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Bringing Nature Closer: A Systematic Review of Virtual Reality's Impact on Students' Environmental Attitudes and Behavior

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ABSTRACT

This study aimed to describe the impact of using Virtual Reality (VR) in environmental education for school students. Environmental education is essential for enhancing students' ecological understanding, awareness, and pro-environmental behaviours. However, today's digital native generation is at risk of experiencing nature-deficit. VR is considered capable of bridging limited access to real nature through immersive and contextual virtual experiences. This research employed a Systematic Literature Review (SLR) method using the PRISMA protocol, analysing nine selected articles from Scopus and ScienceDirect databases. Findings indicated that VR use improves students' understanding of ecological concepts, facilitates the internalisation of abstract material, nurtures connectedness to nature, and fosters empathy and pro-environmental attitudes. Integrating local cultural elements into VR learning also enhances students' appreciation of indigenous wisdom and ecosystem conservation. Nevertheless, the study identified technical challenges in VR access and a lack of long-term research. This study is beneficial for teachers, schools, and educational psychologists in developing technology-based environmental learning to build students' ecological identity and environmental citizenship in a holistic and sustainable manner. Furthermore, this study may serve as a valuable reference in the development of green curricula that systematically integrate VR technology to maximise its effectiveness and scalability.

Keywords: Pro-Environment Behavior, Conservation, Virtual Reality, Students, Systematic Literature Review

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INTRODUCTION

Environmental education is not only crucial for nature conservation but also for the development of students' behavioural and socio-emotional aspects in schools. Research indicates that students engaged in environmental conservation activities experience increased empathy, social responsibility, and psychological wellbeing, as they feel a sense of meaningful contribution to their surroundings and learn to appreciate the reciprocal relationship between humans and nature (Tan et al., 2024). Environmental education also fosters students' awareness of the importance of preserving ecosystems and teaches them values of sustainability and care for other living beings (Cho & Park, 2023).

However, students today, who are digital natives, are at risk of experiencing nature-deficit. Nature-deficit refers to a condition where individuals, particularly children and adolescents, have limited direct experiences with the natural environment, which impacts their cognitive, emotional, and physical development, and reduces their concern for environmental issues (Laine et al., 2023). This phenomenon arises due to modern lifestyles and urbanisation that restrict direct interaction with nature. Consequently, such conditions may diminish children's mental health quality and their motivation to care for the environment.

To rebuild students' connectedness to nature, technological approaches aligned with their generational characteristics are required. Technology can serve as a bridge to introduce virtual nature experiences, motivate interest, and enhance environmental literacy, even when direct access to nature is limited (Feng, 2014). One technology deemed effective is the use of virtual reality (VR). VR enables students to explore natural environments immersively, fostering a sense of wonder, care, and sustainable pro-environmental attitudes (Taylor & Disinger, 1997).

Previous studies on the use of VR in environmental education at schools have been conducted. Sulisworo et al. (2023) found that VR use in primary school environmental education significantly increased students' awareness of wildlife habitats, with students becoming more engaged and interested in the learning material. Additionally, research by Ritter et al. (2019) developed the Virtual Reality Ecoliteracy Curriculum (VREC) for secondary school students in the United States and found improvements in students' environmental knowledge, engagement, and understanding of environmental issues in their communities. Another study by Plechatá et al. (2022) showed that immersive VR could enhance pro-environmental behaviour by increasing students' self-efficacy in making sustainable food choices.

However, many previous studies have focused solely on the development of VR media itself, such as application design and technical feasibility assessment, without comprehensively discussing its impact on students. In addition, existing research is often experimental in nature with limited and specific participants, making the findings difficult to generalise beyond particular groups. Understanding the impact of VR use, including changes in pro-environmental behaviour, internalisation of environmental values, and transfer of knowledge into concrete actions, is crucial to ensure that these technological innovations holistically support the goals of environmental education (Fan et al., 2010).

Despite its potential, there remains a lack of systematic literature reviews that integrate these diverse findings to provide a broader and more generalisable understanding of VR's impact in environmental education. This study aims to describe the impact of VR use in environmental education for school students through a systematic literature review (SLR). The use of SLR is advantageous as it synthesises various empirical findings in a structured and transparent manner, thus providing a comprehensive overview of the effectiveness and benefits of VR in environmental education (Nugroho et al., 2025). The results of this study are expected not only to enrich the academic literature in the fields of environmental education and educational technology but also to serve as a foundation for designing effective VR-based learning programmes that are holistically impactful and relevant to students' needs in the digital era.

MATERIALS AND METHODS

Reseacrh Design

This study employed a Systematic Literature Review (SLR) design to synthesise empirical findings in a structured and comprehensive manner regarding the use of virtual reality in environmental education among school students. The SLR method was chosen as it enables the systematic identification, evaluation, and interpretation of relevant studies to answer the research questions with robust evidence (Glaser & Schmidt, 2021). The SLR process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol to ensure transparency and high-quality reporting of the review (Peixoto et al., 2021).

Inclusion Criteria, Database, and Search Strategy

The inclusion criteria for this study comprised articles published within the last ten years (2015–2025), written in English, and published in reputable international journals or impactful international conference proceedings, addressing topics related to Virtual Reality (VR), environmental education, and school students. These criteria ensured that the selected articles were relevant and of high quality (Eisingerné Balassa & Koteczki, 2023).

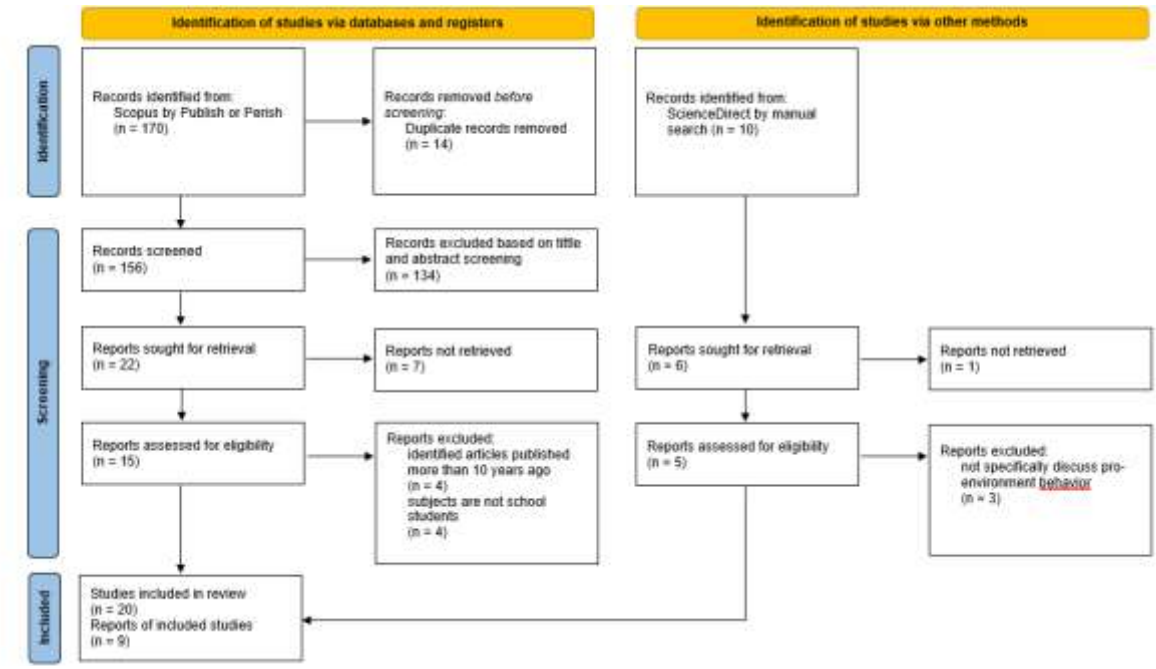
The literature search was conducted through the Scopus database due to its wide coverage of high-quality journals, thereby supporting the integrity of the literature review (Glaser & Schmidt, 2021). Additional searches were performed on ScienceDirect to broaden the findings. The search strategy employed keywords and Boolean operators as follows: ("virtual reality" OR "immersive

experience") AND ("environmental education" OR "nature-based learning") AND ("students" OR "adolescents" OR "learners") AND ("environmental attitude" OR "eco-behaviour" OR "pro-environmental behaviour").

Prosedur dan Analisis Data

The article selection process in this study included initial identification, removal of duplicates, title and abstract screening, accessibility screening, full-text selection, and the addition of further databases as required.

Picture 1. PRISMA



Data were extracted based on the variables of author, year, title, method, subjects and school level, technology/media used, impact on students, and key findings, and were then analysed using descriptive narrative analysis.

RESULTS

Review Summary

The following is a review summary of the selected articles:

Table 1. Article Review Summary

No	Authors (Year)	Article Title	Method	Subjects and School Level	Technology / Media	Impact on Students	Key Findings
1	Rubert James Gestiada et al. (2025)	The 360° View: Contextualized Virtual Reality Tours as an Innovative Teaching Tool in Ecology for Elementary School Students	Descriptive development research using ADDIE model	30 elementary STEM class students in the Philippines	Semi-immersive VR with 64MP camera, AI narration, Head-Mounted Display (HMD)	Significant improvements in ecological concepts, environmental awareness, and learning engagement; mastery levels increased from "low" to "high"	VR bridged abstract ecology concepts and real contexts; effective for ecological topics and validated positively by teachers and students

2	Sunder Kala Negi (2024)	Exploring the Impact of Virtual Reality and Augmented Reality Technologies in Sustainability Education on Green Energy and Sustainability Behavioral Change	Qualitative: semi-structured interviews with 30 participants	10 schools and higher education institutions, 10 teachers, 10 students, 10 administrators (public & private)	Virtual Reality (VR) & Augmented Reality (AR)	Increased environmental awareness, sense of responsibility, personal accountability, and pro-environment behavior	VR/AR effectively increase understanding of environmental concepts, responsibility, and encourage environmentally friendly practices
3	Tarng & Hsu (2024)	Development of a VR360 Ecological Learning System for Indigenous Cultures and Environmental Conservation	Mixed methods experimental (usability, effectiveness, cognitive load)	Elementary students in Taiwan	VR360 with cardboard headset and panoramic videos	Increased learning effectiveness, environmental conservation attitudes	VR360 system helped students understand indigenous culture and environmental conservation through immersive learning
4	Ying et al. (2024)	Sustainable Environmental Education Using Virtual Reality: A Module for Improving Environmental Citizenship Competencies in Secondary Schools	Quasi-experimental and interviews	Secondary school students in Malaysia	VR-based SEE module	Increased environmental citizenship competencies and social responsibility, though collective actions remained low	VR improved students' motivation and environmental competencies, but collective action was still community-oriented
5	Chiang, T.H. (2021)	Investigating Effects of Interactive Virtual Reality Games and Gender on Immersion, Empathy and Behavior Into Environmental Education	Qualitative: experimental 2x2 design with ANOVA	School students (junior and senior high school) in Taiwan	Semi-immersive VR-based games (headset, controller, mouse)	Increased immersion, empathy towards the environment, and pro-conservation behavior; male students showed higher immersion	Learning through VR was more effective in promoting environmental knowledge and empathy, especially for male students

6	Markowitz et al. (2018)	Immersive Virtual Reality Field Trips Facilitate Learning About Climate Change	Four studies (2 lab experiments, 2 field studies) using pre-post tests, movement tracking, surveys, and focus groups	High school students (ages 16-18), university students, and general adults	Immersive VR using Oculus Rift DK2, HTC Vive; ocean acidification reef simulation	VR significantly improved students' understanding of ocean acidification, built a strong sense of presence, triggered curiosity and environmental empathy. High school students showed significant increases in conceptual understanding compared to pre-test, as well as long-term knowledge retention.	VR effectively enhances climate change education, especially ocean acidification concepts. Presence and physical interactivity in VR positively correlated with knowledge retention and learning interest. Embodiment as coral or scuba diver both increased learning outcomes and pro-environmental attitudes.
7	Ritter, Stone, & Chambers (2019)	Empowering Knowledge: Exploring Place-based Environmental Education in Louisiana Classrooms Through Virtual Reality	Design-based research; mixed methods (pre-post test and questionnaire)	130 students, Grade 8, Louisiana, USA	VR-based Unity 3D (VREC: Virtual Reality Ecoliteracy Curriculum)	Increased environmental knowledge, awareness, and understanding of local environmental issues	VR-based learning enhances critical thinking, awareness, and connection to local environmental issues
8	Cheng & Tsai (2019)	A case study of immersive virtual field trips in an elementary classroom	Case study, quantitative and observational methods (pretest-posttest & video coding)	24 elementary students, 3–5 days in summer camp	Immersive VR using Google Expeditions + HMD (cardboard)	Increased learning motivation, reduced test anxiety, improved sense of presence and realism	VR significantly enhanced intrinsic motivation and reduced test anxiety. Teachers reported VR's potential to improve learning effectiveness

9	Fokides & Chachlakis (2020)	3D Multiuser Virtual Environments and Environmental Education: The Virtual Island of the Mediterranean Monk Seal	Experimental; three-group comparison using questionnaires and attitude assessments	326 elementary students aged 10–12, Greece	3D Multiuser Virtual Environment (MUVE)	Increased positive attitudes towards endangered species (monk seals) and environmental issues	MUVE significantly enhanced positive attitudes towards species conservation and increased student motivation and learning interest

The first article, by Gestida et al. (2025), found that after using Virtual Reality (VR) contextualised to the local environment, students showed significant improvements in understanding ecological concepts. They were able to distinguish between biotic and abiotic components and comprehend ecological relationships more concretely. Visual interactions with their surroundings through VR encouraged emotional engagement, strengthened environmental awareness, and fostered a sense of responsibility towards local ecosystems. Students also reported finding it easier to recall lessons as they could see familiar species. This experience activated prior knowledge and promoted metacognition, making learning more relevant and profound. The semi-immersive VR technology successfully provided exploratory experiences that are often difficult to achieve through conventional teaching.

The second article, by Negi (2024), explained that using VR and AR in sustainability education enabled students to experience more immersive and emotional learning, integrating theory and practice within environmental contexts. Such interactions triggered deeper environmental awareness, reinforced personal responsibility, and cultivated more environmentally friendly attitudes and behaviours. Students felt more empowered and motivated to engage in solutions to climate issues. This technology not only enhanced knowledge of green energy and sustainable practices but also encouraged active participation in sustainable lifestyles, resulting in direct behavioural changes.

The third article, by Tarng and Hsu (2024), stated that the VR360 system developed for indigenous schools in Taiwan provided a learning experience that combined local culture with environmental conservation. Students were able to virtually explore the natural habitats of Masu salmon and the Atayal indigenous community, enabling them to understand the interconnectedness of culture and environmental preservation. The use of cardboard-based VR headsets allowed low-cost technology access in remote areas. Findings showed significant improvements in learning effectiveness, motivation, and student satisfaction. VR360 also reduced cognitive load by presenting information visually and interactively, making it easier for students to understand ecosystems and cultural values. Students became more interested in environmental lessons and more aware of the importance of biodiversity and local wisdom. VR interactions fostered respect for nature and ancestral traditions holistically.

The fourth article, by Ying et al. (2024), found that after participating in VR-based learning modules, students demonstrated enhanced environmental citizenship competencies. They felt more emotionally connected to environmental issues, as they could virtually explore dangerous situations such as pollution and deforestation. This experience fostered personal awareness of the need to protect the environment, although their actions tended to remain at the individual rather than collective level. VR also helped them to imagine the global impacts of local problems, shaping more responsible attitudes and increasing motivation to learn and act in real life, even though the scope of their actions remained limited.

The fifth article, by Chiang (2021), reported that the use of interactive VR games in environmental education provided immersive and emotional experiences for students. They found it

easier to understand the impacts of environmental damage, felt empathy for living creatures such as dolphins and polar bears, and developed higher levels of empathy. This experience significantly encouraged students' real-life pro-environmental behaviours. The effect was stronger among female students, who demonstrated higher empathy and actions. VR interactions enabled students to internalise abstract material into concrete experiences, fostering awareness, emotional engagement, and intentions to make behavioural changes in their daily lives for environmental protection.

The sixth article, by Markowitz et al. (2018), revealed that the use of immersive VR in teaching climate change, particularly ocean acidification, had a significant impact on high school students. Through embodiment as corals or scuba divers, students directly experienced the conditions of coral reef ecosystems damaged by ocean acidification. This transformed abstract concepts into concrete and life-relevant understanding. VR fostered a high sense of presence, making students feel as if they were truly underwater, which increased curiosity and motivation for environmental learning. Additionally, the VR experience elicited empathy and concern for threatened marine ecosystems, nurtured pro-environmental attitudes, and enhanced long-term knowledge retention. Thus, VR proved effective in supporting the learning of complex environmental science topics.

The seventh article, by Ritter, Stone, and Chambers (2019), found that the use of the Virtual Reality Ecoliteracy Curriculum (VREC) provided profound learning experiences for Grade 8 students in Louisiana. Students became more emotionally and intellectually engaged in understanding local environmental issues such as erosion and natural resources. VR allowed them to explore locations that are physically inaccessible, building personal connections with their environment. This immersive experience also stimulated reflective discussions and critical thinking about the impacts of environmental changes on local communities. Testing results showed significant improvements in environmental knowledge and awareness after interacting with two VR modules. Learning became more contextualised and meaningful as it connected with students' lived realities. VR interactions were proven to foster a sense of belonging to nature and form a foundation for sustainable behaviour.

The eighth article, by Cheng and Tsai (2019), revealed that the use of immersive virtual field trips based on VR in social studies lessons had positive impacts on students' learning experiences. Students felt "physically present" in the virtual environment, which increased motivation, reduced exam anxiety, and nurtured intrinsic value towards the subject matter. Visual interactions with nature and historical content enabled students to focus better and engage more actively in the learning process. They found learning to be more enjoyable and meaningful. Furthermore, the relationship between perceived presence and motivational beliefs was found to be strong. This activity not only sparked curiosity but also strengthened teacher-student relationships through dynamic interactions during classroom activities.

The ninth article, by Fokides and Chachlaki (2020), found that through the Virtual Island simulation based on a 3D Multi-User Virtual Environment (MUVE), students aged 10–12 learnt about endangered species, specifically the Mediterranean monk seal. This VR experience heightened students' awareness of the importance of protecting endangered animals and environmental issues. They showed improvements in attitudes towards conservation and were more motivated to participate in lessons. Compared to print and web-based methods, the VR group experienced learning as more enjoyable and memorable, despite some technical difficulties. Social interaction within MUVE encouraged collaboration and discussions, reinforcing environmental values collectively. Findings indicated that learning through MUVE was more effective in fostering positive attitudes towards ecological issues compared to traditional methods. Students became more sensitive to the role of humans in protecting ecosystems.

Thematic Summary

Based on the 9 articles reviewed, there are three main themes in the use of VR for environmental education:

Table 2. Thematic Synthesis

Theme	Number of Studies (n)	Example Studies
Environmental Concept Learning	6	Studies on ecology, climate change, pollution, and

		endangered species (Rubert James Gestiada et al., Tarng & Hsu, Ying et al., Markowitz et al., Ritter et al., Fokides & Chachlakis)
Development of Empathy and Environmental Awareness	4	Studies focusing on empathy, responsibility, and citizenship competencies (Sunder Kala Negi, Chiang, Markowitz et al., Fokides & Chachlakis)
Pro-environmental Behaviour and Concrete Actions	5	Studies measuring changes in environmentally friendly behaviours such as reduce-reuse-recycle or conservation (Sunder Kala Negi, Chiang, Ying et al., Markowitz et al., Fokides & Chachlakis)

The thematic synthesis of this systematic literature review revealed three main themes in the use of Virtual Reality (VR) within environmental education: conceptual learning, development of environmental empathy and awareness, and promotion of pro-environmental behaviour.

First theme, conceptual learning emerged as the most common theme, appearing in six of the reviewed studies. These studies demonstrated VR's effectiveness in helping students understand complex environmental concepts such as ecological systems, ocean acidification, biodiversity conservation, and climate change. For example, Rubert James Gestiada et al. (2025) and Markowitz et al. (2018) highlighted how immersive VR environments allowed students to visualise otherwise abstract ecological phenomena, leading to improved comprehension and long-term retention. This finding aligns with cognitive theories suggesting that visualisation and experiential learning can enhance conceptual understanding by bridging abstract knowledge and real-world contexts.

Second theme, four studies focused on the development of environmental empathy and awareness. These studies explored how VR can foster emotional connections with environmental issues by enabling students to experience simulated environments from new perspectives, such as embodying a coral reef organism or witnessing environmental degradation firsthand. Chiang (2021) and Fokides & Chachlakis (2020) showed that VR experiences not only increased students' awareness but also enhanced their sense of care and responsibility for nature. This is significant as empathy has been identified as a key predictor of pro-environmental attitudes and intentions.

Third theme, five studies examined VR's impact on pro-environmental behaviour. These studies assessed behavioural outcomes such as students' willingness to adopt sustainable practices or engage in conservation actions. Findings from Sunder Kala Negi (2024) and Ying et al. (2024) indicated that VR can influence behavioural intentions, although its effects on actual behaviour change remain underexplored. This gap suggests that while VR has potential as a behavioural intervention tool, future research should incorporate longitudinal designs to measure sustained behavioural impacts beyond immediate post-intervention effects.

This thematic synthesis demonstrates that VR is not only effective in enhancing environmental knowledge but also holds promise in fostering empathy and promoting pro-environmental behaviour. However, current studies remain limited in geographic distribution, dominated by Asian contexts, and mostly target elementary and secondary school levels. A brief overview of the demographic statistics is presented below:

Table 3. Educational level distribution

Educational Level	Number of Studies (n)
Elementary School	5
Secondary School (Junior and Senior High School)	3
Higher Education / Mixed Levels	1

Table 3. Geographical distribution

Region	Number of Studies (n)
Asia (Philippines, Taiwan, Malaysia)	5
North America (USA)	3
Europe (Greece)	1

Future research should explore diverse cultural contexts and educational levels to ensure generalisability. Additionally, integrating VR interventions with community-based environmental action programmes may amplify their behavioural impacts and support broader sustainability goals.

DISCUSSION

Enhancing Conceptual Understanding and Ecological Knowledge

The use of Virtual Reality (VR) in environmental education has been shown to significantly enhance students' conceptual understanding and ecological knowledge. Gestida et al. (2025) demonstrated that VR helps students distinguish between biotic and abiotic components and comprehend ecological relationships concretely by activating prior knowledge through contextual visualisation. Similarly, Tarng and Hsu (2024) found that VR360 facilitated indigenous school students' understanding of the interconnections between Masu salmon ecosystems and Atayal culture in Taiwan, reducing cognitive load and increasing learning motivation and satisfaction. Fokides and Chachlaki (2020) also emphasised VR as an effective medium for introducing rare species such as the Mediterranean monk seal through 3D MUVE interactions. Other studies confirmed that the sense of presence in VR promotes deep internalisation of learning material (Markowitz et al., 2018).

Moreover, VR fosters pro-environmental attitudes, values, and behaviours relevant to students' contexts. Ritter, Stone, and Chambers (2019) highlighted how the VREC module increased the engagement of students in Louisiana in understanding erosion and natural resources in their region, building a sense of ownership and local responsibility. Tarng and Hsu (2024) also noted that integrating local culture into VR learning nurtured respect for ancestral traditions and ecosystem conservation. Negi (2024) further added that VR encourages sustainable behaviours by providing immersive experiences that link theory with environmental practice, motivating students to adopt environmentally friendly lifestyles. In the context of conservation-oriented school psychology, VR can serve as a medium for developing ecological identity and environmental connectedness, which form the foundation for long-term pro-environmental behaviours (Alwan, Undarwati, & Purwanto, 2025).

Increasing Emotional Engagement and Environmental Empathy

Findings from various studies indicate that the use of VR in environmental learning significantly evokes students' emotional engagement and empathy. A high sense of presence enables students to feel as though they are physically present in the habitats being studied, fostering deep empathy towards living beings affected by environmental damage (Chiang, 2021; Markowitz et al., 2018). For instance, students felt the suffering of dolphins and polar bears in environmental damage simulations, which triggered awareness and the desire to act in their protection. Negi (2024) also found that VR and AR fostered intrinsic motivation to engage in climate mitigation actions due to the intense emotional experiences during learning.

Ying et al. (2024) demonstrated that when students could virtually explore pollution and deforestation, they developed a stronger personal sense of responsibility towards the environment, although their actions remained individual in nature. These findings align with experiential learning theory, which emphasises the importance of concrete experience and emotional engagement in facilitating learning and behavioural change (Kolb, 1984). In this regard, school psychologists could utilise VR experiences to facilitate the development of empathetic attitudes and conservation behaviours through school-based Eco Clubs and environmental campaigns (Alwan, Undarwati, & Purwanto, 2025).

Fostering Contextually Relevant Pro-Environmental Attitudes, Values, and Behaviours

Beyond enhancing ecological conceptual understanding, VR also nurtures students' pro-environmental attitudes, values, and behaviours within their daily life contexts. Negi (2024) highlighted that the use of VR and AR in sustainability education deepened environmental awareness and fostered a personal sense of responsibility to contribute to climate change mitigation. Similar findings were reported by Tarng and Hsu (2024), where VR360 learning, which integrated Masu salmon conservation with Atayal culture, cultivated respect for ancestral traditions and awareness of the importance of preserving local ecosystems. Ritter, Stone, and Chambers (2019) also showed that the VREC module enabled students in Louisiana to understand local

environmental issues such as erosion and land degradation, fostering a sense of belonging to their region and motivating them to protect it.

Fokides and Chachlaki (2020) added that through MUVE-based Virtual Island simulations, students became more sensitive to the human role in protecting endangered species, developed conservation-oriented attitudes, and were motivated to learn more about ecology. These findings are in line with the concept of environmental citizenship, which emphasises the integration of values, knowledge, and skills in shaping responsible environmental behaviours (Stern et al., 1999). School psychologists play an important role as facilitators of behavioural change through the integration of conservation-based curricula, early development of ecological identity, and community-based interventions to foster connectedness with nature and student resilience (Alwan, Undarwati, & Purwanto, 2025).

Limitations and Challenges of Using VR in Environmental Education

Despite its proven effectiveness in enhancing environmental learning, several criticisms and limitations of VR use remain. Fokides and Chachlaki (2020) reported technical challenges such as internet connectivity issues and unequal access to devices, although the use of cardboard VR helped reduce costs (Tarng & Hsu, 2024). Ying et al. (2024) also noted that students' actions after VR learning tended to remain individual and had yet to effectively promote collective action or environmental advocacy. Furthermore, most studies, such as those by Negi (2024) and Chiang (2021), only assessed short-term effects, meaning that the long-term impact of VR use on sustainable behavioural change still requires examination through longitudinal research employing rigorous experimental designs (Cook & Campbell, 1979). In this context, school psychologists could play a role in evaluating the effectiveness of VR through data-driven psychological approaches (Alwan, Undarwati, & Purwanto, 2025).

CONCLUSIONS

This study concludes that the use of Virtual Reality (VR) in environmental education at schools is effective in enhancing students' ecological conceptual understanding, environmental awareness, emotional engagement, and fostering pro-environmental attitudes and behaviours. VR enables students to concretely comprehend abstract content by providing immersive learning experiences, thereby cultivating empathy and a sense of responsibility towards the environment. Moreover, the integration of local cultural elements in VR learning has been proven to strengthen indigenous wisdom values and build connectedness to nature, which serves as a foundation for sustainable behaviour. However, this study also identified limitations, including technical challenges related to device and internet access, as well as the lack of research examining long-term effects. Therefore, longitudinal studies are required to ensure the sustained impact of VR on pro-environmental behaviour change. Schools and educational psychologists may utilise VR as an innovative medium to build students' ecological identity and environmental citizenship from an early age in a contextually relevant manner. This highlights the urgent need for cross-sector collaboration between schools, educational psychologists, and technology developers to ensure that VR is employed not merely as a technological novelty but as a pedagogically meaningful tool that builds students' ecological identity and environmental citizenship in contextually relevant ways.

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