Chapter 12
Immersive Virtual Reality for Learning Experiences

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Abstract The emergence of immersive virtual reality systems, which offer virtual environments of high interactivity for the user, become attractive to be incorporated into the classroom because they generate motivation in the students and facilitate the tasks that lead to a better representation of spatial knowledge. Virtual worlds are an excellent means of experimental learning, especially to replace real contexts that are impossible to use due to time or space restrictions, or that are unsafe for a student to address. Neuroeducation experts believe that virtual reality technology is promising for its ability to create 3D scenes that allow students to generate vivid and emotional experiences.

Keywords Virtual reality · Virtual world · Immersion · Presence · Learning

12.1 Introduction

Although the term "virtual reality" began to be used in the late 1980s and most of people think that is a very new technology, its origins date back to 1960, when Philco Corporation created the first head-mounted display (HDM) named "Headsight" which had a screen and tracking system and was linked to a closed-circuit TV. In 1968, Ivan Sutherland implemented The Sword of Damocles, the first virtual reality system, by wearing an HMD on which wireframe graphics were displayed giving to the user the feeling of talking up the same space as virtual objects (Pausch, Proffitt, & Williams, 1997; Robertson, Czerwinski, & van Dantzich, 1997).

The National Aeronautics and Space Administration (NASA) defines virtual reality (VR) as "the use of computer technology to create the effect of an interactive three-dimensional world, in which the objects have a sense of spatial presence".

We discover the world through our senses and perception systems. Our best known main senses are sight, hearing, taste, smell and touch, but we have many others, such as our delicate balance system, located in the inner ear.

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In this way, all our experience of reality is a combination of sensory information with a special processing of our brain. Therefore, if a system stimulates our senses with information that would be perceived as real from our sensory perspective, then we would believe it as real. Thus, virtual reality systems recreate a three-dimensional environment through hardware and software with which a user can explore and interact. The importance of this technology is that it creates the effect of interacting with things, not with pictures of things (Bryson, 1996).

12.2 How to Generate Immersive Virtual Reality?

In order to immerse a user in an interactive computer-generated virtual environment (VE), VR systems integrate real-time computer graphics, computer vision, motion capture, all these with processing power (Wiederhold & Rizzo, 2005).

The HDMs have a variety of internal sensors to track the user's position and offer a 3D field of vision for both eyes similar to the visual field of the human eye which spans between 100° and 120° of arc. Among the best-known commercial models, we find Oculus Rift and Vive Pro (with connection to a computer), Playstation VR (proprietary system), Gear VR (designed to insert a smartphone with the application) and Cardboard (the cheaper version of the last one). In Fig. 12.1 we depict different devices for VR systems.

The most advanced HMDs are sold accompanied by external sensors or cameras that track the position of the HMD on the user's face with respect to the surrounding physical room, giving the user the possibility to move freely in the virtual space (Boos, Chu, & Cuervo, 2016). For instance, this set of sensors and cameras receives the name of Constellation for Oculus Rift and Lighthouse in the case of HTC Vive. In

Fig. 12.1 Different devices for VR. On the left, the Oculus Rift and its Constellation; On the right, the Gear VR with a mobile phone in it; In the middle, a Glove controller

Fig. 12.2 Preliminar setting of a CAVE with only one wall projection and infrared cameras for tracking glove movements

addition, so that the user can actively interact with the environment, control devices are incorporated, such as the Oculus Touch System, the HTC Vive controllers, or more sophisticated devices with sensory feedback, which allow the user to receive the feeling of touch (including cold, heat, cold, roughness), as is the case with Gloveone or PowerClaw gloves.

Another alternative is the CAVE system (Cruz-Neira, Sandin, DeFanti, Kenyon, & Hart, 1992), a virtual reality environment created in a room, through the projection of multiple large images onto all walls, ceiling and floor. The user, located inside the room, wears special glasses that give her 3D vision. It also has a sound system through speakers located in different parts of the room, giving the user a very enveloping feeling. The CAVE is a simpler solution although the immersive sensation it offers may not be so complete (Cabral, Morimoto, & Zuffo, 2005). See Fig. 12.2 for details.

We must take into account that, the design of specific VEs for education must contemplate many levels, namely the multisensory representation of the information, the multiple interaction methods, the physiologically appropriate virtual contexts and the structure of the content to be explored. Expanding the current limitations in the design of these environments is an important requirement to build complex environments that can be imagined for education (Bricken, 1991).

12.2.1 Immersion and Presence

Film criticism usually use the term “Suspension of Disbelief” to define the ability to give into a simulation or to ignore its medium (Cruz-Neira et al., 1992). Colloquially, when a person forgets the real environment by being absorbed or feeling deeply involved by an activity, the term is that he is “immersed” in that activity. In this aspect, Robertson et al. (1997) remark that immersion may be experimented not only with the use of HMDs or a CAVE, since mental and emotional immersion may also take place while we are watching a movie or playing video games. In fact, sometimes, immersion occurs by engaging the user in a complex, real-time task, not necessarily with a VR.

However, in an immersive virtual reality (IVR) a stronger concept than immersion appears, and is related to the user's vivid sensation of being part of the virtually recreated environment, that is, to feel strongly "present" in that environment. For this reason, for immersive virtual reality we differentiate between "immersion" and "presence".

Following Slater, Linakis, Usoh, and Kooper (1996), the term "immersion" refers to the objective level of sensory fidelity a VR system provides in order to accurately portray a reality, while the term "presence" refers to the subjective measure of a user experience and it concerns the extent to which the user feels herself to "be there", i.e. within the reality represented by the VR (Knibbe, Schjerlund, Petraeus, & Hornbæk, 2018). The former depends only on the system's rendering software and display technology (including all types of sensory displays) and it can be measured without any user input, by focusing on frame rate, resolution, tracking, and so on (Bowman & McMahan, 2007; Knibbe et al., 2018). The latter is context dependant and draws on the individual's subjective psychological response to VR (Dalgarno & Lee, 2009).

The extent of realism that a user experiences depends on several technical aspects of the VR system. A VE should provide fidelity in visual representations (realistic perspective and occlusion, as well as realistic texture and lighting) and consistency of object behaviors, including appropriate responses in real-time as the person explores their surroundings. For example, the delay in system response time with respect to the user's actions disrupts her/his vivid experience (Dalgarno & Lee, 2009; Slater, Usoh, & Steed, 1995).

The subjective nature of the presence aspect makes that different users can experience different levels of presence with the same VR system, and a single user might experience different levels of presence with the same system at different times, depending on the state of mind, recent history, and other factors (Bowman & McMahan, 2007; Slater et al., 1995).

Creating an immersive experience with a strong feeling of presence relies on many design elements. Head-tracked camera control provides a stronger sense of "being there," compare with a desktop display usage. Another element that aids in the support of feeling of presence in an immersive VE is the way in which the interaction and exploration techniques of the surrounding objects are solved (Kelling et al., 2018; Pausch et al., 1997).

It is important to note that, presence also has a primary effect on the learning outcome. It increases the enjoyment and intrinsic motivation of students thus improving the perceived learning quality and satisfaction (Oberdörfer, Heidrich, & Latoschik, 2019). In this aspect, full immersion is crucial to any type of learning activity that involves body coordination and manual skills, such as medical training for surgery or learning physical therapy exercises (Patel, Bailenson, Hack-Jung, Diankov, & Bajcsy, 2006).

One of the main problems with virtual reality is motion sickness. Some people are affected by this effect after spending half an hour in a VE, while others may spend several hours without noticing any negative effects. These problems arise because the information obtained by the eyes disagrees with the information obtained from other sensory systems (what happens to some people on ships). Undoubtedly, this effect eliminates all feelings of immersion and presence.

Finally, we want to mention a lack that could prevent users from reaching optimal presence states, the usability of IVR interfaces.

The existing usability guidelines are oriented to standard user interfaces with information in a two-dimensional space, but for the 3D virtual reality environment, there are still no standardized definitions that guarantee ease of use, effectiveness and efficiency.

Many control devices, designed for user interaction with VE objects, define specific actions using buttons or keys. While this type of interface is unequivocal, having to hold the controls on the hands that are moving through space can cause muscle fatigue, beyond providing an arbitrary method for indicating commands. The glove device allows somewhat more intuitive gestures, although with more impression, and does not solve the problem of fatigue.

Undoubtedly, much research is still needed on the subject to be able to define a standard gestural vocabulary for IVR. Ideally, in order to ensure a completely immersive experience, it would be to recognize user gestures through computer vision, without requiring the use of any device (Bryson, 1996; Cabral et al., 2005; Kelling et al., 2018).

12.3 Immersive Virtual Reality and Learning

Different attempts have been made to use virtual reality in education since the early 1990s. The research results suggest that IVR, if it is properly designed and used, can provide added value on 2D technologies (desktops, tablets, cell phones) for learning. However, the costs associated with virtual reality equipment represent a limitation for educational institutions, which can reduce the practical impact of the theoretical research obtained (Dalgarno & Lee, 2009).

Today, Neuroscience helps us to understand many aspects of the learning process, something that obviously has a direct application in the classroom. Although we still need to understand the complex interactions of learning in virtual worlds to take advantage of this powerful technology, there are several aspects of IVR that are in tune with the recommended practices based on the discoveries of Neuroscience.

12.3.1 Engagement and Emotionality

An impressive finding of Neuroscience is that the emotional state strongly conditions the how the brain works. Mood can modulate brain functions by determining the acquisition of new knowledge. According to this, learning is more likely to occur with a state of positive emotion since, if we enjoy doing something, we will do it with more interest and better.

In this sense, virtual reality offers a degree of motivation in young students that promises effective learning. In addition, we must not neglect that the new generations are born and grow in a digital age and love all kinds of technologies, especially those that provide an environment close to games.

When students are engaged in learning experiences of which they valuate as relevant for their expectation, they increase the motivation to learn and produce a more significant result than a grade. In addition, if students interact with well-designed immersive environments, they will feel deeply involved and spend more time focusing on tasks.

Pioneering research in IVR has documented emotional reactions such as enjoyment and sense of play (Harrington, 2011). Reinforcing this, Dede, Salzman and Lofdtin (1996) indicate that the virtual reality experience is more motivating for students than a comparable 2-D virtual world.

12.3.2 Multisensory and Whole Body Experiences

Two other important findings of Neuroscience are that learning is obtained with the whole body (the body and the brain learn together) and that multisensory experiences favor learning. This implies that the exercises and movement are closely linked with learning and the experiences that allow us to perceive the world through all our senses allow learning to be much more meaningful.

The VR learning environment includes the multiple nature of human intelligence: spatial, kinesthetic, auditory, verbal, logical/mathematical, interpersonal and intrapersonal (Bricken, 1991).

The ability to capture the movement of the whole body is a distinctive feature of IVR settings and allows people to use their full range of physical movement to interact with objects and with the avatars of the virtual world (Patel et al., 2006).

Additionally, when students interact with virtual reality environments, they use their senses more than in a typical computer application. Punctually, with the high-end VR interfaces, they receive multisensory stimulation, since they can interpret visual, auditory and tactile screens to collect information while using their proprioceptive system to navigate and control objects in the synthetic environment, which deepens learning and memory (Dede et al.,. 1996). In addition, when students use a virtual reality environment, they, have the ability to observe the environment from many perspectives (Bricken, 1991).

12.3.3 Active Learning and Contextualized Skills

It has been scientifically proven that deep knowledge is not achieved by repeating from memory, but by doing and experimenting. Thus, new educational methodologies lead the student towards an active role, making her the center of the learning process. Those things that are experienced are usually remembered for a longer time and with greater clarity than those which are only heard or read, that is, experiencing and acting generates more stable and lasting knowledge over time.

IVR is a better educational tool with respect to 2D applications because it offers the opportunity to visualize, explore, create, modify, manipulate and interact with objects in much the same way we do physical objects (Lee, Wong, & Fung, 2009). Due to this characteristic, one of the areas where virtual reality could be most effective is experimental learning, that is, learning that helps students apply their knowledge and conceptual understanding to real-world problems or authentic situations with the professor as a facilitator.

IVR systems not only allow users to see in three complete dimensions but also allow her to control how to view the environment by allowing her to change aspects such as the position and orientation of the camera, which is impossible in desktop applications or traditional videos (Patel et al., 2006).

It is very important to note that, all theoretical models on acquisition and learning processes recognize the importance of context. Teaching a topic in the context of real-world situations makes the activities to be authentic. In addition, the acquisition of real-life skills may be achieved with greater accuracy if the practices are carried out in the right environment where they will be applied in the future.

The advantage of VR is that allows us to contextualize safe learning in environments that present dangerous locations or processes, such as rescue in a fire or manipulation of radioisotopes in a nuclear reactor.

Also, it allows to recreate places that are simply very difficult to visit, for example, the Moon, planet Mars, an archaeological excavation or the depths of the ocean (Cliburn, 2004; Dalgarno & Lee, 2009; Getchell, Miller, Nicoll, Sweetman, & Allison, 2010; Kuan & San, 2003).

Another interesting benefit offered by IVR is the possibility of breaking the time constraint by allowing students to travel in time and experience the past in first person. For instance, professors can prepare memorable experiences by virtually transporting students to the daily life of ancient Greece or the Stone Age.

The disruptive step that virtual reality presents with respect to other computer systems is that, the skills necessary to function within the virtual world are practically the same skills that we need in the physical world (Bricken, 1991).

A student can develop experiences in VEs of great realism and thus be better prepared for when such experiences occur in the real world. The more students participate in a real commitment, the better they apply and retain knowledge since they feel a connection with the material of the subject.

Based on Neuroscience recommendations, it is important to try to provide students with a positive and safe climate, avoiding stressful situations. Stress, among many other consequences, decreases cognitive ability and emotional state. Thus, virtual reality becomes a very powerful tool by offering students the possibility to practice and improve skills without fear of failure, creating confidence in new areas of learning.

With all the perspectives mentioned, virtual reality can revolutionize learning not only about how people learn but how they interact with real-world applications based on what they have been taught.

12.3.4 Challenges in IVR Experiences

The challenge is to design and build realistic virtual experiences that turn out to be motivating for the student and find variables that allow determining the best devices for each specific task, and even for each individual. Going further, by participating in the development of virtual reality experiences, educators can guide the growth of technology and perhaps influence the course of educational change. Participating in the refinement of this new technology could help to find the right point where it contributes to make teaching more effective and efficient (Bricken, 1991).

The role of the professor is fundamental, since she is responsible for aligning the use of VR with learning outcomes and determines the level of skills and knowledge that the students need to succeed in the most independent stages of experimental learning. It is clear that encouraging to incorporate this new technology in class will imply that the professor must be open to take risks.

On the other hand, the human being needs communication and interpersonal connections. If the virtual reality experience is surprising for a student but is always isolated, this could damage the relationships between students and general human communication. Consequently, it is very important to balance this type of experiences with other real interpersonal experiences or incorporate the group aspect into the virtual reality environment. For instance, the CAVE system opens interesting possibilities for collaborative work.

Sometimes, educators are concerned about the technology that breaks into their classrooms and for which they are not properly trained. Moreover, there is anxiety about the misuse of virtual reality and fear that this technology may produce negative results. As a remedial measure to reduce virtual reality technophobia, Bricken (1991) suggests providing accurate information to separate virtual reality from the fear that science fiction introduces about it, and share experiences and establish a dialogue between developers and the educational community to determine its appropriate use in education.

Finally, we highlight a not minor aspect. High-end IVR technologies have a somewhat high cost to be faced by institutions with low budgets. Keep in mind that, although today, a single HMD is not a very expensive equipment, to purchase the number of devices for a whole group of students could be unaffordable. However, with the advancement of basic hardware, a CAVE system can be designed at a more reasonable cost (Cliburn, 2004).

12.4 Developed IVR Applications for Learning

One of the first applications of immersive VR was military training. In these virtual environments the military can train infantry in urban combat tactics by moving them through a virtual city filled with enemy avatars and friendly troops and pilots can train about the terrain they would encounter over some specific geography, among many others missions (Bowman & McMahan, 2007; Cliburn, 2004; Patel et al., 2006).

Nowadays, the increasing development of VR technologies has matured enough to expand itself from the military and scientific visualization realm into more multidisciplinary areas, such as education, art and entertainment. Next, we will give a very brief list of the possible uses that are being made nowadays. In Table 12.1 you can consult a non-taxative list of other possible applications.

The objective of the rest of this section is to present several virtual reality implementations, some carried out in the classroom and others in research contexts, to highlight the potential of this technology. We show real experiences from different areas, to give a broad overview of the possible use in educational environments and to encourage the reader to generate their own experiences for their classes.

12.4.1 Science and Engineering

George Mason University has worked in the ScienceSpace project since 1994 (Dede et al., 1996) and developed a collection of virtual worlds designed to explore the

Table 12.1 Possible applications of immersive virtual reality

Area	Application of IVR
Science and engineering	Medicine and Health: surgery training, physical rehabilitation treatments, etc.
	Engineering: training on nuclear power plant tasks, device implementation, equipment design, equipment manipulation and calibration, prototype experimentation, training nuclear power plant tasks, etc.
	Scientific visualization, wind tunnel virtualization, visualization and control of scanning tunnel microscope, exploration of data from storms and severe tornadoes, architecture, astronaut navigation training, etc.
Social sciences and arts	Archeology: recreation of lost worlds
	Paleontology: training in fossil manipulation, recreation of prehistoric organic beings
	History: recreation of historical events, recreation of ancient architecture, etc. Art and Tourism: virtual explorations of sites
Sports	Reflex and action training in complex situations

potential utility of physical immersion and multisensory perception to improve scientific education. ScienceSpace consists of three worlds with fully immersive and multisensory interfaces, namely NewtonWorld, which provides an environment to investigate kinematics and dynamics, MaxwellWorld, for electrostatic exploration, and PaulingWorld, which allows the study of molecular structures through a variety of representations, including quantum level phenomena. For the lack of space, we detail only the first one.

The purpose of MaxwellWorld is for students to explore electrostatic fields and forces, in a personalized way and with multiple perspectives of referential frames, to experimentally discover the concept of electric potential and the nature of the electric flow. The system allows students to change world parameters and observe the effects, and has simultaneous visual, auditory and tactile feedback. In addition, "super powers" were incorporated, which allow flying and seeing through objects. The method used consists of a premise given by the professor and a prediction made by the student about what is going to happen. Then, the student executes the action with the VR environment and compares the result with his/her prediction. Results show that the students in the immersive condition were better at describing the 3D nature of electric fields (Dede et al., 1996).

Another example of an immersive environment for the teaching of Physics is the iHABS (Hot Air Balloon Simulation) project of the National University of Singapore (Kuan & San, 2003). Hot air balloons are ideal for demonstrating fundamental scientific principles, such as the Archimedes buoyancy principle and the law of thermodynamics. However, due to the danger involved in offering a student to fly a real hot air balloon, they are not used for teaching.

The goal of iHABS is to use IVR technology and the advantages of active learning to create a virtual, attractive and fun hot air balloon environment for students to learn the principles of physics in a constructive way. In iHABS, students can enjoy flying a hot air balloon personally, controlling all parameters to discover how these affect the vertical and horizontal velocity of the balloon. In addition, iHABS also allows students to virtually experience changes in weather conditions as the balloon rises. To complete the VE, each student is represented as an avatar that can be preselected by oneself before the start of the simulation system (Kuan & San, 2003).

Taking into account that the study of related transformations in mathematics is a complex, not very intuitive and difficult to visualize topic, at the University of Würzburg, an intuitive IVR application was developed: GEtiT (Oberdörfer et al., 2019). The refined transformations (translation, rotation, scaling and refection) are crucial knowledge for many engineering areas, such as robotics and 3D computer graphics, hence the importance of achieving a deep learning of them. The GEtiT application was designed to achieve effective learning of the subject. It uses game mechanics, with levels of progress that moderate the level of content abstraction and feedback, both on the effects of the applied mathematical operations, as well as their learning progress (Oberdörfer et al., 2019).

At the University of the Armed Forces-ESPE of Ecuador, the researchers have developed an IVR application focused on the teaching-learning process in the area of Automotive Engineering (Ortiz et al., 2017). In general, the applications of virtual reality in automotive engineering allows to strengthen learning due to the flexibility it offers to develop VEs of design, prototyping, manufacturing and assembly processes. This application allows students to submerge and interact bilaterally in a virtual 3D controlled learning environment, in order to perform the assembly and maintenance of engines, optimizing resources, materials, infrastructure and time. The system makes use of virtual reality devices such as HMDs and haptic input controls that allow the complete interaction of the students with the environment. In addition, the system allows students to select the work environment and the level of difficulty during the teaching-learning process. The results showed that the students who used the IVR application obtained better results at the time of handling the materials when performing the actual practical work with respect to those who used traditional learning (Ortiz et al., 2017).

12.4.2 Social Sciences and Arts

As an example of the possible applications in the teaching of History, we detail below the work of The Hellenic World Foundation (FHW), a non-profit institution, based in Greece, whose objective is to preserve and spread the culture Hellenic, through the creative use of multimedia and cutting-edge technology (Gaitatzes, Christopoulos, & Roussou, 2001).

Its virtual reality department, established in 1998, uses virtual reality technology to create interactive immersive experiences for research, understanding and dissemination of Hellenic culture. The project includes different applications, such as “Temple of Zeus in Olympia”, “The magical world of the Byzantine costume” and “Olympic ceramic puzzle”. As an example, we detail the first one.

In this VR application, visitors not only have the opportunity to admire the splendid temple, but also the famous statue of Zeus, one of the seven wonders of the ancient world, of which today there’s nothing left. Participants can walk or fly over the precise three-dimensional reconstruction, explore the city and experience habits and customs of life in those days. In addition, by walking through the back of the temple, users can enjoy the battle between the people of Lapithes and the Centaurs (Gaitatzes et al., 2001).

Laconia Acropolis Virtual Archeology (LAVA) is a project of the University of St Andrews (United Kingdom) (Getchell et al., 2010) that consists of a cooperative exploratory learning environment for students to participate in the complex excavation practice, because of excavation scenarios are generally inaccessible due to travel, time and cost barriers. Students are at the center of an immersive, interactive and collaborative environment that provides learning scenarios that foster the exploration, application and evaluation of knowledge and reflection on performance. Each excavation is divided into several global levels, where each of them is defined as an activity that is central to the excavation process and must be completed by the team before it is possible to advance to the next level. To add realism to the relationship between resources and the number of findings discovered, there is a certain degree of non-determinism to ensure that the findings returned to each team are different, even if the same resources are allocated to each stage of the process of excavation. The results of the evaluation process have been positive, especially due to the high degree of commitment that the students have demonstrated (Getchell et al., 2010).

Following the same lines, in the Brown University (Providence, USA), researchers have developed the ARCHAVE application which was implemented with a CAVE (Acevedo, Vote, Laidlaw, & Joukowsky, 2001). The reported use case consisted of the archaeological analysis of the findings of lamps and coins in the current ruins of the Great Temple of Petra in Jordan, with a real-size representation. To do this, the developers built a geometric model of the site and of the trenches used to excavate the site and populated that model with visual representations of the artifacts that had been unearthed. The user interface allowed navigation using models at different scales and of different types. The archaeologists who used the system were able to synthesize findings, test hypotheses and detect anomalies. They reported that ARCHAVE allowed them to understand the findings in situ, explore excavated areas with which they were not previously familiar, and make discoveries that opened new lines of research on excavation. Undoubtedly, the most surprising thing was that a group of expert archaeologists were able to formulate new hypotheses based on the connections they could make and which would have been practically impossible to achieve using traditional analysis methodologies. This supports the belief that access to site data in its 3D context can greatly facilitate archaeological analysis and that IVR is a natural way to provide that context (Acevedo et al., 2001).

Beyond the immersive systems that have begun to introduce the museums, to present their collections in a more attractive and exciting way, even allowing visitors to interact with virtual objects (since many times it is not possible to do so with real objects) (Wojciechowski, Walczak, White, & Cellary, 2004), a joint work between the Technological University of Tampere (Finland) and the University of Tampere (Finland), has allowed the development of a new prototype for a cultural and journalistic experience, which uses virtual reality to tell the story of an artist known through his art (Kelling et al., 2018). It combines elements of storytelling and journalism, and "transports" the user to the National Gallery of Finland to discover works by artist Hugo Simberg.

At the University of Cadiz (Spain), the "Let's Get Out!" application was developed (Berns, Mota, Ruiz-Rube, & Dodero, 2018), using virtual reality technology, to create immersive environments in which language students can foster their language skills through real situations. The application recreates a dating agency that gives students the opportunity to immerse themselves in a real emulated world and interact with an agency employee. Once the students have installed the application on their mobile devices, several 360º video clips are shown that allow students to immerse themselves in a VE that requires them to interact with an appointment agency employee. It was developed using 360° videos and chatbots that respond to the language to practice. A chatbot is a software program that interacts with the users of a system using natural language and simulating a human conversation. The interaction is facilitated by the use of VR headsets that allow students to visualize and interact using voice commands with the virtual world. In terms of learning, the benefits of this virtual reality application is not only that students have the opportunity to experience the target language in real-world situations, but also that their actions receive comments in real-time, so that students can review and eventually correct their actions and responses (Berns et al., 2018).

Finally, we cannot fail to mention a low-cost resource for VR experiences, which can be useful in the classroom: Google Expedition. This virtual reality tool allows you to lead or join immersive virtual trips around the world. This makes it possible for professors to apply virtual reality trips to places they deem necessary, from geographical landscapes to museums, or whatever they choose. You only need to download the Google Expedition application and use low-cost mobile devices and virtual reality viewers, such as Cardboard.

12.4.3 Sports and Entertainment

The Carnegie Mellon University Entertainment Technology Center has presented a virtual reality wireless system and a prototype full-body Tai Chi training application (Chua et al., 2003). This highly IVR system tracks the entire body in a working volume of 20 m^2 of base by 2.3 m in height to produce an animated representation of the user with 42° of freedom. This, combined with a lightweight video receiver and an HMD, provides a broad and untethered VE that allows exploration of new application areas, especially for training for a full-body motor task. The entire system is wireless, which frees the student from the burden of trailing wires. Using this system, an application was generated to mimic traditional Tai Chi instruction, where a virtual teacher is provided directly in front of the student. The student learns by imitating expert movements, similar to real-world Tai Chi instruction.

In particular, Tai Chi was chosen because of the slow nature of the movements and the range of movement fit well with the properties of the virtual reality system. In addition, it offers evaluation and comments to the student during the training. Tai Chi is a challenging training application because the sequence of movements, called the “shape” (for example, the crane), is complicated and performance standards are demanding. Because the emphasis is on balance and body shape during slow movements, students can adjust their movement according to teacher comments during the sequence. The conclusion is that virtual reality has great potential to improve physical training, with the ability to record a movement once and then reproduce and practice it unlimitedly, allowing self-guided training and evaluation.

12.5 Discussion and Conclusion

The growing development of IVR technologies has matured enough to expand from the field of military training and scientific visualization to a wide range of other areas, including education.

The results of current research foresee great potential in the use of IVR, if it is properly designed and used. Among the advantages that it presents, we find the possibility of observing events at both atomic and planetary scales, and offer the possibility of interacting with environments that, due to space or time constraints or security factors, would be impossible to access.

We know that technology alone does not improve education and it is essential to apply it properly to be effective. While there is still no deep applied research to clarify the relationships between the unique characteristics offered by IVR systems and their possible benefits for learning, we detect several aspects that respond to recommended practices based on the findings of the Neuroscience, namely, achieve motivation and emotionality, carry out multisensory experiences that use the whole body, apply active learning and tend to contextualize the practice for the achievement of skills.

In this sense, the challenge for the teaching staff is to design and build realistic virtual experiences that are motivating for the student and effective for learning. Ideally, it would also help to detect the variables that allow determining the best devices for each specific task, and even for each individual.

From the technical point of view, in order to make learning totally enjoyable through this technology, improvements are still required in the aspects of human-device interaction and in the definition of a standard gestural vocabulary for IVR, to guarantee completely immersive experiences, with high degree of presence and without distractions. It is also necessary to improve multi-user applications, in order to use them in collaborative learning environments.

Finally, we recognize that the application of this technology still represents high costs, which not all educational institutions can afford. If having an updated and successful education system is a priority for society, the resources to offer financing lines from government organizations and the private sector must be established.

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