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# Immersive experiences in environmental learning: How interactive media can drive sustainability awareness

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### Abstract
Immersive technology can take the difficulty out of complex ideas and re conceptualize them into more easily digestible forms, radically enhancing learning. Few studies have investigated the newest evidence-based immersive learning programs employed in the classroom or distributed to the general populace. A user-friendly VR headset like Oculus Rift and improvement in mobile technology have eased the process of creating an application that offers both pleasant and captivating experiences to users. For this reason, VR and AR have great popularity in gaming and entertainment; on the contrary, some believe that XR has other practical uses than those mentioned above. Large companies like Microsoft and Meta have funded new projects and invested in developing the current work and collaboration capabilities for XR. Such investments aim at setting up XR, with the seamless integration of embodied interaction modalities, as the leading media delivery platform that can redefine computational settings. Besides this increasing interest in XR within a variety of fields, including retail and occupational training, there is a body of studies that environmental researchers have developed. Although communicating about climate and environmental changes can be difficult and abstract, there are other barriers to public action, such as physical and human issues. In fact, as evidenced by ongoing studies looking for obstacles to public action, the problem is complex as it can possibly be, much like environmental change itself. This attribute creates a situation in which it is even more difficult to devise means of reducing or working around these problems and heightens the need for public awareness of environmental alteration through various forms of media. Given the scope of the impact technology has on our life, a decent starting point in that respect would be to consider our technological habits. The same sentiment is echoed by researchers in human-computer interaction-indeed, sustainable human-computer interaction has emerged as a subfield of the discipline.

**Keywords:** Augmented reality, climate change, environmental sustainability, extended reality, systematic literature review, virtual reality

## Introduction
Virtual reality, also known as VR, is the technology capable of simulating a realistic environment. Virtual reality has been in development for many decades and has reached every other professional field known today, including engineering, health, and education. People can access virtual reality through mobile devices, desktop software, or VR headsets. VR is an effective tool in education because of how immersive and interactive it can be. Moreover, as 360-degree films and photographs may occupy the gaze of the audience from all sides, they are among the items that can be experienced through virtual reality and offer a high level of immersion.
The use of digital technology has also been motivated by a deeper concern for environmental justice. To confront colonial and corporate epistemologies, limits, and practices, advocates and activists for land and environmental justice, for instance, have used digital cartography to disseminate and support counter and commune centric mapping initiatives. In addition, modern environmental activists frequently use social media and digital technologies to plan events and disseminate images, videos, and other materials that may supplement or contradict the views of the corporate sector, the government, or the mainstream media.

In order to generate visual artefacts that depict, dispute, and disrupt socio environmental issues, injustices, and hierarchies, environmental educators, scholars, practitioners, artists, and activists are also increasingly interacting with and connecting digital and non-digital traditions.

**Influence of immersive technology on environment education**

There is a lack of any collective efforts to explore, discuss, and debate the influence of digital technology on EE (Environmental Education) research and practice, and previous efforts to present and call for critical perspectives and the emerging pervasiveness of digital technology in EE. Through citizen science initiatives and other similar programs, digital technologies have the potential to serve as exceptionally powerful tools for collecting, monitoring, and distributing key ecological data and trends to students and the public. Instructors and students who are less willing or able to take their learning out of the classroom will naturally be attracted to these technologies for many reasons, including institutional risk management concerns, lack of funding, experience, knowledge, or access.

The term "immersion learning" has been defined in various ways by different authors. For example, immersive learning has been described by some authors as learning made possible through the use of immersive technologies. On the contrary, some researchers reasoned that technology and its impact should be distinguished. The term "immersion" characterizes both the technological aspects of a medium and the response emerging from integrating the human motor and perceptual systems. Immersion learning becomes ageless and unaffected by technological advancements when it focuses on the effects of immersion on learning and perceptual processes rather than technical qualities. Therefore, by utilizing technology affordances, immersive learning promotes learning while fostering a sense of presence the sensation of being there co-presence the sensation of being there with others and identity construction the process of establishing a link between oneself and the visual representation.

A number of frameworks and models that focused on the educational uses of immersive affordances were introduced and discussed. For example, a framework for the use of IVR technologies based on cognitive theory about multimedia learning, to identify the objective and subjective elements of the presence, is utilized. The objective elements are immersion technology, while the subjective elements include motivational, emotional, and cognitive factors. Due to these reasons, another model was also presented, which is known as the cognitive-affective model of immersive learning. It was introduced in order to understand better the usage of immersive technology in learning environments based on cognitive and emotional factors such as interests, motivation, self-efficacy, cognitive load, and self-regulation. It explains how these elements make a contribution to obtaining procedural, conceptual, and factual knowledge. Immersion technology can improve instruction.

Generally, VR is understood as a combination of technology and software that creates an artificial experience, which may either be similar or different from the real world. The concept of virtual reality was talked about in the writings of ancient times before this was developed as a technology. However, Ivan Sutherland introduced it, according to many, for the first time as a computer technology in his PhD thesis. He contributed to the Sketch Pad man-machine graphical communication system. However, it is Jaron Lanier, who founded the virtual programming language research community that is credited with popularizing VR. The technique was then researched and studied by the researchers in minute detail. The engineering, physics, and chemistry communities have contributed to the changing faces of the technology over time.

A virtual reality technology is a technique of simulation that simulates the physical world. Morton Heilig developed the concept of virtual reality and came up with the idea in the 1950s. He built Sensorama, a multisensory, immersive device and among the first virtual reality systems. However, Sensorama was far from what today's VR headset is. Ivan Sutherland and his research group created the first functional interactive head-mounted display system later in the 1960s.

After years of research and development in the field, several varieties of VR equipment exist. Various gadgets can be employed to adjust the degree of immersion of the VR experience. Normally, an immersive VR experience requires a head-mounted display, abbreviated as HMD.

The alternative virtual reality experience is a non-immersive VR system, more accurately called a desktop VR system. An HMD is normally a helmet-shaped device that provides a three-dimensional view and monitors the movement of the user in order to refresh the view on the HMD accordingly. Nowadays, it is universally acknowledged that immersion and interactivity are the two most important advantages of VR. Corresponding to the two conceptions, there are five key characteristics of virtual reality technology in relation to creating a simulated realistic setting and providing people with a high degree of immersion and interaction.

**Key features of VR**

1. Three-dimensional viewing provides a more real environment compared with two-dimensional viewing.
2. Dynamic display: Enhancement of realism in user experience.
3. Closed-loop interaction: A VR system provides greater mastery to the user over the virtual environment because one is both an active navigator and an observer
4. Inside-out frame of reference: Sometimes also referred to as ego-referenced frame of reference, this approach projects an image of the virtual world onto the mind of the explorer from a camera viewpoint.
5. Due to recording the user's movements and then feeding this information back to the VR system via a headset and gloves, it will open up a completely new dimension in sensory experience. Since VR has all the above-mentioned qualities, it is useful for environmental education.

First, to understand how VR can help, one needs to consider where VR fits in with the fundamentals of environmental education.

**Especially, we want to consider how VR might support these ideas in order to provide better environmental education**

1. **Representative and inclusive:** All environmental education resources must be inclusive and representative in the capturing of the nature of the environment in all its forms.

2. **Emphasis on the development of skills:** The center of gravity for environmental education must be to provide lifelong skills to the students.
3. **Depth of learning:** The educational materials should enhance students' ecological awareness and self-consciousness.
4. **Civic and personal responsibility:** Both of these pillars form a very important base on which actions and decisions should be made in relation to the environment.
5. **Instructional effectiveness:** It is very important that educational resources establish inclusive, productive learning environments for all learners.
6. **Ease of Use:** Products should be designed and intuitive to use from both the instructor and student perspectives.

We can make some connections between environmental education and VR tools and approaches based on these concepts and the features of VR identified above in the Introduction. In other words, VR could be useful both as a tool and in relevant content for environmental education.

**Features of AR**

Augmented reality systems integrate real-world and virtual imagery. AR can enhance the interaction with the real world by showing concepts and principles in their real environment, since this happens in real time when a user is working with the system. Multiple taxonomies of augmented reality considers input/output, popular uses, technology used and education-related factors.

These systems can be both marker-based and marker less AR systems. The marker-based AR systems depend on the use of fiducially markers, such as bar codes or QR codes, which are placed strategically and detected by the camera to present an enhanced reality. The markers can also be printed onto a sheet of paper. Using a handheld device or a see-through head-mounted display, users scan the marker to view imagery. Instead of using fiducially markers for tracking, natural features are relied on by marker less AR systems. Calibration, precision, and ergonomic comfort are some of the objectives of tracking systems. Evaluation of marker less augmented reality systems should therefore include the user experience. Systems that depend on location, projection, and superimposition are examples of marker less augmented reality. This type of AR uses a GPS, an accelerometer, and a gyroscope in order to present information with respect to its user's position. Location-based augmented reality make use of such technologies as those used by Google Maps, whereby users are given directions and information about places of interest in the vicinity. Projection-based AR projects images on to their surfaces for the enhancement of 3D surroundings or objects in the real world.

While the scientific community has clearly separated the concepts of VR from AR, as long as AR changes the way users perceive things by giving them an opportunity to interact with the real world, VR allows users to handle digital objects in an artificial environment. Mixed reality is a new type of immersive technology. On the other hand, there is a difference of opinion on what MR is. Many practitioners do not differentiate between MR and AR. Yet others view MR as a superset of AR. For our purpose, however, we stick to the definition in, which says that MR extends AR in that users are allowed to touch and even walk into virtual objects superimposed on the real world. Currently, this technology has increasingly pushed by giant tech companies.

Compared to other areas of human-computer interaction, immersive technologies render task performance more complicated in an actual or virtual 3D spatial environment. Immersion technologies create a plethora of possibilities for interaction since they require non-traditional methods of device setup, techniques, and metaphors, besides a wide variety of input and output methods. It would be possible to obtain the interaction strategies from both the task and input levels. The interaction can be inputted by a range of methods ranging from hand gestures, voice commands, gaze, orientation, or head gestures, hardware-based controllers can also be used. Menu-based selection, rotation, pointing, selection, translation, scaling, and abstract functions can be supported by the interaction.

**Immersive technologies for environmental sustainability**

The other most important factor that determines how well the leveraging of XR to meet environmental sustainability objectives is down to human-computer interaction. In whatever context, the design of technology and user experience have played a vital role in the development and success of XRs technology. While early large, non-immersive displays made for a bad user experience and thus were not well-received, over time, improvement in display technology along with greater emphasis on HCI design for XR has significantly improved the said technology. Along this line of reasoning, HCI is vital to all technical advancement-not only for improvements in the practicality of the use of XR for the accomplishment of aims within ES but also general advancement. A new topic in HCI (Human-Computer Interaction, namely Sustainable HCI-abbreviated as SHCI-is concerned with using technology in order to solve issues related to sustainability. Two over-arching themes in SHCI research relate to the environmental and societal dimensions of sustainability: minimizing impact on the environment, stopping depletion of natural resources and the social, political, and economic issues of sustainability. Even as ES (Environmental Studies) focused on the necessity for changing individual behavior, SHCI has pressed for shifting away from these techniques and presenting questions about their efficacy. The meager decrease in unsustainable behavior with the former techniques as well as the lack of empirical proof about long-term change are compelling reasons for worry. A move away from SHCI contradicts others in the field of environmental psychology and environmental communication who argue that its inclusion is necessary, notwithstanding that the nature cannot be focused solely on this level, because individual action may directly affect the creation of a culture of sustainability and the establishment of an environment of sustainability. The focus on the person is not irrelevant to reach the broader objective: the fulfillment of sustainable transformation. However, those who can effect change are usually kept aloof from issues affecting our society and environment. Research into the impact of VR on human rights beliefs and helpful behavior toward others suggests it could be a useful tool for SHCI to bridge this gap and reach such individuals using XR. The type of work, such as those mentioned above, illustrates how XR can also serve as a participant in the wider-scale, societal changes which SHCI strives for-by way of changing beliefs and behaviors. This study hence aims to provide new insights for the SHCI researchers into how their work can address the issues of sustainable consumption and behavior change, with regard to XR technologies.

**Designing of interactive game can also have impact on environmental studies**

The video game has grown to be one of the defining features of contemporary life, with billions worldwide regularly engaging in it. According to studies, games have the ability to influence attitudes and behavior among players; hence, they are an effective method of lobbying and teaching. Immersive experiences through games can simulate real-world experiences and afford players the opportunity to test different outcomes and understand what the consequences of their decisions will entail. With the potential to create memorable and powerful experiences, video games are poised to be one of the more unique mediums through which social change can be mobilized. While the main aim of game design is always entertainment, now there is a growing trend toward positive purpose in games; more moral dilemmas, social, and instructive content are being added by a growing number of game developers into their productions. Such change points to one greater movement within the media sector for sustainability and social responsibility. A further obvious extension of this is to take the so-called sustainable development goals-SDGs-in game design, providing a framework to create games that inspire, educate, and entertain. The goals of sustainable development range from social justice to the preservation of the environment. Activism, behavioral change, and increased awareness can be elicited by the goals of these games. For instance, emulation of some of the environmental challenges through games can spur their players into the practice of sustainable behaviors by teaching them about the complexity of climate change. Similarly, video games that raise awareness of social issues such as discrimination and injustice develop feelings of empathy and may probably prompt their players into community activities.

## Conclusion

This is not hyperbole, but rather fact, that the media and content are positioned to influence consumption habits, community building, and well-being around the world. They will also play an important role in promoting sustainability.

Given the cultural importance and potential of the media industry to shape investor, customer, and even congressional decisions, there are varying ways and vehicles through which to educate and inform consumers. Sustainable development encompasses a range of goals, including those related to social justice and environmental preservation. Games based on these goals have rallied people to take action, shift behaviors, and increase awareness. For instance, games based on simulated environmental challenges can spur players to engage in greener behaviors-exposure to the complexity of climate change in these games does. Likewise, video games that outline social issues like discrimination and injustice can show empathy and stir the player into action within their communities. Future research should take into consideration the development of immersive learning opportunities outside of STEM areas, including the arts and humanities. Future researchers are encouraged to conduct experiments using the tools available to them that will facilitate virtual learning environments. Researchers may study how easily these tools can be used and if they are appropriate for a learning environment. Moreover, in addition to providing support for deployment and integration into classroom settings, further research could be directed toward the development of a conceptual framework guiding educators on how to identify cases for deploying immersive learning experiences. Last but not least, assessing immersive learning experiences on the grounds of usability should be a job for future scholars during the design stage.

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