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Advantages of Applying VR in Education: A Survey

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EDUCATIONAL RESEARCH

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Abstract:

Virtual Reality (VR) is attracting attention from more than just the technical applications from which it originated. It is a promising tool, approach, and method, with application in many different fields. In this paper we focus on VR applications in education, specifically some of the most relevant and vibrant disciplines in education such as archaeology, architecture, engineering, medicine, and military. We found that students who are currently working with VR are: (1) simulating environments very different from those found in the ordinary classroom; (2) testing and exploring actions/reactions and observing the results under simulated real-life conditions in time and space; (3) training with manipulation and design of three-dimensional (3D) objects; (4) improving the quality of the visual scenarios for understanding space (visualization). It has been applied in many different areas in education and it has proven an efficient method for increasing the speed of learning, technical skills, knowledge perception, and more.

Keywords: Archaeology, Architecture, Education, Engineering, Medicine, Military, Surgery, Virtual Reality.

Introduction

Approximately every half-year the computer processing speed doubles. This evolution is especially noticeable in the area of the Computer Graphics (CG) technology. The computers we use everyday are in fact dual processor machines. They contain the classic Central Processing Unit (CPU), as well as a Graphics Processing Unit (GPU), an independent and sophisticated piece of hardware fully dedicated to graphics. Not only because of the advancement in CG technology, but also because of Internet and communication in general, a paradigm shift is silently occurring in the way we communicate.

Computers with highly sophisticated three-dimensional (3D) CG are now the standard. They are used in many applications and they influence our lives and decisions in a silent way. New technologies arise and then quickly age. These innovations

manipulate old techniques, approaches, traditions, and customs, thus influencing a newer and better technology. Many innovations are productive, as in the case of *education*. Yet others are destructive, such as indiscriminate piracy of music and software over the Internet. The focus of this paper covers one of the productive innovations, education, more specifically, Virtual Reality (VR) in education.

One of the most promising and controversial areas of modern technology is VR. VR promised to be a universal cure for issues in different areas of human activities. Its application is not as fast as presented, the dreams are not yet reality, but as it is, it has found strong support in different subject areas.

But, does VR provide an advantage to the education field? To answer this question, and based on the number of existing applications reported in literature, we have detected some of the most significant disciplines utilizing VR applications in education, and we have analyzed them. They are *archeology*, *architecture*, *engineering*, *medicine*, and *military*. In the following sections each discipline is reviewed in depth with the goal of first detecting the common factors and benefits within each discipline, and then as a whole. This leads to a common conclusion showing the advantages of applying VR technology in the field of education, and concludes with some closing thoughts about the possible future of VR in education. This format illustrates the *bottom-up* approach in research and analysis.

What is VR?

VR is “An artificial environment created with computer hardware and software and presented to the user in such a way that it appears and feels like a real environment”

(Webopedia, 2004). VR applications “immerse the user in a computer-generated environment that simulates reality through the use of interactive devices, which send and receive information and are worn as goggles, headsets, gloves, or body suits” (Encyclopedia Britannica Online, 2005). In order to create a VR environment designers begin with a CG program.

CG is a way of processing data. Modeled objects are stored in the computer memory and displayed using highly sophisticated algorithms called rendering. If two images are displayed in a stereoscopic way, each to a different eye, the human brain fuses them to create an immersive stereoscopic experience.

The geometric 3D models displayed on the computer screen are not VR. To achieve VR there are two more fundamental requirements – *immersion* and *interaction*. The user must become part of the virtual environment. This is achieved by *immersion*, “the stereoscopic projection that delivers two parallaxically shifted images to both human eyes in a separate way” (Watt and Watt, 1992, p. 39). The human brain composes this information into the complete 3D information. *Interaction*, the second fundamental requirement of VR, means that the user can influence the virtual environment in some way and the environment responds appropriately.

VR is classified into two important classes, *immersive VR* and *augmented VR*. Immersive VR was just described. Augmented VR enriches the existing world by displaying additional information through CG. For example, a technician working in an airplane construction company needs to see additional information stored in the memory of a computer. The technician has special glasses which detect his/her position in the

plane. The chaos of cables that this person sees is enriched by information displayed on the lenses, explaining the function of each, which one is defective, etc. (Rheingold, 1992). We will *not* consider augmented VR in this paper.

What VR is not

Because VR requires interactivity and immersion in a 3D virtual environment, a 3D computer game displayed on a computer screen cannot be classified as VR. It is a 3D CG interactive application. To call this VR, some level of immersion must be provided.

VRML, *Virtual Reality Modeling Language*, is used to design virtual environments (Web3D Consortium, 2005). The latest version of VRML is X3D, a modeling language, able to permit some interaction. But just as isolated letters are not a book, VRML is not VR.

The above-mentioned Virtual Environment is a common term coined for an environment that simulates some aspects of reality. An example is a virtual classroom, where students interact and communicate. However, if not fully immersed and not displayed in 3D, it is not VR.

VR in Education

In this section we will focus on the application of VR in different educational disciplines. We will describe the applications, highlight the advantages the application provides, and describe the common patterns established.

Archaeology

VR development has advanced general Archaeology education. The effects are aptly described in “Is the Elephant Really There? Virtual Reality in Education”

(Macpherson and Keppell, 1997) where they use the *Learning Sites Project*, a team comprised of experts who create graphic, audio and textual databases that enable users to explore a number of archaeological sites. Through the use of VR users are able to interact with virtual versions of archeological sites, created by the rendering of meticulously recorded data from the real site. The user decides how the interaction should occur. For example, an obscure corner of a wall may be of interest to a particular user. So, if he/she wants, he/she can zoom in on the area and investigate it in more detail.

VR is also used in virtual reconstruction, for example, the Abbey of Cluny which was originally built in 909. In fact, Jean-Pierre Mohen, associate director of the Musées de France noted:

...with it [VR] we can reconstruct in volume buildings, towns, and even prehistoric camps, of which we have vestiges as small as a couple of centimeters thick. We can proceed by trial and error, verify hypotheses, study results and place objects, even food, where they probably belong. And there is, of course the great pedagogic value of a spectacular reconstruction that brings to life vestiges of the past. (Dorozynski, 1993, p. 544).

In fact, after applying various VR tests “The Visitor as Virtual Archaeologist: Explorations in Mixed Reality Technology to Enhance Educational and Social Interaction in the Museum” study (Hall et al., 2001), summarizes that VR provides: (1) practical exploration of artifacts; (2) collaboration/discussion among participants; (3) excitement created by curiosity and sense of imminent discovery; (4) exploration of interesting, problematic issues surrounding the making of inferences about history based on artifacts, the material residue of the past.

Additionally, Barcelo, Forte and Sanders (2000), in their book “Virtual Reality

Archaeology” explains that an accessible, highly visual, and interactive means of representing difficult-to-see data opens up new ways of presenting research. VR models allow us to put all of our contemporary knowledge and thought about an object into a user-interactive presentation.

The visualization process resulting from solid modeling can reveal relationships within an archaeological *reconstruction* more clearly than any other current methods of display (Fletcher and Spicer, 1992). Consequently, those models permit spatial queries such as what is next to, what surrounds, what is above, below, to the side of, and so forth (Harris and Lock, 1996). They also provide complete physical properties (mass, volume, centre of gravity, moments of inertia, radii of gyration etc.), as well as the ability to generate section views, add full visual physical properties, and detect interference between adjacent components (Daniels, 1997). By constructing detailed models of the excavated material, archaeologists can re-excavate the site and search for evidence which escaped attention during the actual dig (Reilly, 1990).

The VR process taught historians and archeologists that the images they produced add an important visual element to understanding the purpose and the use of the building being studied. Although VR technology has only just become practical, it is already being integrated into all aspects of archaeology, from research, to teaching, and into tourism (Gay, 1997). In fact, when archaeology is implemented in augmented reality it enhances collaboration and learning within the scenario provided. The more detail presented in the findings expands the VR presentation of our past. Renderings from ancient architectural structures provide a tie to our cultural history, and a greater

understanding of our ancestors. Although it is an expensive tool, everyday we see VR used more and more in museums, archeological sites, and schools in order to better understand Archaeology, from ancient textures to the engineering of its structures.

Architecture

One of the oldest and most apparent disciplines for VR application is architecture. 3D objects are inherent to 3D CG modeling, so there are many opportunities for VR application in architecture.

Winn (2002) describes simple applications where virtual worlds are created by students at George Mason University. Students manipulate atoms by hand in a collaborative way and create organic molecules. They reported that students were able to collaborate and learn how to deal with 3D information efficiently. This format also helps to develop early skills for working in 3D.

Petric, Ucelli and Conti (2003) applied VR in architectural design. They show how collaboration in learning and teaching in VR helps students as well as professionals in the early stages of architectural design. A key factor that helped to improve learning was the collaborative design experience. Students worked together using VR devices in creating and building virtual architectural buildings. They saw how students were able to collaborate and efficiently manipulate 3D objects. Kalisperis et al. (2002) mentioned the need for more VR applications in architecture, pointing out that learning architectural design can be accelerated by VR namely at the beginning of a professional career. Students are able to actively participate, and that is an important shift from passive observation of 3D buildings.

For example, Dvorák, Hamata, Skácilík and Beneš (2005) reviewed and evaluated the experience of twenty students who accessed their architectural design course through a VR dedicated architectural education lab. In comparison with the classic desktop-oriented way of teaching architecture, they concluded that the advantages of applying VR in architectural education are: students understand what VR is, and they are ready and able to use it in their future; VR assists students in thinking in 3D, namely in the first stages of education; VR helps to improve planning stages of design, errors can be detected much faster, the model can be parameterized by a simple property modification, such as color and texture, thus improving the quality of the final model. Teachers are also impacted by VR technology. They reported that VR provided a much easier format for exploring each project and detecting errors easily hidden through classic rendering. Through collaborative learning in VR, teachers can explain the problems and change the models together with students.

A comprehensive book by Bertol (2004) discusses various aspects of VR and its application to architecture: walkthroughs, simulations, reconstruction evaluation, networked environments, as well as the potential impact of digital architecture on the building environment of the future.

In conclusion, some of the benefits of applying VR in architectural design education include the development of 3D manipulation skills in early stages of education, the enhancement of collaborative skills among peers, allowing for project evaluation with their teacher's assistance, and the significant improvement providing teachers the ability to quickly detect errors and flaws in design.

Engineering

VR has undergone a change which makes the technology attractive to the many industries of engineering education. Even though some engineers are still reluctant to use it, they are realizing that VR is an important tool in their field. Most importantly, VR applications can formulate solutions to risky maneuvers prior to carrying them out in reality by providing opportunities for accurate scenario visualization and outcome.

The VRiChEL (Virtual Reality in Chemical Engineering Laboratory) was founded by the Department of Chemical Engineering at the University of Michigan “to explore and develop the use of virtual reality in chemical engineering”(Bell and Fogler, 1996). Here they use VR to assess the reactions that chemical products generate. The focus is educational, with the goal of providing real-life application.

In mechanical engineering the automotive design process uses VR applications for three main reasons:

First, time constraints, requires a reliance on electronic prototypes. Second, delivering products to meet rapidly changing customer needs requires fundamental design and engineering changes that can be accomplished only by restructuring the design process. Third, the automotive process requires frequent CAE models, rapid adaptability, and concurrency of all phases of design. (Stewart and Buttolo, 1999, p. 19).

Cave Automatic Virtual Environment (CAVE) is utilized in civil engineering to create the illusion of immersion by projecting stereo images on the walls and floor of a room-sized cube. It can be used in engineering education to review the construction of buildings and tunnels as well as in building failure explanations which also provides the ability to virtually fix construction issues (Messner, Yerrapathruni, Baratta & Whisker, 2003).

The impact and advantage VR, specifically interactive product simulation, has provided engineering illustrates an “emphasis is on interactivity: empowering engineers to go beyond visualizing last week's model to actually changing component designs on the fly and evaluating, in real time, the impact of those changes on the ability to assemble, use, and maintain the complete product or system” (Deitz, 1997, p.76).

Specifically,

virtual reality is lowering the cost and increasing the efficiency of an ever-expanding variety. By immersing themselves in computer-generated 3-D environments, technicians can safely practice maintenance procedures at one virtual plant while planners design the next one (Wicker, 2004, p. 59).

The value of VR is that it allows engineers to focus on solving problems without spending time gathering, modeling, and analyzing information. VR allows students the ability to manipulate and design 3D objects creating a virtual world free of risks. With the assistance of VR technology engineers are training to find and provide possible solutions to engineering issues in many areas, including pipes, bridges, buildings and even nuclear plants.

Medicine

VR applications in the field of Medicine are growing fast. VR can be used not only as a tool of teaching and learning for doctors and medical students, but also for patients in which skill-development is needed. Even more, VR may have some therapeutic uses, especially among patients with some nervous system dysfunctions like Parkinson's disease, hyperactivity and attention deficit disorder, as well as those with specific sequels of a brain disease. This section will analyze only VR for teaching doctors and medical students.

Teaching a medical student is becoming an impressive challenge, since modern society is every day less and less prone to tolerate medical errors, not to mention novice mistakes. Medical curricula designers have long been studying the ways in which medical students can develop good technical skills for use on patients, but without the actual participation of living patients and their corresponding risks (Kommers, Rödel, Luursema, Geelkerken & Kunst, 2003). One of the most rudimentary ways of developing surgical skills is by using corpses, but they differ substantially from living patients in many ways. Live animals can offer an alternative, but as the *animal rights* movement increases, the possibility for using animals as teaching tools diminishes. Mannequins are expensive, roughly imperfect and can usually be used only once. VR offers a good substitute for corpses, animals, and mannequins for teaching skills to medical students, and it is probably the best field of VR application in the medical curricula (Cooney, 2002).

Since surgeons have to be qualified, skilled, and properly trained to perform human interventions, there is a crucial need for surgical residents to go through a variety of critical and ordinary everyday-surgical eventualities in order to learn the correct approach for each. Surgical internship and residence are time-limited, so it is very important to use this time efficiently. For example, students in the role of doctor are presented with a medical situation. Through the use of VR they are able to work-up a prognosis without the stress and risks inherent to a real patient (Kommers, Rödel, Luursema, Geelkerken & Kunst, 2003).

First introduced to surgery in 1991 (Satava, 1993), acceptance of VR training has

been slow, partly because of skepticism within the medical community, but also due to lack of well-controlled clinical trials (Gallagher and Cates, 2004). However, Mangan (2000) affirms that medical colleges are now equipping their laboratories with VR devices where surgical residents can practice their skills in a safe, and long-term less expensive, environment. Moreover, she states: “before long, there will be a virtual-reality simulator in every surgical-training hospital, so that while they [surgeons] are waiting for the patient to go to sleep, they [surgeons] can be practicing the procedure” (p. A50).

Delingette and Ayache (2005) support the creation of a simulator for training physicians to perform minimally invasive surgical procedures. It provides highly realistic training and increases the diffusion of innovative and less-invasive procedures to surgical residents. Furthermore, Delingette and Ayache explain that “it is essential for effective training that surgeons act as if they were operating on an actual patient” (p. 35).

Surgery has a long history of employing tools to aid in operation planning and all may be regarded as an attempt to “simulate” the operation in a medium other than reality. The model for a VR surgical device is a realistic computational representation of the patient, the operating room, and the surgical instruments. Through the use of a glove, it allows the user to manipulate the “scalpel” three-dimensionally into the virtual tissue, making the user “feel” its resistance (Rosen et al., 1996). Good-quality simulators already exist for interventional procedures in flexible endoscopy, laparoscopy, arthroscopy, otolaryngology, robotics, and endovascular procedures (Satava and Jones, 1999).

Studies have been performed to prove the value of simulation in improving surgeons' performance. In the training center of the University of Massachusetts, surgical residents trained with VR simulators did laparoscopic surgery with fewer errors than peers without the computer training (Cooney, 2002). The researchers suspected that the residents who trained with the VR simulator would be more precise and make fewer errors, but they did not expect their speed and efficiency to improve as well. There are studies that found that residents who were trained with VR made six times fewer intra-operative errors and were 30% faster than the control group (Gallagher and Cates, 2004). Although the number of participants was small, the statistical power of the differences was large¹.

In conclusion, the use of VR devices for training and assessment in medical schools looks promising. Students learn hands-on how to proceed in difficult decision-making situations, as well as skills on how to face common and rare eventualities. VR will also be a helpful tool for providing comprehensive standards to ensure efficiency and proficiency expected in a quality surgeon.

Military

“The U.S. Army trains 80,000 new recruits annually, the vast majority of whom are recent high school graduates. These young men and women must be trained to operate complicated weapon systems, make quick, multi-faceted decisions, and participate in high pressure, complex missions where the consequences for mistakes can be severe” (Macedonia and Rosenbloom, 2001, p. 79). With the use of VR tools the Army and its other Military counterparts have an opportunity to place their recruits in

these complex mission and tactical training situations, each time adding new scenarios, and thus engaging them into a state of active and applied learning.

Take into consideration the following situation:

In a war-ravaged village, an Army lieutenant sets off on a spy mission. As he navigates a dank tunnel on his way to the enemy's hideout, rats scurry around his feet and bats flutter overhead. The bone-jarring rumble of a passing enemy vehicle shakes rocks loose from the bloodstained walls. Watchdogs soon spot him and bark furiously, causing his heart to race (Weintraub, 2002, p. 124).

This event is actually an excerpt from DarkCon, a virtual-reality video game, which was created at The Institute for Creative Technologies at the University of Southern California, with the funds from the U.S. Army “and working in partnership with Hollywood's top brass” (Robbins, 2002, p. 27). DarkCon and other virtual-reality games like

Mission Rehearsal Exercise, a simulation that takes place in a virtual-reality theater with an 8.5- by 32-foot screen with a 150- degree curve, [where] players are plunked into a computer- driven wartime storyline (complete with Dolby sound and rumble floor) that forces them to make decisions. Players navigate through hostile settings, such as a reconnaissance mission in a creepy culvert, (Robbins, 2002)

are providing military forces with new tools for training and mission preparation.

In fact, the military is now providing virtual-reality training to some of its National Guard and Army Reserve officers, like the C-141 Starlifter aircrews. In this case, the administration’s dilemma was how “the unit [was] going to pay for refresher parachute school [for this air reserve crew] and how were they are going to find time to fit that training into their [the reserves] busy schedules” (Klemack, 2001, paragraph 2). The answer came in April of 2001 with the introduction of “the Virtual Reality Parachute Flight Simulator” (Klemack, 2001, paragraph 3). "I'm impressed with this technology,"

said Brig. Gen. Paul R. Cooper, 445th AW commander, "it enables us to prepare for emergencies without having to send our people away to schools that would be too costly or to participate in training that would be too risky" (as quoted in Klemack, 2001, paragraph 14). "Developers of virtual reality training systems are trying to take advantage of the military's growing need for such systems as the [military] services learn to cope with limited budgets for hands-on training" (Armed Forces Newswire Service, 1998, paragraph 1). "So many government and military divisions began seeking virtual training tools that the Army opened up a studio in North Carolina to handle the influx of orders. Already the Secret Service has a classified system in the works that allows its agents to train in a virtual White House" (Gaudiosi, 2004, p. 46).

The military's use of simulation technology began in the late 1920's and 1930's when the Link Company built and delivered flight trainers.

These trainers looked like sawed-off coffins mounted on a pedestal, and were used to teach instrument flying. The darkness inside the trainer cockpit, the realistic readings on the instrument panel, and the motion of the trainer on the pedestal combined to produce a sensation similar to actually flying on instruments at night. The Link trainers were very effective tools for their intended purpose, teaching thousands of pilots the night flying skills they needed before and during World War II (Baumann, n.d., paragraph 2).

In conclusion, the introduction of VR to the Military field provides multiple new opportunities in the areas of training and education. New recruits, experienced officers, as well as reserve and National Guardsmen now have the necessary training tools available to them. Whether for basic training, advanced mission preparation, flying condition changes for pilots, new equipment introduction to parachuters, or any other situation in which a soldier may face while in the line of duty, VR can now prepare them

for it. These are just a few of VR's advantages in the Military, and as technology continues to advance, so will the military's utilization of it.

Discussion

Commonalities

There are many significant implications of VR in education. Obvious potential uses for this advanced technology exist in design, research, testing, and training, but, according to the previous survey, students who are currently working with VR are using the technology in the following ways: (1) simulating environments very different from those found in the ordinary classroom; (2) testing and exploring actions/reactions and observing the results under simulated real-life conditions in time and space; (3) training with manipulation and design of 3D objects; (4) improving the quality of the visual scenarios for understanding space (visualization).

We have defined through our research that the important distinguishing features of VR are that it is highly immersive, interactive, visually oriented, highly sensory, colorful, and generally exciting and fun.

Advantages

VR provides students the opportunity to become an integral part of their own learning process, allowing them to experience situations, instead of simply reading or hearing about them. Chen and Yu (2000, p. 261) further state that "given the same level of cognitive abilities, user(s) tend to perform better with simpler visual-spatial interfaces".

VR can be used to allow students to direct their own learning. They can

investigate different educational processes and techniques, and create learning environments that work for them (Traub, 1991). Students can use VR to simulate work and learning situations without risk. Porter (1993) explains that students using VR can see the consequences of their actions and learn from their mistakes; they can gain experience in areas which in reality might be potentially life threatening or intimidating.

VR is a good tool for presenting 3D objects and relationships, and for illustrating concepts that have been covered before by the students. VR is *not* a substitute for traditional educational methods. However when used properly, it can supplement traditional methods to the benefit of many students, thus adding a new dimension to the learning process. Compared to the traditional educational strategies of lecture, drilling, reading, and testing, VR offers entirely new formats for learning.

Dale maintains that we only remember “10% of what we read, and 20% of what we hear, but that we retain up to 90% of what we learn through active participation” (as cited in Bell & Fogler, 1998, p. 1). Thus the interaction and immersion of VR may improve long-term retention of material. The other influential benefit of educational VR involves reaching students with different learning styles (Felder & Silverman, 1988). Some students learn very well from oral lectures and written words. While others are more visually oriented, and do not fully understand the words they hear and read until they can visually see an illustration of the concepts. VR can help this latter group to better understand material covered in class and texts.

Disadvantages

As with every technology, VR has its dark side. Brooks (1988, p. 4) inquires, “VR

can simulate reality, but it can never duplicate it in detail. If you create more and more realism, but never actually achieve reality, are you teaching people things that are not so?" The lack of emotional immersion is a major gap in current simulations, as abstracts do not generally induce intense emotions. Brooks also suggests that the potential exists for creating erroneous environments which students might come to falsely accept as fact.

In addition, VR can also produce *motion sickness*.

The problems may include nausea, sweating, headache, gastric upset, vomiting and diarrhea. As with motion sickness in general, the majority of people have a similar amount of tolerance, while a few can tolerate any amount and another few cannot tolerate any (Viirre, n.d., paragraph 9).

In a questionnaire utilized to measure differences in immersive tendencies of individuals during a VR experience, it was found that those who report more simulator sickness symptoms report less *presence*² than those who report fewer symptoms (Witmer & Singer, 1998).

VR also has the potential to drastically alter our social interaction with one another. Rheingold (1991, p. 27) asks, "What will we think of each other, and ourselves, when we begin to live in computer-created worlds for large portions of our waking hours". Could virtual reality become yet another drug? Horton (1990) wonders whether children's social skills will suffer from increased computer learning. He also asks if our dependence on computers for information will cause us to lose trust and rely less on our fellow human beings. Social behavior is also part of the learning process, and allowing students to immerse themselves in virtual realities exclusive of contact with other people and real life could prove detrimental to their development.

Closing Thoughts

What will the future of VR technology look like? It may not develop as quickly as proposed; its needs are more specialized and it is quite expensive. However, based on the evolution of other technologies, in the not-so-far future VR will become cheaper and the devices used will become more versatile, technologically better, and in the same way more useful. It is possible that the participants will be fully immersed physically, intellectually, and emotionally.

In this paper we have highlighted the benefits that VR offers in diverse educational fields, and we have taken a glimpse into the disadvantages that it poses as well. As the result, we can claim that VR is a promising field for different educational disciplines. The common advantages open endless paths for exploration. A “virtual reality” that offers the opportunity to practice real-life situations without human risk implies promising benefits for many fields of study. VR has extensive potential, especially as an educational tool. It has been applied in many different areas in education and it is proven to increase the speed of learning, technical skills, knowledge perception, and more. VR appeals to the senses, vision, sound, and the others which are not stimulated in the current learning format. In order to immerse students into their education, many tasks can be transformed into a VR scenario. For example, students can experience a history lesson in 3D VR, where they interact with historical figures and stroll down the streets of times past. Therefore, although we have detailed the present utilization of VR, as well as suggested future uses, the real future of VR will be told by the books available in the year 2100.

Footnotes:

1. The means obtained were: VR-trained 1.7, standard-trained 7.4; $p < 0.001$.
2. Presence is defined as the subjective experience of being in one place or environment, even when one is physically situated in another.

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