comprehensive understanding while encouraging pro-environmental behavior. The following discussion outlines the main findings from the analyzed literature, as well as its implications for climate education in Indonesia (Djalante, 2018). Mitigation and adaptation strategies need

to be understood as a conceptual foundation in climate education. Mitigation focuses on efforts to reduce greenhouse gas emissions through various policies and practices, such as the transition to renewable energy, energy efficiency, and greening. Adaptation, on the other hand, emphasizes adjusting to climate change that has already occurred, for example, by building disaster-resistant infrastructure or developing more resilient agricultural systems.

In the context of education, these two concepts are not only studied as theory but can also be translated into practical learning activities. For example, students can perform simulations of carbon footprint calculations, design a sustainable school garden, or map flood risks in their local environment. Thus, mitigation and adaptation are no longer seen as abstract concepts, but as part of a contextual learning experience. Climate literacy as a long-term strategy requires integration into the formal education system. Climate literacy includes the ability to understand the basics of climate science, assess its impact on daily life, and make informed decisions to reduce vulnerability. This literacy is also related to social awareness and environmental ethics. According to Boca and Saraçlı (2019), climate literacy should not be taught separately from other subjects, but integrated interdisciplinarily so that students can see the connection between various aspects of life. In this case, the *Merdeka* Curriculum provides a wide opportunity because its flexibility allows teachers to develop contextual learning that is relevant to local issues.

The multidisciplinary approach is one of the most effective strategies in climate education. Duncan (2020) shows that collaboration between subjects can enrich students' understanding of complex issues such as climate change. A science

teacher, for example, can explain the greenhouse effect scientifically, while a social studies teacher links this issue to the socio-economic impacts experienced by the community. An Indonesian language teacher can help students express ideas through persuasive texts, while an arts and culture teacher facilitates the creation of environmental campaign posters. This kind of integration results in a learning experience that is not only cognitive but also affective and psychomotor, thus forming a stronger pro-environmental attitude.

Implementation of the Strengthening Pancasila Student Profile Project (P5) opens a space for students to be involved in real actions. P5 emphasizes project-based learning that is oriented towards sustainability values, such as mutual cooperation, independence, and social responsibility. In the context of climate education, projects that can be developed include school waste banks, environmental greening, water conservation, or simple research on local climate impacts. Such activities foster 21st-century skills, such as critical thinking, problem-solving, collaboration, and communication. Furthermore, this direct experience strengthens the relationship between the theory learned in class and the daily reality faced by students. The educational psychology approach also needs to be considered. According to Goldman et al. (2017), the formation of an environmentally friendly attitude is influenced by the interaction of cognitive, affective, and social factors. This means that climate education is not enough to just focus on the knowledge aspect, but must also involve the emotional and social dimensions of students. For example, through group discussions, role-playing, or personal reflection, students can feel the impact of climate change emotionally while understanding its social

connection. In this way, climate education is more effective in encouraging long-term pro-environmental behavior.

Digital technology plays a transformative role in climate learning. EzGCM (Easy Global Climate Model), as shown by Bhattacharya et al. (2020), allows students to perform global climate simulations directly. Students can change variables such as carbon emission levels or deforestation, and then observe their impact on global temperatures or greenhouse gas concentrations. This activity encourages *discovery learning*, increases curiosity, and strengthens the understanding of causality in the climate system. In addition, mobile learning based on gamification is also proven effective. Seibert Hanson and Brown (2020) found that applications with spaced repetition techniques and game elements were able to increase concept retention by up to 21.5%. Thus, digital technology not only functions as a support medium but also as a pedagogical tool that strengthens students' cognitive and affective involvement. Multimedia learning theory Rau (2017) provides a scientific basis for the use of text, visuals, animations, and interactive infographics in climate learning. Abstract material such as the carbon cycle, the greenhouse effect, or the impact of climate change on ecosystems can be visualized so that it is easier for students to understand. By reducing cognitive load, multimedia design helps students process information faster and more deeply. This is very important given that many climate concepts are complex and invisible.

Study results also show challenges in the implementation of climate education. Some of the main obstacles include the limited resources of schools, the lack of teacher competence in integrating climate issues into the curriculum, and the

gap in access to digital technology in various regions. In addition, not all schools have utilized the flexibility of the *Merdeka* Curriculum to develop environment-based local content (Azmi & Iswanto, 2021). Therefore, there needs to be stronger policy support, continuous teacher training, and the provision of inclusive learning resources. Ninth, the integration of climate education in the *Merdeka* Curriculum also has implications for the formation of a young generation that is adaptive, creative, and ecologically responsible. With a solid scientific understanding, critical thinking skills, and real experience in environmental projects, students will be better prepared to face the challenges of climate change in the future. Furthermore, climate education also strengthens national identity by linking global issues to local wisdom, so that students not only become environmentally concerned citizens but also cultural heirs who are able to preserve the sustainability of natural resources.

The discussion from various literatures confirms that climate education in the *Merdeka* Curriculum should be seen as a transformative effort, not just an additional subject. The integration of mitigation and adaptation, a multidisciplinary approach, P5, educational psychology, and digital technology will result in a holistic and relevant climate education model for the needs of the 21st century. Effective climate education not only strengthens students' cognitive knowledge but also fosters the affective awareness and practical skills needed to face the reality of climate change at the local and global levels. Thus, the results of this study support the view that climate education is a long-term investment for sustainability. Through the *Merdeka* Curriculum, Indonesia has the opportunity to integrate climate issues in a more systematic, innovative, and contextual way. This effort needs to be continued with a

strong commitment from all stakeholders, from the government, schools, teachers, students, to the wider community. Only with close collaboration can climate education truly build a generation that is caring, adaptive, and empowered in the face of climate change challenges.

5. Conclusion

Climate change is a global challenge that requires complementary mitigation and adaptation strategies. Climate literacy is a long-term key to equipping the community, especially the younger generation, with the understanding and skills to deal with the impacts of climate change. Education has a strategic role in fostering this literacy through curriculum integration, a multidisciplinary approach, project-based learning, and the use of digital technology. The *Merdeka* Curriculum provides broad opportunities to develop climate education that is relevant to the local context through local content and the Strengthening Pancasila Student Profile Project. The multidisciplinary and real-experience-based approach is proven to be able to increase conceptual understanding while forming a pro-environmental attitude in students. Furthermore, digital technologies such as EzGCM, gamification-based mobile learning, and multimedia learning enrich learning methods in an interactive, contextual, and effective way.

However, challenges still exist, especially the limited resources of schools, teacher competence, and access to technology. Therefore, policy support, continuous teacher training, and cross-sector collaboration are needed to ensure the optimal implementation of climate education. Climate education in the *Merdeka*

Curriculum can be a transformative strategy to build a generation that is environmentally conscious, adaptive to change, and actively contributes to sustainability. The integration of science, psychology, pedagogy, and technology will make climate education not just a subject, but a part of the identity and lifestyle of the future generation.

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