Introduce Virtual Reality to College Technical Training Program —Intensified VR Training for Safety and Economic Efficiency

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Introduction

With the advancement of technologies in many fields, educational technologies are becoming more diversified nowadays. Especially with the development of immersive learning and education gamification [1], both the learner and educators are seeking innovative, effective, and cost-efficient ways for education today. As educational institutions that offer technical training in colleges, the availability of the educational technology in the classrooms would build competitive advantages of the programs provided and enhance the training outcomes for the students. After the integration of multi-media, computer-aided instruction, and internet-based training, virtual reality (VR) is emerging as another efficient training tool in education. Traditionally, training is often done in classrooms, laboratories, or workshops, which gives the students physical access to the learning materials, learning objects, and tactile experience of operation environment with direct communication with peripheral stimulus. However, VR provides the possibility of perceiving and interacting with the objects without their physical existence. Therefore, it eliminates the cost of purchasing and updating the fixed assets in the classrooms, reduces the safety risks to the minimal, and the most extent, maximizes the chance to study the small-scale, sophisticated space, dangerous, or highly valuable/sensitive objects. To the purpose evaluate and promote the application of VR in colleges, this paper will investigate the scope of virtual reality, its benefits, the need for education in college technical training programs, application areas in training, and the challenges in implementing VR in classrooms.

Scope and philosophy of VR

Virtual reality (VR) is a three-dimensional, computer-generated representation of physical worlds. The principles are the same for all the VR technologies to enable a user to be immersed in a simulated environment created by three-dimensional images to simulate an environment that is impossible or costly to replicate in real circumstances.

The hardware for VR primarily consists of input, processing unit, and output. The input hardware generates signals for movements and operations that the user reacts with the surrounding virtual reality. They can include the keyboard, mouse, controller, treadmills, and motion trackers. The tracker has various forms, such as head sensors, hand controller, data glove, and data suit that is embedded with directional sensors to record and collect the position data in real-time and transmit the wearer's movements to the computer in digital forms. Output devices include video display monitors, audio devices, and other devices that can have feedback to the users.

The processing unit is the core of the VR hardware system, which enables fast reaction and powerful processing ability. It is critical in generating real-time graphics in VR. The processing units can be a computer, console, or smartphone with substantial computation and graphics-processing capacity. The actual gestures of the head and body movement are captured by the input device to the computer to calculate the corresponding real-time synthesized graphics and audio effects.

The most characteristic output is the visual content that can be displayed through Head-Mounted Display, creating a distraction-free immersive visual and audio environment for the users. However, it is also common to have multiple large projecting screens in specially designed rooms to generate the immersive environment in entertainment and highly professional special training applications, such as flight training, sports training, and entertainment. In the case of using the mounted headset, the design of the holographic view of the surrounding with different angles and perspectives for the left and right eye respectively can create an immersing effect. VR would create a distraction-free environment that the user is observing the graphical surrounding with his own eyes as if the objects are presenting in the same physical dimensions as the user. Figure 1 shows a typical structure of a VR system.

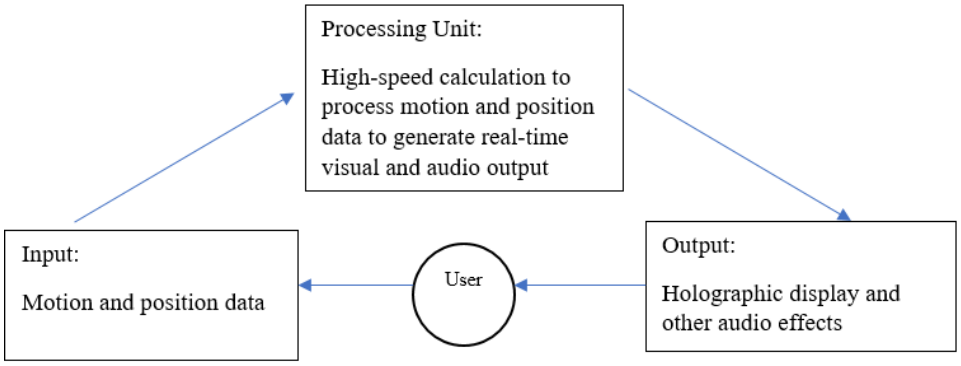

Figure 1: The typical structure of a VR system

Software development requires the 3D models, animations, the scenes with appropriate visual effects and lighting, and control of the objects using logic scripts to translate the design of the interaction into programming languages. The design of the learning process in the software contributes significantly to the effectiveness of the information and content delivery to the users.

The merit of using VR in training

VR has a significant advantage in technical training courses that require substantial practice and consequently high cost in maintaining lab equipment and materials. For the subjects that are focusing on hands-on skills and expertise, VR provides an immersive learning experience to the users that help the learners to explore the learning content and interact with the virtual surrounding and minimize the internal distractions of wandering thoughts or exterior distractions from the physical surrounding. The integration of VR training may improve knowledge retention, boost students' motivation, and reduce neophobia [2]. A meta-analysis study of the effectiveness of VR based learning examined 69 studies and concluded that the use of games and virtual worlds is effective in improving learning outcome gains [3]. Because VR is so immersive and compelling, learners absorb information faster and retain what they have learned longer [4]. Memory formation is linked to emotional responses, and VR can help to generate an emotionally charged experience.

1) More standardized learning modules

Most of the courses offered in the colleges are taught based on textbooks. Despite the difference in knowledge organization, the structure of the topics, there are some essential core contents in each discipline. These core contents can be created as standardized modules and using VR technologies would strongly enhance the program quality without being affected by the variance of the textbooks adopted. Therefore, standardization of the core modules in courses is of significant value for VR training.

2) Increased engagement of the students

The immersive training environment provided by VR boosts engagement, which is critical to training outcomes. Under the traditional education model, the students usually passively receive the information and are disengaged [5]. However, VR is not a complete solution to inattention and distraction, which are the common problems encountered in traditional classroom teaching, the implementation of VR is an applicable way of enforcing active participation and involvement of the learners. VR requires the user to give feedback to the system to drive the learning process, and the engagement of the user in VR training is maximized. Furthermore, students can perceive the relevance of material learning with applications in theoretical scenarios or real-world situations.

3) Customized training progress

While the college classes are tending to become bigger with the increasing registration of the students, focusing on the students' needs and tailoring the courses to smaller groups is always one of the efforts that the instructors are making to maximize the learning outcomes. VR is a feasible solution to personalized learning. The students can use the system to control the learning process, such as spending more time on the topics where they can study at their own pace, practice as much as needed, and reflect more to get the most of the training.

4) Cost reduction

VR training may reduce costs on upgrading facilities and eliminate costs associated with travel. Most of the technology-related subjects, such as electronics, mechanics, hydraulic systems, labs are essential for demonstrating the system functions and providing practical experience of the technology fundamentals. However, the training machines and pieces of equipment that are for education purposes take large capital to purchase, maintain, and upgrade the hardware and software. The use of VR training allows learners to get access to the equipment and devices without being physically present in the laboratory or the facility. Therefore, purchasing and the associated cost of maintaining the equipment can be dramatically reduced. The cost can also be

saved for the learners in terms of travel time and expenses. Some stage scenarios that are too costly or difficult to replicate can be simulated in VR settings. Less traveling allows more time for learners to absorb and practice training materials.

5) Optimal safety solution to a training environment that have dangerous or risky elements

VR training has the incomparable advantage of safety in the training process. In some training environment that involves heavy machinery, hazardous substances, natural disaster, vulnerable groups, or life-death critical situations, the learners can avoid the potential negative consequences that caused by insufficient experience or false operations. The learners can repetitively practice, make trials and errors, and learn from mistakes until proficient enough to make decisions and perform in real situations.

6) A platform for experimental solutions

VR supports creative and high-risk solutions to problems. The virtual interaction nature of VR allows the learners to have less pressure to pursue creative, high-risk solutions to problems, without causing any negative consequence in the real world. For example, in VR training in medical assisting procedures, the system can comment on the performance of the learners and help them to achieve similar training goals that unavoidably place tension on the learners when they are trying to make more innovative and effective solutions. The test runs by VR training give the learners more chances to respond to the issues with innovative perspectives.

The need for technical training programs

Technology training based courses, such as CAD-drawing, medical assisting, food and beverage management, are highly practical and leading the students to a specialized career that requires the labor force to be well-trained and experienced in handling certain circumstances at work.

Knowledge and theories can be learned through textbooks and other media. However, hands-on practice is essential to help the learners comprehend and digest the knowledge to make applications, develop proficient operation skills in real scenarios. The maturity of VR technology enables the possibility of using VR to implement training in several possible fields of study. The most promising areas in technical training programs are:

1) Healthcare-related training

VR has already been adopted widely in medical and surgical training in medical schools. Colleges that are offering healthcare-related certificates and courses would greatly benefit from

introducing VR in cadaver labs, simulating operation rooms, and bringing avatar patients and physicians into nursing programs. The opportunity cost for medical errors in surgery and operations would be much reduced for patients and healthcare practitioners involved. VR provides a fast venue for perfecting skills or reviewing the medical operations procedures. Furthermore, VR training can be designed to involve a medical group to practice interaction among each other through the models in the programs. By using VR, the students will get familiar with healthcare settings, routines, procedures, and medical terms with a highly focused virtual environment. Some online healthcare degree programs are using VR systems. A program which is called Second Life [6] c deliver online nursing disaster drills for training purposes, creating virtual patient labs, or virtual hospitals to interact with avatar patients with various symptoms and vital signs.

2) Training for standard procedures

In the learning contents that involve memorizing standard operation procedures, following specific processes, internalizing repetitive practice of execution and methods, VR provides an effective solution for drill of learners.

Because VR supports the interaction with the virtual objects and environment in the display, it is very efficient to use VR to simulate the procedures and get the user to familiarize themselves with the equipment, device, and walk through the standard operations. Most importantly, with minimal physical investment and the intervention of the instructor, the students can get instant feedback to make corrections and reinforce the practice of the correct operation. For example, the safety procedure in chemistry labs and assembly procedures are all good areas of application in training for standard procedures. Repetitive practice during the class or after class assignment as a supplement to traditional instruction would allow the students to internalize the learning material as their knowledge and experience.

3) Objects involving vulnerable or sensitive groups

For service-based training courses, such as operations or interactions involving patients, young students, children, or the elderly, it is of vital importance to have interactions that would not harm the objects due to errors in practice or inexperience. For example, in some teacher training, or nursing courses, VR can be used to replicate the scenarios that the user can safely interact with the patients or vulnerable groups without possible negative consequences that would happen otherwise in the real world.

4) For the training that involves interactions with the environment in multi-locations or sites are that not convenient to get access or require long-distance traveling

In VR training, the environment can be switched among different sceneries created in the system. Therefore, it is an important fact that VR eliminates the traveling and movement that are necessary for the training programs that are otherwise needed to be present in the physical facilities. In an example of a hospitality management course, VR can be introduced to create multiple scenarios in a hotel, and the students can have an overview of the knowledge and tasks that are associated with each location, such as front desk, guest rooms, conference rooms, dining area, etc. without going into a real hotel section in operation. Therefore, a significant amount of time and cost in organizing and traveling can be saved. Moreover, most professional training places that are restrictive and even not accessible for beginners, such as interior design for vehicles, metal cutting or welding shops, where safety is a prominent issue preventing the learners from getting close access to the operation sites. However, with VR, the teachers and students can implement training when a need arises regardless of the travel arrangement to be made to make the lesson happen.

A Case study of VR training implementation

In order to assess the effect of VR in training, a topic of simulation of the influence of alcohol consumption on driving was conducted under the VR environment at the Department of Industrial Management and Technology, Texas A&M University-Kingsville (TAMUK) campus. The purpose of the study was to investigate how VR would help users to understand the effect of alcohol consumption on driving performance, educating people about the effects of alcohol-impaired driving through the use of virtual reality technology as an interactive educational tool.

Traditionally, it is not realistic to observe the actual driving performance for the subjects who consume alcohol. Thus the education about the effect of alcohol-impaired driving can be only through paper media of textual or graphic information. VR simulation can provide real-time, near the first-hand experience of driving under the influence and internalize the training materials. Statistical data of environmental hazards and interactive responses from the National Highway Traffic Safety Administration (NHTSA) was used in the design and development of the virtual simulation. The virtual environment sceneries include a city environment with traffic and road signs, as well as different accidents and risks that drivers might be exposed to, such as pedestrians, distractions from the roads. Other created scenarios include a bar, streets, traffic lights, urban

buildings, and a parking lot. The equipment used in this study is the headset, Oculus Rift VR controllers, and a computer.

The design of the study

In this study, 30 students were recruited to use the VR training program to learn about the effects of alcohol-impaired driving and get their virtual driving performance recorded. Participants were allowed to review the different impairment levels based on their decisions and provided feedback on their observations and get an assessment of their knowledge level of driving under alcohol influence. All participants for the study were recruited from the students of the Department of Industrial Technology and Management based on a screening process that includes demographic features, driving experience, and alcohol consumption history. The virtual simulation for this study is designed to simulate six different BAC levels with different intoxication and interactive ability. As shown in Table 1, the NHTSA results on the effects of different blood alcohol concentrations will be used to set up the simulation.

Blood Alcohol Concentration (BAC) in grams/deciliter	Predictable Effects on Driving
0.00	None
0.02	Decline in visual function of rapid tracking of a moving target and ability to perform two tasks at the same time
0.05	Reduced coordination, difficulty steering, reduced response to emergency driving situations
0.08	short-term memory loss, reduced information processing capability (e.g., signal detection, visual search), impaired perception
0.10	Reduced ability to maintain lane position and brake appropriately
0.15	Substantial impairment in vehicle control, attention to driving task, and in necessary visual and auditory information processing

Table 1 NHTSA Effects of BAC on Driving Performance

The simulation scenario starts with a virtual environment of the drinking bar, and the user can choose the amount of alcoholic beverage they virtually consume. Upon virtual consumption of the content, the participant is expected to go out of the bar and drive to a specific location in the virtual city. The user can operate the vehicle and make options in the virtual environment using Oculus Rift VR controllers and use a head-mounted display to perceive the surrounding city environment and adjust the visual effects while virtually driving in the vehicle. Each subject was asked to complete the driving task under three choices of Blood Alcohol Concentration (BAC) conditions and respond to the posttest questionnaires regarding their training experience. Five minutes of break periods between each task was administered to reduce the risk of any form of anxiety or nausea. Then posttest questionnaires were completed to gather feedback on the training experience. The study did not offer any financial or non-financial compensation for the participants, neither any academic grade reward issued for participating, to eliminate any bias response from the participants.

The findings of the study

The study shows that it was statistically significant that 67% higher scores with 95% confidence interval were obtained for overall training satisfaction scores after participating in the interactive virtual reality simulation [7]. Additionally, there was a statistical increase in knowledge of impaired driving experience corresponding with the effects as predicted by NHTSA. The mean score of correct answers from the participants of the NHTSA Effects of BAC on Driving Performance after VR training was 4.67 while the mean score was 4.07 without VR training. With 1.70 t critical one-tail value, the t-statistics value of 5.29 at a 95% confidence level, it is statistically safe to conclude that VR training significantly improved the training outcomes of getting the users to understand and retain the information. This serves as strong evidence of the positive outcome brought by VR in an experiential way of learning.

Challenges in implementing VR training in educational modules

VR training technology is relatively new, while there are lots of potentials in the application; yet challenges exist for its spreading in educational purposes. The first challenge among these is technical problems that might occur. Technical failures include hardware and software issues, and they bring frustrations and confusion into the learning process. VR requires high-speed computer processing and a stable internet connection, as well as a precise motion tracking system.

Furthermore, software issues are also common obstacles in VR usage. Additionally, it is reported that VR may lead to sickness and discomfort of some people, such as eye strain, eye fatigue, and disorientation [8], especially in using the head-mounted display. Last but not least, while VR provides an immersive and engaging educational experience, the interactions and communication, especially between the students and the instructors should not be eliminated. Nevertheless, VR training provides immersive and engaging hands-on learning experience. VR training is a highly engaging and low-risk, low-cost technology solution in a great variety of training processes that enable the participants to have the interaction with the equipment and surrounding environment. Implementation of VR will explore the possibility of combining the traditional lab training and virtual reality training, thus find a safe and economic venue to build successful technology training programs in college curricula. Therefore, the VR training can be adopted as a supplemental solution of the entire education and not substitute for the entire traditional teaching and learning modules.

Conclusion

The advancement of VR technology opens a new opportunity to deliver educational materials in university technical programs. The programs offer fundamental subjects, such as physics, math, biology, as well as highly practical topics that hands-on training is mandatory for the students to master the skills, such as mechanics laboratory sessions, health-related practice courses. VR training may provide more standardized learning modules, increase engagement of the students while giving the students an option to keep their personalized study learning pace. VR also can reduce the cost of purchasing and maintaining equipment, and the time and expense of traveling to the physical sites that are often dangerous or difficult to accommodate the students to have real first-hand experiences. Because of these merits of VR training, it can be applied in the four areas, which are 1) healthcare-related training, 2) standard procedures, 3) vulnerable or sensitive groups involved training, 4) environment that is not convenient to get access to. The case study included was an example of implementing VR training and assessing the training effect of college students learning the effects of driving under the influence of alcohol. It was confirmed that VR training substantially improved the training outcomes for the participating students.

Although challenges of technical issues and discomfort of using VR were reported, it still presents itself as a good supplement in college education, especially in laboratory teachings, as a source of cost-reduction, and safety-enhancing teaching tool to engage the students.

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