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Interactive and immersive media for environmental education

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Abstract

Recently, sustainable development practices have increased attention as climate change and environmental impacts have increased. Interventions to encourage sustainability awareness are developing, so fostering them through education is crucial. Evidence-based studies conducted in this field have suggested the use of different digital tools to promote environmental learning gains and to foster better sustainability awareness among students. Following the PRISMA method, we found 21 articles published between 2013 and 2023 showing an interest in the use of digital tools in environmental education to foster sustainability awareness among learners. Findings indicate that virtual reality tools and climate change topics are the most trending in this research area. Further, the results show a positive impact of the use of digital tools on students' concern for the sustainability of the planet.

Keywords: Sustainable development goals (SDGs), environmental education, digital tools, sustainability awareness

Introduction

The adaptation of the 2030 Agenda, through the United Nations intergovernmental negotiations, led to the elaboration of 17 sustainable development goals (SDGs). Since 2015, the SDGs have proved to be crucial in ensuring human development, offering students empowerment in decision-making, integrity in achieving environmental responsibility, social justice, and economic viability. As such, students develop future-oriented skills, as well as the ability to think critically, solve problems, and learn in a self-directed manner. Furthermore, in the flow of achieving Goal 15 of the SDGs, which is to “protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss”, UNESCO considers education as crucial to achieving the goal. In fact, biodiversity education not only contributes to integrating the protection of ecosystems and biodiversity into students' local and national values but also helps students to develop processes, set strategies, and accounts to reduce poverty. According to Lysgaard et al., the implementation of sustainability and SDGs in education has so far failed to have a real impact on environmental sustainability projects in policy circles. In this regard, Kopnina underlines the need to assess the integration of SDGs in education in general and in environmental education in particular. Rieckmann suggests that if education at all levels integrates sustainable development principles into its practice, then education itself could be a powerful tool for achieving the SDGs; that is, learners are prepared with knowledge about the SDGs and with the ability to achieve the SDGs. However, for this to happen, education itself needs to be transformed and new approaches need to be adopted. Today, voices are being raised about how digital technology, due to its critical cross-sectoral nature, will be the contributing force that will make it possible to achieve the SDGs. In addition, digital technologies have been incorporated into teachers' training and practice to promote SDG awareness among them and their students. According to Lay, a variety of digital technologies can be used to engage students in environmental stewardship, including video conferencing, mobile applications, virtual reality, and augmented reality. Students can be captivated by such technologies as they capture experiences of local and distant environments, collect data, and share findings.

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That is, digital technologies in EE can contribute to developing students' sustainability awareness on issues related to SDG 15, such as eco-citizenship, climate change, ecology, and environmental sustainability.

This systematic review aims to cover the state of the art of digital tools used in environmental education (EE) to promote sustainability awareness among learners at all stages of learning. Given the relevance of the use of digital educational approaches in strengthening environmental awareness strategies to reduce the severity of environmental complications, it is important to investigate the impact of the trend in the use of digital technologies that can benefit educators by providing them with insights into their effectiveness for learning and teaching. Although this field has been covered by Fauville et al., no literature review has addressed this topic in the last decade. According to Dubé and Wen, little attention has been paid to the changes brought by the effects of rapid technological development. Therefore, it is relevant to update the list of trending digital tools used in the service of EE topics.

Background for Instructors

Environmental education has become increasingly important as human beings continue the extensive exploitation of nature and threaten the existence of other living creatures on Earth. Both environmental and geography education aim to bridge the connection between learners and the world, fostering a deeper comprehension of the bond between humans and their environment. Several curriculum standards have documented the critical need to raise children's environmental awareness and care. However, the excessive amount of time children spend online (Beresford et al. Citation 2023) inevitably compromises their chances to experience the physical world, which in turn could lead to disconnection from the local natural environment and decrease their sensitivity and responsibility for environmental conservation.

VR is a computer-simulated platform that lets users immerse themselves in a realistic three-dimensional (3D) environment through use of specific equipment. Teaching and learning with VR technology has been applied to develop learners' environmental awareness and care. However, empirical findings mainly were based on instructional pedagogy that positioned students as consumers of VR content, as opposed to students as content creators. Fewer studies explore the effectiveness of a "learner-as-creator" approach regarding VR in education. Creating VR content in a project-based learning setting has been articulated to be able to facilitate meaningful learning experiences by creating authentic VR artifacts that were meaningful to them. The VR project experience enables students to construct authentic VR artifacts, fostering immersive and personally relevant learning experiences. This approach deepens knowledge retention and skill construction through active participation and meaningful project involvement.

This lesson plan is designed to provide a meaningful learning experience for children by leveraging the capabilities of VR technology to increase children's engagement with local environmental issues and further their environmental awareness and care. This lesson plan employs the place-based education approach, with the goal of connecting students to their local communities and environments. It is designed to make learning more

meaningful and impactful by weaving local contexts and experiences into the educational context. In addition, this lesson plan is grounded in social constructivism, emphasizing the essential role of student interactions, discussions, and sharing in the process of co-constructing knowledge. Students actively engage in collaborative learning activities, including brainstorming, researching, developing ideas, creating, and sharing. The integration of the place-based education approach and social constructivism occurs through the implementation of project-based learning. Children are encouraged to collaboratively and proactively take the lead in identifying their local community's environmental issues, investigating potential causes, suggesting viable solutions, and ultimately creating a place-based VR tour to present their research findings. Put simply, students will construct a virtual representation of local environmental issues, their causes, and potential solutions with geographic tools (e.g., 3D photography) and geographic information (e.g., the location of air pollution). This hands-on approach not only offers an opportunity for children to learn about the technology behind VR but also instills a sense of responsibility and ownership over their local environment. This approach conceptually aligns with the method of creating spatial stories (De Certeau Citation 1984; Elwood and Mitchell Citation 2012) [23, 24] to promote learners' community engagement. By embedding learning within the context of local environments, the creation of spatial stories allows learners to articulate their spatial experiences and establish meaningful connections with their surroundings, thereby enhancing their understanding of and commitment to community involvement. The primary goal of this lesson plan is to increase children's sense of environmental awareness and care by allowing them to deepen their understanding of their surroundings. Children will be inspired to become protectors of their community, understanding the importance of preservation and sustainable practices.

Learning Goals

1. Understand VR technology's interactive and immersive features to promote environmental awareness and care.
2. Develop digital literacy by engaging in a place-based VR tour project that explores the community's environmental issues, their causes, and their potential solutions.
3. Enhance geographical investigation skills, capturing both the physical environment and its intricate relationship with human inhabitants, all within a VR content creation context.
4. Develop proficiency in incorporating various geographical tools, such as maps and images, for investigating and analyzing environmental issues, their causes, and their solutions.
5. Foster a deep appreciation for local communities by exploring the lives, cultures, and professions of its residents, emphasizing their bond with the surrounding environment.
6. Cultivate a heightened awareness of the local natural environment, understanding its intrinsic relationship with the lives of its inhabitants, and inspiring a sense of responsibility toward conservation and sustainability.

Immersive media and spatial presence: Immersive forms of media, such as virtual reality simulations, omnidirectional

360° videos, and 3D movies, possess especially high levels of vividness and are intended to enable perceptions of interactivity. With the recent introduction of new and affordable forms of media technology such as HMDs and 3D televisions to the mass market, the popularity of immersive devices has increased. The psychological feeling of spatial presence might explain why immersive media are believed to be especially captivating and enjoyable, thus accounting for the growing popularity of immersive devices. Vivid and interactive forms of media can enhance the perception of actually being in the depicted media environment, thus creating the illusion of non-mediation, which is commonly referred to as telepresence, physical presence, spatial presence, or simply presence. The term "presence" may be ambiguous in this context, however, because multiple forms of presence have been introduced, such as social presence (i.e., being with another; Biocca, Harms, & Burgoon, 2003)^[25] and self-presence (i.e., having the perception of embodying an entity in a virtual world; e.g.). Consequently, the term "spatial presence" will be used in this study to describe media users' perceptions of being part of the mediated environment and being able to interact with the virtual environment. Spatial presence has often been considered responsible for the persuasive effects of immersive media forms because the psychological perception of non-mediation has been linked to different constructs that are relevant to persuasion, such as increased credibility and emotionality of the media message, as well as reduced cognitive resistance. Therefore, various communication disciplines, including public relations, advertising, and environmental communication, have employed immersive media forms to enhance the effectiveness of their persuasive appeals. Furthermore, immersive media, through evoking feelings of spatial presence, has been proposed as a suitable tool to illustrate abstract topics, such as the long-term risks of an unhealthy lifestyle or energy consumption.

Construal level theory

Construal level theory proposes that individuals can only directly experience the here and now—not other places, people, realities, or the past or the future. Therefore, people form abstract mental construals of distant objects, such as speculations, memories, or predictions. These mental constructions represent objects that are psychologically distant and thus far away from the self. Psychological distance comprises four dimensions: Objects can be spatially distant (e.g., something happening in another country), temporally distant (e.g., something happening in the future), or socially distant (e.g., something happening to someone else who is not perceived as similar to oneself). Furthermore, the probability of the occurrence is covered in the hypotheticality dimension of psychological distance (e.g., how likely it is that something is happening or going to happen). For instance, when a media experience is framed as having happened in a distant location, it is remembered in more abstract terms than when the same experience is framed as having happened nearby. The four dimensions of psychological distance are interdependent and guide evaluations and predictions as well as behavior.

Psychologically distant objects are processed and perceived differently from psychologically proximal objects. For instance, in previous work, individuals have been found to perceive psychologically distant objects as less risky and less likely to occur, compared with psychologically

proximal objects. Furthermore, media users process proximal and concrete objects attentively and quickly. Additionally, proximal and concrete issues are perceived as more personally relevant, more likely to happen, and more urgent, compared with distant and abstract issues. Exposure to proximal and concrete issues has thus been found to result in stronger persuasive effects than those caused by exposure to distant and abstract issues. For instance, participants were more likely to donate money to a prosocial cause if it was perceived to be spatially close. This tendency also aligns with previous studies on the two-process models of persuasion (e.g., the elaboration likelihood model; Petty & Cacioppo, 1986)^[26] that have manipulated individuals' levels of involvement by framing a topic as either proximal or distant. For instance, in some studies, participants have been told that a product launch would affect their own town or a spatially distant town. Participants who believed that their decision would affect their own town were more involved and thus more likely to carefully process the presented information. Similar experimental designs have been employed to manipulate levels of personal involvement by varying the level of temporal distance (e.g., describing something that would happen immediately or after 10 years). Persuasive messages are generally believed to be more elaboratively processed and more effective if they are relevant to the audience. For these reasons, several researchers have claimed that the perception of environmental problems should be brought closer to individuals to foster engagement, stress the need to address these issues, and pave the way for pro-environmental behavior.

Findings and Discussion

Theme 1: Technology Enhances Engagement and Experiential Learning

Participants acknowledged that technology, particularly augmented reality (AR) applications, enhanced student engagement and provided experiential learning opportunities. One teacher remarked, "AR allowed my students to interact with virtual ecosystems, making the learning process more exciting and immersive." Similarly, a student stated, "I felt like I was exploring a real forest through the AR app. It made learning about ecosystems fun and memorable."

The teacher's remark highlights how AR brings a new level of excitement and immersion to the learning process. By using AR, students can transcend the confines of traditional textbooks and static learning materials. Instead, they can actively engage with virtual environments that simulate real-world ecosystems, fostering a deeper connection to the subject matter. This interactive approach has the potential to captivate students' interest and motivation, making environmental education more enjoyable and meaningful.

The student's statement further emphasizes the positive impact of AR on the learning experience. Feeling like they were "exploring a real forest" through the AR app showcases the transformative potential of technology in environmental education. AR allows students to step into the shoes of environmentalists, researchers, or explorers, virtually immersing themselves in different ecosystems and understanding their complexities. This immersive approach not only enhances their knowledge retention but also leaves a lasting impression, making the learning process more memorable.

These findings align with existing research that highlights the benefits of technology in education, particularly in experiential learning contexts. Studies by Katika, et al. (2022) ^[7] have demonstrated the effectiveness of augmented reality in fostering engagement and enhancing learning outcomes in various educational domains, including environmental education. Such technological interventions provide a bridge between theoretical concepts and real-world applications, nurturing students' ecological awareness and encouraging them to explore and understand environmental complexities.

The integration of AR in environmental education aligns with constructivist learning theories, which emphasize the importance of active engagement and interaction in the learning process. By immersing students in virtual ecosystems, AR facilitates a constructivist learning environment where students construct knowledge by actively participating in the learning experience. This approach encourages critical thinking, problem-solving, and an emotional connection to the subject matter, ultimately fostering a deeper understanding and appreciation for the environment.

The findings of the study highlight the transformative potential of augmented reality in environmental education. Participants' acknowledgment of the enhanced engagement and experiential learning opportunities provided by AR applications underscores the value of integrating technology in educational contexts. By incorporating AR into environmental education curricula, educators can harness its immersive capabilities to foster ecological awareness, responsible behaviors, and a deeper understanding of environmental issues among students.

Theme 2: Digital Distractions Challenge Environmental Learning

The study's findings shed light on the challenge of managing digital distractions in technology-integrated lessons, as highlighted by both teachers and students. The teacher's concern about maintaining students' focus is not unfounded, given the ubiquity of smartphones and the constant influx of notifications. Digital distractions have the potential to divert students' attention away from the intended learning objectives, which can hinder their engagement and overall learning experience.

Teachers highlighted the challenge of managing digital distractions during technology-integrated lessons. One teacher expressed, "It's sometimes difficult to keep students focused when they have access to their devices. We need to set clear boundaries to maintain a conducive learning environment." A student shared, "I admit, I sometimes get distracted by notifications when we use technology in class. It takes away from the learning experience."

To address this issue, the teacher emphasized the importance of setting clear boundaries in the classroom. Establishing guidelines for technology use during instructional time can help create a conducive learning environment. For example, implementing a "device-free zone" or designating specific times for device usage can minimize distractions and allow students to concentrate on the subject matter.

The student's acknowledgment of being occasionally distracted by notifications reflects the reality of navigating technology in educational settings. The allure of social media updates, messages, and notifications can be tempting,

even during class. Such distractions can disrupt the learning process and lead to reduced attention and retention of information.

To mitigate digital distractions and promote focused learning, educators can adopt various strategies. One approach is to integrate technology purposefully, incorporating interactive and engaging activities that leverage students' devices as learning tools rather than distractions. Additionally, raising students' awareness of the impact of digital distractions and encouraging them to practice self-regulation can empower them to stay more attentive during technology-integrated lessons.

These findings align with broader research on digital distractions in educational contexts. Study by Osias Kit Kilag and team (2023) ^[8] have shown that students' use of mobile devices during class can lead to lower academic performance and reduced learning outcomes. Thus, managing digital distractions is a crucial aspect of successful technology integration in education. By setting clear boundaries and purposefully integrating technology, educators can create a focused learning environment that maximizes the benefits of technology while minimizing its potential drawbacks.

Theme 3: Empowering Critical Thinking through Online Information Evaluation

The study's participants acknowledged the significance of teaching students how to critically evaluate online information, particularly concerning environmental issues. In the digital age, where information is readily accessible online, the ability to discern credible sources from unreliable ones is paramount to becoming informed and responsible environmental advocates.

Participants recognized the importance of teaching students how to critically evaluate online information related to environmental issues. A teacher emphasized, "With the abundance of information on the internet, we must teach students to distinguish credible sources from unreliable ones." A student commented, "Learning to verify information online helped me become a more informed environmental advocate."

The student's comment underscores the practical impact of learning to verify information online. As an informed environmental advocate, the student recognizes the value of being equipped with the tools to assess the accuracy of information they encounter. By verifying information from credible sources, students can contribute to informed discussions and promote evidence-based approaches to environmental challenges.

These findings align with the broader literature on media literacy and information literacy education. Koltay (2011) ^[17] has shown that teaching students to critically evaluate online information is essential for their digital literacy development. It not only improves their ability to identify misinformation but also empowers them to become responsible digital citizens who can navigate the vast information landscape with discernment.

Theme 4: Digital Divide: Access Disparities and Equity Concerns

Several participants raised concerns about the digital divide and its impact on equitable access to technology-based learning. A teacher voiced, "Not all students have equal access to devices and the internet, which creates disparities

in their learning experiences." A student shared, "Some of my friends don't have devices at home, so they miss out on online discussions and activities. It's not fair."

The study's findings highlighted participants' concerns regarding the digital divide and its implications for equitable access to technology-based learning. The teacher's observation underscores the reality that not all students have the same level of access to devices and the internet, leading to disparities in their educational experiences. This inequality in access can hinder students' opportunities to engage in technology-integrated learning activities and may impede their academic progress.

The student's comment further illustrates the impact of the digital divide on individuals' experiences. The lack of devices at home can prevent students from fully participating in online discussions and activities, potentially limiting their exposure to critical learning resources and collaborative opportunities.

Addressing the digital divide is crucial for fostering an inclusive and equitable learning environment. Policymakers and educators must work together to bridge this gap, ensuring that all students have access to the necessary technological tools for their educational journey. Implementing initiatives to provide devices or internet connectivity to disadvantaged students can help level the playing field and promote equal opportunities for learning and growth.

Conclusion

This study illuminates the multifaceted dynamics between technology and environmental education, as perceived by teachers and students. The integration of technology, particularly augmented reality applications, offers promising avenues for enhancing engagement and experiential learning in environmental contexts. Participants' positive feedback regarding the immersive experiences and interactive learning opportunities provided by technology underscores its potential to revolutionize environmental education and inspire the next generation of environmentally conscious global citizens.

However, the study also highlights critical challenges that must be addressed to maximize the benefits of technology in the classroom. Digital distractions and information credibility concerns pose significant obstacles that educators must navigate skillfully. Moreover, the digital divide remains a pressing issue, hindering equitable access to technology-rich learning environments.

This research underscores the importance of providing targeted training for teachers to effectively integrate technology into environmental curricula, while also emphasizing the need for cultivating students' digital literacy. Additionally, a comprehensive approach is vital, with policymakers and educational institutions collaborating to bridge the digital divide and ensure that technology becomes an inclusive tool for all learners.

By synthesizing the perspectives of teachers and students, this study contributes to the broader discourse on technology in education and environmental learning. The findings serve as a clarion call for transformative change, urging stakeholders to embrace technology as an empowering force to nurture environmentally literate, critically thinking, and socially responsible individuals.

As we envision the future of environmental education, let us harness the potential of technology as a catalyst for positive

change. By fostering an inclusive, technology-enabled learning landscape, we can equip the current and upcoming generations with the knowledge, skills, and passion needed to safeguard our planet and create a sustainable future for all living beings. Let us embark on this journey together, driven by the vision of an environmentally conscious and technologically empowered society.

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