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Virtual Transformations in Human Learning Environment: An Extended Reality Approach

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Abstract:
Today, learning environments (LEs) are proceeding towards virtual environments (VEs) in which a sense of reality can be presented in three dimensions (3D) and a sense of inclusion can be experienced. A virtual learning environment (VLE) can be presented in a more realistic and visual manner with the use of innovative technologies such as virtual reality (VR), mixed reality (MR), and augmented reality(AR). This paper examines how extended reality (XR) approaches and its applications are transforming virtual learning environments in the context of human education and learning. A systematic literature review from the Scopus, Web of Science, IEEE, ACM and Google Scholar databases was conducted in order to better understand XR's contributions to human education as well as learning.The potential uses of XR technology have been discussed in terms of its structure, past, present, and future directions of XR concerning education.The research conducted in this context has determined that XR is mostly being used in fields of education, learninig and simulating an emergency situation. XR technology can be applied to solve problems without causing harm to people or property, particularly in emergency scenarios and safety training. Finally, this study offer several novel approaches for addressing these challenges, as well as potential directions for future researchers seeking to specialize in using these emerging technologies for human education.

Keywords: Human learning environment; Virtual transformations; Extended reality; Virtual reality; Immersive technology

1. Introduction

Extended Reality (XR) encompasses several immersive technologies, including Augmented Reality (AR), Mixed Reality (MR), and Virtual Reality (VR). Immersive Education refers to using XR for teaching and learning purposes. The use of immersive technology is rapidly enhancing the digital transformation of transportation, reducing complexity and cost, especially during the pandemic. Digital technologies such as VR, AR, and MR offer more natural and intuitive ways to interact with engineering systems than traditional screens, such as gestures, eye movements, and brain dynamics. Consequently, immersive technology-enabled digital transformation has attracted an increasing amount of attention from industry and academia in recent years. It is expected that immersive technology will transform several fundamental aspects of transportation and lead the way to digital transformation as a type of digital technology [1].

Consequently, student learning motivation, engagement, and performance can be enhanced through immersive education in a virtual learning environment. However, virtual reality helps students enhance their experiential learning. Students can also experience the world virtually in educational settings, which is an effective and efficient way to practice. In educational environments and learning, knowledge transfer is critical. In our society, it represents one of the foundations. We have many opportunities in the digital age to enable better learning through technology. As a result of these technologies, virtual learning environments can also be created, which can contribute to improved learning.

Traditionally, learning environments such as learning and teaching activities typically are conducted in a specific environment and time. In contrast, virtual 3D worlds that represent realistic environments have begun to replace those traditional learning environments. The 3D virtual worlds are defined as environments where the real world is simulated and users can communicate with each other through avatars [2]. Its features such as offering new ways and channels to its users in the context of communication, cooperation, and interaction. Additionally, this type of platform is becoming more popular as it offers multi-user and 3D interactions over the internet, as well as support for learning and teaching processes. In 3D virtual environments, where learning environments can be presented in a more visual and realistic structure. Furthermore, students can engage in a series of tasks to achieve a specific learning objective without losing focus by adhering to their learning goals [3]. By creating a safe and realistic learning environment with 3D learning environments [4, 5], students can be motivated [6, 7] and enable them to transform their learning into behavior [8].

The 3D virtual learning environment (VLE) simulations offer and provide students with a bridge between theoretical knowledge and practice individually. Moreover, it is enabled students to try new ideas, and learn from their mistakes. In addition, simulation-based activities in such environments improve students' critical thinking skills, allow them to take risks and support their ability to make decisions independently. Studies have shown the contributions of VLE to the learning-teaching process, cooperative learning, visualization, behavior synthesis, presence, containment learning, simulation of high-cost, and dangerous scenarios [9]. In VR, emergency or dangerous situations are simulated in a realistic virtual environment that is impossible to recreate in the real world. XR's high level of presence allows learners to experience the virtual experience as 'real', while its high level of agency allows them to feel in control of their behavior, allowing them to gain mastery in the experience, experiencing it as a performance accomplishment. IVR training may increase learners' self-efficacy in comparison to traditional media.

The use of IVR can improve generative processing by facilitating user engagement [10]. As a result of IVR, participants experience high levels of embodiment, which is consistent with embodied cognition theory. A common application of IVR is the acquisition of procedural knowledge, especially for procedures that are difficult to train in the real-world. As well, studies have demonstrated that implementing generative learning strategies into IVR encourages procedural knowledge acquisition [11]. In the light of technological developments, the XR approach has gained importance with a new transformation. In recent years, it has become increasingly important for virtual worlds to reflect real-life virtual environments as closely as possible.

2. Virtual Reality

The concept of VR is not a rather than hardware or software, it is an approach that surrounds the efforts made to feel the reality in the virtual environment (VE). There are several proposals for the definition of Virtual Reality (VR).In general, VR is a computer-generated three-dimensional simulation of a real-world situation, and the user perceives this simulation environment emotionally with the help of special devices that the user wears on his body [12]. It can be defined as systems that can communicate and interact with an object in virtual space [13, 14]. Virtual reality environments (VREs) consist of advanced computer technology and an interaction-based on human-computer interaction interface. In this kind of environment, the images exhibit dynamic reflections of real-world objects, unlike static computer graphics, and can also be controlled with various devices [15].

There are two types of VR approaches, immersive and non-immersive, depending on the real-world reflection situation. Non-surrounding or desktop virtual reality is defined as 3D visuals created with multimedia tools on personal computers that can be explored interactively using a monitor, keyboard, mouse or joystick [16]. Virtual worlds, 3D games, and simulations are examples of non-surrounding virtual reality. Along with the developments in web technologies, many users are provided with the opportunity to work collaboratively in VEs such as Altspace VR, Titans of Space, ActiveWorlds and Second Life [17]. Therefore, VR in non-enclosed environments has begun to become more immersive, enhancing the experience of presence and interaction.

Essentially, the concept of containment is expressed as the feeling of being in the context of a task in a VE without being conscious of time. In VR, participants are immersed in a feeling of being surrounded by the environment [18] and the user feels as if they are in the physical environment [11]. On the other hand, the feeling of being present refers to aware and interacting with an environment offered through various communication channels in a VE. Therefore, the feeling of being can be presented with traditional media tools even before virtual worlds exist. During the reading or watching of a book or television, users feel like being in a 3D virtual world at the same time as a computer game. This feeling can be given as surrounding VR is offered with technologies such as room-sized 3D multiple displays a cave automatic virtual environment (CAVE) and a head-mounted display (HMD) [19, 20].

Over the past few years, the use of VR headsets has increased more than CAVE technology. VR provides the opportunity to interact with the environment as though it were a part of the environment since it creates the feeling of being surrounded by the environment [21]. With the development of immersive virtual reality (IVR), the feeling of being surrounded and being in 3D virtual worlds has gradually developed in the context of human-computer interaction (HCI), becoming more similar and compatible with the real world [22]. In this direction, VR applications have developed with technology from past to present and it is thought that more advanced applications will emerge in the future.

3. Extended Reality in the Context of Teaching and Learning

Virtual reality glasses are a full-immersion system that displays the virtual world. Immersion has been shown to have a positive effect on learning outcomes in recent years. studies indicate that fully immersive learning enhances learning outcomes [23]. For example, the learners took the fully immersive learning environment more seriously or they voluntarily spent more time on the learning task in the fully immersive learning environment. To determine the best VR learning application to be used in teaching, it needs to be evaluated individually when using VR in that role. Due to their affordability, VR glasses have become increasingly popular as learning technologies.VR headsets can increase motivation and engagement in learners as well as offer advantages for universities over traditional methods such as text work or classroom teaching [24, 25]. In addition, VR training is not expensive and allows the practice of complex processes [26].

Studies indicate that nursing students learned how to care for a patient either in VR or using a simulation manikin [27]. While learning transfer was equally strong in both groups, VR training was significantly less expensive. The risk of causing damage to a patient is also lower in a VR simulation, for example, training in the operating room, since patient-related cases can be simulated in VR and practised as often as desired and without risk before the actual intervention [28]. In addition, people who are far away can interact with each other and with the virtual world, regardless of their location, without incurring travel costs. With the learners, instructors can practice scenarios that are dangerous in reality and pose high risks for participants or that occur so rarely that regular practice is difficult. VLEs can always be adapted to the learning context, so the specific situation can be tailored to meet the needs of the learners or teachers. In pretests, learners' abilities can be determined so that the application can be tailored accordingly [29]. However, It is also possible to use information about user behavior during the implementation of the training to adjust the displayed content accordingly and to provide feedback. In experimental studies, simulative and immersive devices proved to be effective in enhancing cognitive learning, which requires high levels of visual awareness and visualization. Furthermore, immersive virtual reality learning with nuanced 3D visualizations of the human body and animal body provided more incredible learning results than classroom instruction or traditional instruction. One main factor for technical usefulness was increased focus and interaction with the IVR environment.

Furthermore, it is possible in VR to create realistically designed learning environments in which one can interact almost naturally and intuitively. According to situational learning theory and experiential learning, this closeness to reality and interaction with the learning material can help to better apply what is learned to reality transferred [30]. Due to the high controllability of the VR learning environment, it is also possible to link the feedback for the learners to the interactions in VR, so that the feedback is situational and direct for the learners.

4. Trends in Extended Reality

The first VR application in the modern sense is a multi-sensor simulator named "Sensorama" developed by Morton Heiling in 1962. With this prototype, a motorcycle experience in New York City could be simulated as if it were in the real world. The sense of reality has been tried to be increased by presenting the wind, smell, and city noise in the simulator. By the 1970s, VR applications were mostly developed for military purposes. Simulations using high-level surrounds were developed by the USA to increase the helicopter, tank, and flight experience [31]. In recent years, increasing interest in VR and decreasing hardware costs have paved the way for non-military applications of VR. One example of this would be the VR-based ship firefighting training application developed by [32, 33], and VR-based work machine training applications.

Nowadays, VR increases the learning experience, thus making it suitable for educational purposes [34]. The first applications for the educational use of VR were the NICE project [35, 36], which was used for teaching the relationship between plant growth and the relationship between water and sunlight. The Atlanta project was designed to teach university students about natural life. Virtual Zoo Project [37], which is a computer simulation based on learning environments use and experience of stereoscopic with 3D film viewed via a VR headset at the zoo.

The benefits and potentials of VR in education are within the framework of the components of immersion, interaction, and participation in the environment [22]. The researchers also stated that VR increases student engagement in learning. Based on a study that examined studies published between 2012 and 2020, it was determined that VR was mostly used for higher education and adult education for certain special situations[38–40]. With VR applications, students can make educational trips. Thus, they experience the feeling of being in the places they go virtually and can hear the sounds of the objects in that environment. The applications are used in military training in defence and attack strategies with the support of simulations.

Researchers primarily conduct their research in the fields of computer science, engineering and medicine [41–44]. In medical education, students can work on virtual cadavers or living human bodies and experience realistic situations. On the other hand , engineering students in VR laboratories can repeatedly perform experiments without hazardous [45]. As a result of the research, it is pointed out that VR has the potential to be used for situations that are not possible to practice and cannot be experienced in real life because it contains a high level of hazards. The use of online multi-user virtual reality applications allows users to experience, communicate, and interact with each other in the same VE using different VR devices. This enables effective training with fully collaborative environment.

On the other hand, with the use of technologies like AR and holographic imaging in combination with VR, virtual images can be presented in a way that is more similar to and compatible with the real world. AR can be defined as a mixed reality environment created by adding virtual data to the real-world image simultaneously [46]. AR allows individuals to see, feel, smell, hear and even taste more [47]. The major advantage of AR technology it strengthens the reality that users can perceive with their sense organs by supporting them with virtual data [48]. Another technology developing for VR is cinematic reality. This technology, developed by Google and still under development, is offered with a wearable device called Magic Leap HMD as shown in Figure 1.

Figure 1. Magic Leap HMD

This device is a 3D computer-generated imagery over real-world objects, by projecting a digital light field into the user's eye involving technologies potentially suited to applications in AR and computer vision. It is designed to bring movies to a real-life environment without any physical screen. It aims to provide users with a completely different reality experience with such cinema-like image effects. The goal is to bring surreal imagery and environments into the everyday world. In VR development, the hardware device plays an important role, since the interactiveness of the simulation is also influenced by the device type as shown in Table 1.

Table 1. Example of popular tools for VR

Types of VR	Hardware	Properties
Watched VR	Google Cardboard and Samsung Cardboard	Simple, cardboard-made VR solution, cost-effective, dynamic, and mobile learning experiences
Semi-interactive VR	Samsung with one controller	Uses a smartphone with the Gyroscope screen
Interactive VR	HTC Vive, HP Reverb G2 and Oculus	HMD standalone and desktop version creates more interesting hands-on experiences, HMD with room-sized tracking allows users to move around and interact with the objects in the 3-D environment , offers a higher comfort level for viewing and physical movements

5. Educational Usability of Virtual Reality

Today, learning activities can be carried out with more comprehensive and realistic experiences in environments such as Second Life which represents Mozilla Hubs, VRChat, Furcadia and OpenSimulator. With the integration of surrounding VR technologies, the training given in such environments can be carried out in a more realistic and safer environment [48]. Especially with the use of technologies such as VR headsets. With the content of the application environment, the user can experience an interactive and high-level sense of presence.

With its focus on interactivity and user participation, VR offers a high potential as a learning environment for making learning more motivating and interesting [49]. There is an increasing trend toward VR-based education in schools and universities. Several educational institutions have recognized this potential technology and conducted VR training courses in virtual learning environments on virtual space [50].VR technology allows students to feel their classmates more cognitively in VLEs. However, the student receives real-time feedback from teachers, engages and experiences the feeling of reality in the same environment more despite being in different locations physically [51]. The general achievements of using VR in learning environments are listed below in Table 2.

Table 2. Use of VR technology in human learning environment

VR in human learning environment	Reference
Supporting peer collaborative learning	[52, 53]
Ability to develop students' problem-solving and discovery skills by providing rich teaching content	[54, 55]
Ability to provide learners with highly interactive experiences	[56, 57]
Increasing learner motivation and engagement	[22, 49]
Enabling learners to gain knowledge with less effort compared to the traditional teaching process	[58, 59]
Making the teaching process more realistic and safe space	[60–62]

VR also has a remarkable feature in terms of providing a safe environment for training with real danger potential. With VR, situations that are risky, physically inaccessible or require high costs can be experienced by visualizing and simulating [63]. VR applications can be used for emergency scenarios, training, and safety [64]. It can be operated without causing loss of lives or material damage and risk [65]. Research in this framework is mostly carried out in areas such as military education, medical education, physical rehabilitation, psychological treatments and simulating risky emergency scenarios [66]. The VR-based training simulator was developed during a fire [67, 68].

The use of a new method has been tested for very dangerous situations, such as heat and toxic gases generated by flames and smoke. Using VR glasses, the researchers found that simulators developed based on VR are effective. firefighters can intuitively prepare for escape and rescue activities in such cases in case of fire that may occur in tunnels [69]. Creating an environment in which children can practice real-world danger scenarios [70] reduces the risk that they may experience and allows users to practice real-world danger situations. In the research, fire protection and escape training for children was carried out with a VR-based learning environment surrounding it. As a result of researchers concluded that demonstrations of fire safety training were the most effective way to teach children about fire safety.

In VEs, they were more enthusiastic and interested in game-based safety training. Moreover, it was emphasized that it is promising to conduct such security training through VR. Regarding the usability of VR in the medical field [71], it was tried to give medical students the ability to perform surgical operations in the treatment of cancer patients by using VR glasses. The research was conducted with finger tracking pointers, a video camera, and computer software. The finger movements of the instructor performing the surgical operation were recorded with a video camera and finger tracking pointers, and the software developed was transferred to the computer environment. Thus, it was ensured that the students were able to monitor and examine the hand movements of the instructor in detail.

At the end of the study, it was determined that VR headsets increased the interaction and communication between the student and the instructor and supported the learning of the students. The use of VR in education may differ slightly from typical educational research methods. As a matter of fact, in some cases, data collection includes scales, surveys, etc are determine student's perceptions. The researcher may need to observe behaviors directly and make measurements to connect the displayed behavior with the technology used in the research. In such instances, graded observation forms are used to measure behavioral skills. On the other hand, to determine the effect of the VR environment on the behaviors that emerge as a result of VR-based training. Furthermore, scales evaluating how the feeling of presence offered by the environment is perceived and whether participants are prone to feeling such a sense of presence are also needed.

6. Conclusion

Today, traditional learning environments, where education and training processes are carried out in a certain place and time, have begun to be replaced by 3D virtual worlds, which have no time and place limits, together with changing and developing technologies. With the development of virtual worlds, where the real world is simulated and where the participants have the opportunity to interact and communicate with each other through the virtual world in a similar way to the real world. virtual reality has started to become a concept that society has started to hear frequently. It has been expressed in different ways in the literature such as situations encountered in real life, three-dimensional simulation, special devices worn on the body, perception of reality and sense of presence by components of VR. When we look at its historical development, it is seen that virtual reality started to be used for military purposes and then continued to be used in fields such as computer science, engineering and medical education.

Since the studies carried out in these areas are examined, it is tried to determine the usability of virtual reality for situations that involve a high degree of risk when practised in real life. VR has been shown to enhance learning and motivation by making the process of learning safe, supporting collaborative learning, developing problem-solving skills, and providing high levels of interaction experience. Although it seems like it is too early for teachers to incorporate virtual reality technologies into the classroom, especially in the case of earthquakes, storms, floods and fires. Applications containing such technologies must be employed by relevant institutions and organizations in natural disasters. In this direction, while dealing with the development of the enclosing feature of VR technology by determining possible application areas.

On the other hand, XR technology can be an effective tool for supporting the educational process in the future, for instance, in virtual laboratories, especially during epidemics. In terms of training, virtual laboratories play an important role in refining skills. VR technology can be used to design a virtual laboratory that simulates practical exercises carried out by students in real life, thus saving on equipment and preventing injuries and accidents during work.

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