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Engaging Learning for Environmental Awareness: Integrating Virtual Reality in Ecological Citizenship Education

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ABSTRACT

Virtual reality (VR) technology is increasingly being adopted in education, offering innovative and engaging methods for teaching. This study examines the application of VR-based learning media in Ecological Citizenship education, with a focus on enhancing students' environmental awareness. Through VR, students can engage in interactive simulations that realistically depict various aspects of the environment—from biological dynamics to the impacts of environmental changes. The findings demonstrate that VR not only improves students' technical understanding but also strengthens their attitudes towards environmental conservation through active participation. This research employs a qualitative approach, utilizing in-depth interviews, document analysis, and classroom observations to gather data. However, challenges at Lambung Mangkurat University, such as inadequate technological infrastructure, limited lecturer proficiency in effectively utilizing VR, and the need for curriculum-aligned content, hinder the full implementation of VR-based learning. Based on these results, the study recommends integrating VR into the curriculum as an effective pedagogical tool to foster environmental awareness and prepare future generations to be more responsive to environmental issues.

Keywords: citizenship, learning media, virtual reality, ecological citizenship

ABSTRAK

Teknologi realitas virtual (VR) semakin banyak diadopsi dalam dunia pendidikan, menawarkan metode pengajaran yang inovatif dan menarik. Penelitian ini mengkaji penerapan media pembelajaran berbasis VR dalam pendidikan Kewarganegaraan Ekologis, dengan fokus pada peningkatan kesadaran lingkungan siswa. Melalui VR, siswa dapat terlibat dalam simulasi interaktif yang menggambarkan berbagai aspek lingkungan secara realistis—mulai dari dinamika yang sifatnya biologis hingga dampak perubahan lingkungan. Hasil penelitian menunjukkan bahwa VR tidak hanya meningkatkan pemahaman teknis siswa, tetapi juga memperkuat sikap mereka terhadap konservasi lingkungan melalui partisipasi aktif. Penelitian ini menggunakan pendekatan kualitatif, dengan memanfaatkan wawancara mendalam, analisis dokumen, dan observasi kelas untuk mengumpulkan data. Namun, terdapat beberapa tantangan di Universitas Lambung Mangkurat, seperti infrastruktur teknologi yang tidak memadai, keterbatasan kemampuan dosen dalam memanfaatkan VR secara efektif, dan kebutuhan pengembangan konten yang sesuai dengan kurikulum. Berdasarkan temuan ini, penelitian merekomendasikan integrasi VR ke dalam kurikulum sebagai alat pedagogis yang efektif untuk menumbuhkan kesadaran lingkungan dan mempersiapkan generasi mendatang agar lebih responsif terhadap isu-isu lingkungan.

Kata Kunci: *kewarganegaraan, media pembelajaran, realitas virtual, kewarganegaraan ekologis*

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Introduction

Climate change and environmental degradation have become pervasive global challenges that demand urgent attention and concerted action. The consequences of these environmental crises are felt not only in specific regions but across the globe, posing significant risks to human well-being, biodiversity, and the overall sustainability of our planet. From rising sea levels and extreme weather to the depletion of natural resources and loss of biodiversity, the impacts of climate change are already reshaping the world we live in. As a result, addressing these issues requires a multi-faceted approach that includes government policy, scientific research, technological innovation, and most importantly, education.

It is essential to educate the younger generation about the severity of environmental challenges and equip them with the knowledge, skills, and values necessary to address these problems. Educating students to become environmentally conscious citizens is an imperative for ensuring a sustainable future. One of the most effective ways to foster environmental consciousness is through ecological citizenship education, a concept that emphasizes the role of individuals in protecting and preserving the environment. According to UNESCO (2017), ecological citizenship education aims to cultivate an understanding of environmental issues and encourages students to take responsibility for their actions in relation to the planet. It is not simply about raising awareness of environmental problems, but inspiring students to become active participants in fostering the development of an environmentally responsible character. This character development is crucial for future leaders who will be tasked with implementing policies and practices that mitigate environmental damage and promote sustainability.

However, traditional environmental education methods often face limitations in their ability to engage with students. Most of students feels that learning on environmental issues in the classroom can feel abstract and distant from their own lived experiences (Zhang , 2017). The challenge for educators is to find ways to bridge this gap and make environmental education more tangible, impactful, and relevant to students. To address this issue, innovative approaches are emerging in the field of education that leverage advanced technologies to provide immersive, hands-on learning experiences.

One of promising innovation is Virtual Reality (VR)**,** a tool that offers students the opportunity to experience and interact with environmental issues in ways that traditional methods cannot do. Virtual Reality is a cutting-edge technology that creates immersive, interactive environments through computer-generated simulations. VR enables students to "step inside" different environments, engage with them directly, and experience phenomena that would otherwise be difficult to observe firsthand. For example, students can virtually visit endangered ecosystems, explore the impacts of deforestation, or witness the devastating effects of plastic pollution in the oceans. These experiences are not only educational but also highly engaging, creating a deeper emotional connection to the subject matter. VR-based learning experiences have been shown to increase empathy, enhance understanding, and inspire action (Bailenson et al., 2008), which makes it a powerful tool for promoting

environmental awareness and fostering an environmentally responsible character among students.

The potential of VR-based media in environmental education lies in its ability to make abstract concepts more tangible. Rather than reading about environmental degradation, students can witness its effects in real-time, experiencing firsthand the consequences of human actions on the environment. For instance, a VR simulation of ocean pollution might show students the accumulation of plastic waste in marine ecosystems, illustrating how pollution disrupts wildlife and ecosystems. Similarly, simulations of forest destruction due to illegal logging or agricultural expansion can provide students with a vivid representation of the environmental toll of deforestation. These experiences are not just informative—they evoke strong emotional responses, fostering a sense of urgency and responsibility to protect the environment.

Moreover, VR-based learning aligns with the philosophy of active learning, which emphasizes student engagement and critical thinking. (Dewey, 1938), a leading figure in educational theory, argued that learning should not be passive but should involve direct, meaningful interaction with the subject matter. In the case of environmental education, VR facilitates active learning by allowing students to immerse themselves in real-world environmental challenges. Instead of passively receiving information, students actively participate in their learning process, gaining deeper insights into the complexity of environmental issues and the interconnectedness of human activities and ecosystems.

Several studies have demonstrated the effectiveness of VR in enhancing environmental education. Research by (Mikropoulos and Natsis, 2011) found that VR-based learning not only increases student engagement but also improves their knowledge retention and understanding of environmental issues. In a study exploring the use of VR in environmental education, students reported greater motivation to engage with the content and expressed a stronger commitment to environmental stewardship after participating in immersive VR simulations. This highlights the potential of VR to go beyond traditional learning methods, encouraging students to take a more active role in addressing environmental challenges.

One key advantage of VR in environmental education is it's ability to simulate complex, large-scale environmental phenomena that are often difficult to replicate in a classroom setting (Sun, 2020). For example, students can virtually witness the effects of climate change on polar ice caps, observe the process of desertification, or experience firsthand the impact of industrial pollution on air quality. These immersive simulations allow students to explore environmental issues on a global scale, making the content more relevant and urgent. Furthermore, VR can also help students understand the long-term consequences of environmental degradation, fostering a sense of responsibility to protect the planet for future generations.

While VR-based media offers exciting opportunities for environmental education, it is not without it's challenges. One of the primary obstacles is the accessibility of VR technology. While the cost of VR equipment has decreased in recent years, it may still be prohibitive for some schools and institutions, particularly in developing countries or underserved areas. Moreover, integrating VR into curricula

requires specialized training for educators, as they must become proficient in using the technology effectively. Educators must also ensure that the VR experiences are designed to align with educational objectives and facilitate meaningful learning experiences (Mantovani, 2003). This calls for collaboration between educators, designers, and environmental experts to create VR simulations that are scientifically accurate and pedagogically sound. Despite these challenges, the potential benefits of VR-based environmental education are too significant to overlook. By integrating VR into ecological citizenship education, educators can create dynamic, engaging, and impactful learning experiences that inspire students to take action on environmental issues (Ruchliyadi, 2023). As the world becomes increasingly interconnected through technology, the ability to simulate environmental phenomena and provide real-time, interactive learning experiences will be an essential tool for preparing students to face the challenges of the future (Wu, 2013). This article will explore the development of an environmentally responsible character through VR-based media in the context of ecological citizenship education.

Referring to previous research, found that the use of VR as a learning medium has a positive impact on the learning process, such as increasing effectiveness in the learning process, enhancing students' enthusiasm for learning, and boosting students' interest in the learning process (Suri, 2023). The use of VR included an evaluation, seen as effective and practice in the context of education (Dunser, 2008). Overall, the study concluded that VR holds great potential for positive transformation in education. Compared to these studies, there are distinctions in this research. This study focuses on character development through the use of Virtual Reality. The difference lies in the specific focus, which relates to the learning experience in the environmental citizenship course on wetlands. It does not merely review the effectiveness of VR in learning but also emphasizes the cultivation of character among students.

Drawing from existing research and best practices, this article will examine how VR technology can be utilized to foster environmental awareness and cultivate a sense of responsibility among students (Makransky, 2018). This article will discuss the potential challenges and limitations of implementing VR-based environmental education and provide insights for educators and policymakers on how to design curricula that leverage this innovative technology. Ultimately, the goal is to explore how VR can contribute to a more engaging, effective, and relevant environmental education system that prepares students to not only understand the complexities of environmental issues but also take active steps to preserve and protect the planet for future generations (Nugroho, 2021). This article will try to answer the question: how does the use of VR-based media influence students understanding and awareness of environmental issues?

Research Method

This study employed a qualitative research approach to gain a comprehensive understanding of how Virtual Reality (VR)-based learning media contributes to the development of an environmentally responsible character among students, particularly within the context of ecological citizenship education. Qualitative research is well-suited for exploring complex phenomena in-depth, especially those that involve human experiences and perspectives. By focusing on the experiences of students, teachers, and educational practitioners, this study sought to examine the ways in which VR can influence students' attitudes and behaviors toward environmental issues, as well as how it may shape their understanding of ecosystem conservation.

According to (Creswell, 2013), qualitative research methods are particularly effective in capturing the richness of human experiences and providing detailed insights into complex social and educational phenomena. In this study, qualitative techniques were employed to explore how immersive learning environments, such as VR simulations, could alter students' perceptions of environmental challenges and encourage environmentally responsible behaviors. The study aimed to explore not just the cognitive impact of VR learning but also the emotional and attitudinal shifts that might occur as students engage with these advanced technologies.

The primary data collection methods in this study were in-depth interviews and classroom observations**.** In-depth interviews were conducted with three key groups: students, teachers, and educational practitioners involved in ecological citizenship education. These interviews provided a platform for participants to express their thoughts, experiences, and reflections on the use of VR as an educational tool. For students, the interviews focused on how VR simulations influenced their understanding of environmental issues such as climate change, deforestation, and pollution. The researcher sought to understand whether VR experiences led to any changes in students' attitudes towards conservation and environmental sustainability. For teachers and educational practitioners, the interviews explored how VR-based learning media were integrated into the curriculum, their perceived effectiveness in enhancing student engagement, and any challenges they encountered during implementation.

By conducting these interviews, the researcher was able to gather a range of perspectives on the impact of VR on students' learning processes and attitudes. The interviews also provided a deeper understanding of how students cognitively and emotionally processed their experiences within virtual environments. For example, the researcher explored whether immersive VR experiences, such as simulations of environmental destruction or the visualization of sustainable practices, fostered empathy toward ecosystems and a sense of urgency about addressing environmental challenges. In addition to interviews, classroom observations were conducted to provide real-time insights into how students interacted with VR learning tools during ecological citizenship lessons. These observations were critical for understanding how students engaged with the technology in an actual learning environment. The researcher carefully monitored student behaviors, participation levels, and interactions with VR simulations. The goal was to assess the extent to which VR-based

tools facilitated active learning, promoted critical thinking, and encouraged deeper reflections on environmental issues. During the classroom observations, the researcher also noted the ways in which VR helped to bridge the gap between theoretical knowledge and real-world environmental issues. By observing student reactions and engagement with the simulations, the researcher could assess the effectiveness of VR in making abstract environmental concepts more tangible and meaningful. The observations also allowed the researcher to evaluate the potential of VR to stimulate interest in environmental topics, foster empathy for nature, and encourage environmentally responsible behaviors among students.

This combination of in-depth interviews and classroom observations provided a holistic view of the impact of VR-based media on the development of an environmentally responsible character among students. Based on the explanation above, there are steps or a framework for qualitative research, as follows:

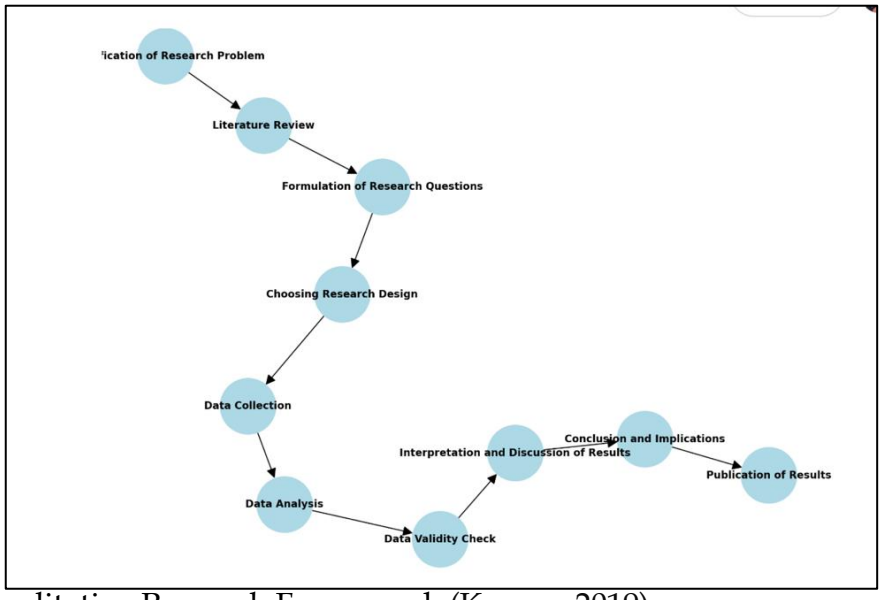

Fig.1. Qualitative Research Framework (Kumar, 2019)

Research Result and Discussion

In this section, we will discuss two problem formulations related to the formation of environmentally caring character through Virtual Reality (VR)-based media in the context of ecological citizenship learning. The main focus of this discussion is the application of VR in the Pancasila and Citizenship Education Study Program at Lambung Mangkurat University, especially in the Ecological Citizenship course.

The use of VR-based media offers a unique and immersive learning experience. Students can experience simulations that display various environmental issues directly, such as deforestation, pollution and climate change. According to qualitative research conducted by (Anderson et al, 2018), students who participated in VR-based learning showed a significant increase in understanding of ecological concepts. They not only learn from theory, but also through direct experience which allows them to relate the material to existing reality. VR provides new conveniences for students and

makes it possible for students to always develop and care about the environment.

In the Pancasila and Citizenship Education Study Program, the Ecological Citizenship course focuses on the importance of environmental awareness in the context of citizenship. By using VR media, students can feel the impact of human actions on the environment, thereby increasing their empathy and commitment to protecting the ecosystem. This is in line with findings by (Slater and Wilbur, 1997), who showed that VR can create immersive experiences that increase emotional involvement. Through this experience, students can understand the importance of their role as citizens who care about the environment. This immersive learning experience allows students to critically reflect on their daily actions. For example, simulations about waste management and its impact on public health can encourage students to change their behavior in everyday life.

Research by (Bailenson et al, 2008) supports that more real experiences can motivate individuals to behave more proactively in protecting the environment. VR experiences can give students a global perspective on environmental issues. By exploring locations around the world, students can see how issues such as global warming and pollution don't just affect one area, but have far-reaching impacts. This helps them understand the interconnectedness of countries and the need for global cooperation to overcome environmental challenges. With VR, students can engage in problem-based learning that is more relevant to the real world. For example, they may be asked to solve a specific environmental challenge, such as developing a plan to reduce carbon emissions in their community. This approach not only improves understanding of concepts, but also teaches students how to apply their knowledge to solve real problems.

The application of VR-based media in ecological citizenship learning can be done through several strategic steps. The following are concrete ways that can be implemented, based on research results: (1) identify learning objectives before starting, it is important to set clear learning objectives. For example, a goal could be to increase students understanding of certain environmental issues, such as pollution or climate change, related materials in civic education. With specific goals, teaching can be designed more focused. (2) Integration in the Curriculum, integrate the use of VR in the course curriculum. For example, after a theory session about ecosystems, hold a VR session where students can “visit” and explore the ecosystem virtually. This can be done as part of a group project, where students can analyze specific impacts on the ecosystems they visit. (3) Learning Session Preparation, before implementation, prepare the necessary infrastructure, such as VR devices and a comfortable space for the learning experience. Make sure all students are familiar with the use of VR devices. Provide a brief guide on how to use the technology. (4) Implementation of VR Sessions, conduct VR learning sessions. Give students time to explore the simulation and encourage them to observe carefully. During the experience, the lecturer may provide instructions and questions that encourage reflection. For example, ask "What do you see in this neighborhood?" or "How do human actions affect this ecosystem?" In accordance with the material being discussed in ecological citizenship. (5) Discussion and Reflection After the VR Experience related in civic education, after the

VR session, hold a group discussion to discuss the experiences they have had. Facilitate reflection on what they learned and how the experience can be connected to real-world environmental issues.

This discussion include: What surprised them most during the VR experience? How do they see their role as citizens in these issues? What solutions can they propose to address the problems they observe? VR Based Assignments and Projects assign projects that require students to apply the knowledge they gain from VR experiences. For example, they could be asked to create an action plan to increase environmental awareness in their community or conduct further research on a particular issue they experienced in the simulation. After the activity is complete, carry out an evaluation to find out to what extent the use of VR contributes to student understanding and awareness. Use questionnaires or discussions to get feedback about their experiences. Questions that can be asked include: To what extent does the VR experience help them understand environmental issues? What are some things they hope to improve in future sessions? The lecture can also invite collaboration with other institutions or environmental organizations to develop joint programs that can utilize VR technology. This can broaden the scope of learning and give students a broader perspective on environmental issues.

The use of Virtual Reality (VR)-based media in ecological citizenship learning in the Pancasila and Citizenship Education Study Program at Lambung Mangkurat University has great potential to increase students' understanding and awareness of environmental issues. With immersive learning experiences, students can directly experience the impact of human actions on ecosystems, which not only enriches their cognitive knowledge, but also increases empathy and emotional engagement towards environmental issues. Through implementing strategic steps—from identifying learning objectives to evaluation and reflection—lecturers can maximize the benefits of using VR in learning. Post-simulation discussions allow students to reflect on their experiences, connect theory to practice, and formulate relevant solutions to the environmental challenges they face.

The challenges faced in implementing VR media for ecological citizenship learning at Lambung Mangkurat University

Although the use of VR-based media in learning offers many benefits, there are several challenges that need to be considered in it's implementation in the Pancasila and Citizenship Education Study Program at Lambung Mangkurat University. One of the main challenges is limited access to VR devices. Based on qualitative research by (Zhao et al, 2020), inadequate technological infrastructure in many educational institutions, including Lambung Mangkurat University, can hinder the implementation of VR-based learning. This is very important considering that not all students have the same access to this technology outside of campus.

In addition, training for lecturers is also a significant challenge. Without a deep understanding of how to utilize VR effectively, lecturers may struggle to design optimal learning experiences. According to (Tondeur et al, 2017), developing teacher

capacity in the use of new technologies is critical for the successful integration of VR in the curriculum. Therefore, structured and ongoing training needs to be carried out so that lecturers can make good use of VR media in learning ecological citizenship.

Other obstacles include the need to develop content that is relevant and aligned with the curriculum. In the context of the Ecological Citizenship course, the material taught must be in line with the values of Pancasila and the goals of environmental education. This requires collaboration between lecturers, content developers and other stakeholders to produce simulations that are not only informative, but can also foster environmentally caring character in students.

The implementation of Virtual Reality (VR) in ecological citizenship education at Lambung Mangkurat University has demonstrated both significant potential and notable challenges. As an emerging technological tool in education, VR offers a unique, immersive learning experience that enhances student engagement and fosters deeper understanding of complex environmental issues. However, its integration into the curriculum requires careful consideration of various factors, including technical infrastructure, pedagogical strategies, and student readiness.

Technical difficulties remain one of the primary obstacles to successful implementation. Issues such as hardware malfunctions, software compatibility problems, and the need for frequent updates to VR systems can disrupt the learning process. In the case of Lambung Mangkurat University, some VR systems experienced glitches or incompatibility with the existing computer infrastructure, making it difficult to maintain a smooth and continuous learning experience. These technical challenges not only reduce the effectiveness of VR as a learning tool but also require significant resources for troubleshooting and system maintenance.

In addition to technical issues, pedagogical challenges were also identified. Many lecturers were initially unfamiliar with how to effectively integrate VR into their teaching practices. Although VR can enhance learning, it requires careful alignment with learning objectives to ensure that it adds value to the educational experience. Lecturer needed to undergo training to learn how to facilitate VR-based lessons and how to use the technology to support active learning. Without this training, the use of VR may not fully realize its potential, and lecturer may struggle to maximize its benefits.

Furthermore, VR technology requires new approaches to assessment and feedback, as traditional assessment methods may not be suited to evaluating immersive experiences. Infrastructure limitations also played a significant role in hindering the widespread use of VR in ecological citizenship education. While VR is a promising tool, its implementation requires specialized spaces and equipment. In Lambung Mangkurat University, the lack of sufficient VR devices and dedicated VR classrooms meant that only a small number of students could participate in VR-based lessons at any given time.

CONCLUSSION

The use of VR in this article is a novel approach that has a significant impact on the development of students' character and creates an enjoyable learning experience for the students. The integration of VR in ecological citizenship education at Lambung Mangkurat University has shown both promising potential and significant challenges. This study explored the use of VR-based media to enhance students' understanding of environmental issues and foster a sense of responsibility for ecosystem conservation. Through immersive simulations, students were able to engage with complex environmental topics in a more interactive and emotionally resonant way, which is often difficult to achieve through traditional teaching methods.

One of the key findings of this research is that VR has a transformative impact on how students engage with environmental education. By immersing students in realistic simulations of environmental destruction, such as deforestation, plastic pollution, or habitat loss, VR enables them to visually and emotionally connect with the material. These immersive experiences foster empathy and a deeper understanding of the consequences of human actions on the environment. As opposed to merely reading about environmental issues or watching videos, VR allows students to experience them firsthand, which enhances their ability to grasp the urgency and complexity of environmental challenges. This aligns with active learning approaches that encourage students to engage with the material in a way that promotes critical thinking and problem-solving.

Despite its clear educational benefits, the integration of VR into the curriculum faced several challenges. First, technical issues were a major barrier. Hardware malfunctions, compatibility problems between VR systems and existing computer infrastructures, and software glitches all disrupted the learning process and hindered the smooth delivery of lessons. In some instances, technical issues led to delays in lessons or a reduction in the quality of the VR experience, which in turn affected student engagement and learning outcomes.

Addressing these challenges—through proper training for instructors, investment in infrastructure, and providing ongoing technical support—is crucial for maximizing the impact of VR as a tool for environmental education. As VR technology continues to evolve, its potential for transforming environmental education will grow. If universities like Lambung Mangkurat University can overcome these barriers, VR has the potential to become a central tool in shaping a generation of students who are more aware, empathetic, and proactive in addressing environmental issues.

The results of this study are expected to serve as a reference for future research focused on the development of learning media. The findings of this article highlight the internalization of students' character, which can serve as a reference for subsequent researchers in conducting studies on efforts to internalize character.

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