Experimental study on consumer-technology supported authentic immersion in virtual environments for education and vocational training

Torsten Reiners
Curtain Business School
Curtain University

Lincoln C. Wood
Business Information Systems
Auckland University of Technology

Sue Gregory
School of Education
University of New England

Despite significant and rapid technology improvements, educators have frequently failed to make use of the new opportunities to create more authentic learning scenarios. Virtual worlds offer an attractive proposition to create 3D representations of real business environments to provide an authentic learning activity for higher education students to take part in. However, the controls and displays are still clunky and unnatural, reducing the opportunity for students to immerse themselves in the event and focus on experiential learning. To overcome this challenge we examine the role of using a headset display that allows the user to change perspective with a flick of the head, improving their ability to 'feel' part of the environment, and thus increase their immersion in the activities that they are engaged in through more realistic control and improved perspective in the virtual environment. A series of experiments are conducted comparing the technology to established technologies and the level of control exerted by the learner (e.g., they either 'control' or they 'passively observe' as someone else controls). These experiments provide evidence that consumer-technology can improve immersion and equip educators with an affordable instrument to present classes that learners 'take more seriously'.

Keywords: virtual worlds, Second Life, Gartner's Hype Cycle

Introduction

The use of virtual worlds within education and entertainment has been rising during the last decade. While many elements have been considered and studied carefully, one component always restricted the true immersive authenticity: the traditional flat monitor. Recently, different consumer-technology has been introduced to increase the immersion into the 3D space and provide an authentic experience. In the past, researchers and developers created technology for 3D visualisation while using 2D devices (e.g., monitors and projectors), enhanced interaction with the 3D space (e.g., Kinect, Razer Hydra), direct transfer of full body movements (e.g. treadmill), or even complete Caves (specialised room) (Boas, 2013).

This paper explores the readiness and the need to push towards higher levels of immersion in the classroom using low-cost equipment priced for a consumer market. Currently, virtual worlds can achieve a moderate level of authenticity while being integrated in the classroom; educators and instructional designers are yet to explore and understand the untapped potential applications and the contribution that they can make in emerging pedagogical models. We consider an increase in authenticity and perception of higher immersion crucial; i.e., to connect the learner with the business/real world and demonstrate the implementation of theories. This is especially important as training positions and internships are often severely restricted due to cost reduction programs. Nevertheless, the continuous and rapid additions of new technology are not a panacea as it often counteracts learning and results in overtraining students while losing the focus on the core learning objectives. Thus, more use of virtual environments for training and education will require integration of the technology with educational systems and suitable immersion to provide a sense of realism and connection with what is being learned. The more immersed a user becomes within a Virtual Reality (VR) system, the more realistic that reality is perceived to be and user responses will adapt accordingly. This may lead to improvements in highly immersive environments; e.g., health and safety training. While it is commonly accepted that high levels of immersion can be achieved with significant investment in specialised equipment, we explore these relationships with the Oculus Rift head-mounted display (HMD); this is a low-cost device targeting the consumer market. If low-cost equipment and similar HMDs can significantly improve the immersion in educational activities, this may prove to be extremely beneficial to educators as they will be able to be easily deployed in a number of educational institutions.

The following section depicts virtual worlds, discusses the idea of authentic immersion, and introduces the Oculus Rift; an affordable head mounted display capable of pushing the immersion to the next level. In Section 3, we discuss the six-scenario experimental design created to achieve an understanding if and when the technology and the classroom is ready for integration and which design elements should be used for one of the first scenario. Section 4 discusses the results; while we sketch our current development in Section 5. Section 6 concludes the paper.

Background

Immersion and authenticity: Immersion is the "suspension of disbelief possibly being given by any media" (Dalgarno et al., submitted), p.6; and "the subjective impression that one is participating in a comprehensive, realistic experience" (Dede, 2009, p. 66); "the greater the participant's suspension of disbelief that she or he is 'inside' a […] setting" (Dede, 2009), p.66; the more immersed they are; e.g., captivating movies, books, or games that so completely enthrall viewers, readers, and players that they ignore basic needs for hours. Immersion can be classified from a system perspective (non-immersive, semi-immersive, full immersive (Kalawsky, 1996)), experience level (SCI-model with sensory, challenge-based, and imaginative; (Ermi & Mäyrä, 2005)), or degree of user immersion (engagement, engrossment, total immersion). We further can distinguish the perceptual immersion as the degree of submerging user in the virtual environment (Biocca & Delaney, 1995) and psychological immersion as the how much the user feels being involved, absorbed, or engrossed by stimuli from the environment (Palmer, 1995). However, all classifications agree that immersion can be increased by different means; either technology, perception of the user, or experience. Authentic, or 'true to life', tasks and activities can further heighten the users' experience.

Authentic learning is a pedagogical model based on learning occurring within environments replicating practices and actions being found in real-world situations, forcing learners to engage with similarly authentic materials and responses before receiving valuable feedback. Authentic learning focuses on putting the learning into context. Gamification adds game-based elements into non-game activities to incentivise and change user behaviours (Reiners et al., 2012). Authentic learning through gamification enables the learner to make mistakes in context without the real life consequences (Brookes & Moseley, 2012). While authentic learning is generally based in the real-world and often uses work placement, internship, or practical training, many educators in the tertiary sector have eschewed truly authentic learning as this can be costly, dangerous for students, and administratively difficult to arrange (Reiners & Wood, 2013). Learning does not need to occur within the real environment for it to be authentic learning; *where* the learning occurs is not crucial, but it is instead that the learning must reflect how the knowledge would be used in that real environment (Herrington, Reeves, & Oliver, 2010) .The scenario must enable learners to engage in parallel thinking processes and problem solving activities as they would have had to in the real environment, to deliver a suitable outcome. Thus, it becomes clear that using technology does not, in itself, create authentic learning; instead, sensible incorporation of appropriate technologies into carefully designed scenarios means that authentic learning takes place with technology (Herrington et al., 2010). True and accurate 3D representations and 'natural' controls can also heighten learner engagement with the activity while increasing the authenticity of the learning experience, delivering significantly more value.

Virtual worlds: Virtual worlds are 3D spaces in which user recreate real-world-based or imagination-based scenarios and engage in various activities; e.g., entertainment, socialising, education, and simulation. The user sees the world through the eyes of an avatar; using a dynamically rendered 2D image based on the current position and the information about the objects and other avatars in proximity (Warburton, 2009). The advantage of virtual worlds over other 3D environments, and even virtual reality systems, is not the (often questionable) realism of virtual worlds (e.g., basic graphics and weak physics engine), but rather that they connect people in the most immersive way by facilitating communication with a 'real' representation in a 'real' 3D space. And they allow users to transcend beyond the physical real-world limitations (Twining, 2009) to experience new perspectives including the flight of a bird, becoming an astronaut, or exploring a fuel cell from the inside-out (Boerger & Tietgens, 2013). Virtual experiences in support of real-world situations have been used in several areas including teacher education (Gregory et al., 2011), engineering (Bresciani et al., 2010), logistics and manufacturing (Wriedt, Reiners, & Ebeling, 2008), and has value in other areas, such as the simulation of hazardous situations for training purposes (Reiners & Wood, 2013). Virtual worlds play an increasingly prominent role in education where they can take the distance out of distance education, increase engagement with online learning students, and blend the new environment with the traditional learning approaches from the classroom environment (Reiners & Wood, 2013). Role-plays in a virtual world can be undertaken by students who are not physically present on campus (distant students), receiving a context-based visual realism and the appearance of the roles to engage more deeply with the activity and identify more closely with their allocated role (Gregory & Masters, 2012; Jamaludin, Chee, & Ho, 2009). Virtual environments facilitate novel forms of assessment based on these activities (Wood, Teräs, & Reiners, 2013) and may be further supplemented with gamification principles (Wood & Reiners, 2012). Arsenault (Arsenault, n.d.) emphasised that the achievement of the deepest level of immersion is only possible if all barriers are eliminated and the user can identify themself with the system and expected activities. From this statement, we have to consider *v*irtual worlds like Second Life as non-immersive as interaction in the 3D space is driven by keyboard and mouse, output is on a monitor, physical model ignores basic features like mass, and gestures are repeated too often to feel truly natural and authentic.

Immersive technology: Lavric (Lavric, 2013) frames virtual reality as “the effect of an untrue world in the real world” without the physical form. We require technology to be able to experience the virtuality with our limited, biological sensors. We use computer monitors daily as windows to peek into another world where we examine everything from data in spread sheets describing global financial markets to fantasy worlds like World of Warcraft.

The limitations of haptic feedback (e.g., vibrations and shocks) and input (e.g., keyboard or mouse for motion) are challenged by wearable technology. These emerging technologies are capable of transferring the observed motions of the user into the virtual environment and allow a perceived solidification of virtual objects. Technology can detach the user from reality, matching the virtual movement with the input device; e.g., eschewing the use of keyboard and mouse and rather recognising the corresponding hand movements. The output of virtual worlds is crucial and our sensory system is anticipating feedback. Pressure vests can simulate the sensation of touch over the body (or impact by objects), force feedback gloves allow hands to mould the form of objects even in mid-air, and 3D earphones provide spatial sound. Yet two different sensors are ignored; i.e., our remarkable vision is fed with a rectangular 2D window into the 3D space. Expensive head mounted displays or Caves exist and provide enough stimuli to receive a true understanding of the space. Yet, most systems are, as mentioned, too expensive for the consumer market or have other disadvantages like delay of mapping the image with the tracking of the head, incomplete coverage of the viewing area, and wrong distortion from the 2D image to the requirements for the eyes. If the Oculus Rift HMD can significantly enhance the immersion that users feel in the virtual environment, it may surpass the use of caves and other extremely expensive equipment and enable educators to more readily enhance their practices with more engaging and immersive tasks. Note that the preliminary nature of this study focuses on core factors related to the technology platforms only. Yet, we acknowledge that further studies – incorporating all factors to describe immersion– must be completed.

Methodology

The research objective in this experiment is centred on the Oculus Rift with respect to the acceptance by different stakeholders and whether they would like to see it integrated in their classroom in case of availability of equipment and learning material. In this study, we explicitly ignored other factors than related to immersive technology in order to make the experiment more achievable. The sample size is 13, consisting of six male and seven female participants (20-24 (3), 25-29 (2), 30-34 (3), 35-39 (1), 40-44 (2), 50-54 (1)). There was a wide cross section of all working adult age categories to demonstrate the advance in technology is not just accepted with the so called y-generation but is instead independent of age. The sample included four academic staff, two general staff at university, two PhD students, four students, two non-university members from different fields with varying background and interest in emerging technologies or 3D spaces.

The experiment is designed to elaborate the device and provide exhaustive evidence to justify a replacement of current, yet more expensive, technology. On the consumer market, the Oculus Rift caused an immense shift as the innovation outranked state-of-the-art-technology for a percentage of their cost. Nevertheless, applicability for educational purposes varies from games, thus preliminary experiments are necessary to evaluate the potential of the technology. The outcome of this experiment influence ongoing research and development of educational scenarios.
Greater perceptual immersion within the virtual world includes more than simply ‘seeing’; the more senses that are included the more complex and expensive the setup becomes. Enclosed virtual environments like Caves present users with 3D spaces and respond to the movement of the user to project a 3D image around them. Thus,

this “room-sized, walk-in virtual reality […] display is to a typical computer screen what a supercomputer is to a laptop computer” (DeFanti et al., 2009); they are expensive to install, require specialised equipment, occupy considerable space, and are clearly unsuited for home users.

A similar setup is a HMD using LCD screens to cover the complete range of viewpoints. Low-latency sensors detect even small head movements so the visual display can be updated accordingly. Kinect uses a depth scanner to analyse the space in front of the device to identify movements, while the Razor Hydra tracks the movements by being held in the hands.

The Oculus Rift HMD started as a Kickstarter project to “revolutionize the way people experience interactive content.” (Oculus, 2013) by building a head-mounted display intended for the consumer market (i.e., affordable for a home-user), while being far more advanced compared to comparable and more expensive systems. The advantage is that the images are directly matched with the head tracking; eliminating the delays that generally most systems have and by this causing motion sickness. Furthermore, the visible area is fully covered, not leaving blind spots. That is, the Oculus Rift allows the user to be truly immersed in the 3D space. The possibility to cover the whole sphere around you without interruption and sudden distraction like having a person standing in the view or finding a modern TV screen on the historic market.

Disadvantages: Compared to professional flight simulators, movements are not matched with the corresponding movement of the body, hence the movement of the avatar to any direction besides moving the head causes a conflict between the visual perception of the scene and the equilibrium sense; representing a potential source for motion sickness comparable to reading on a car ride or being on a vessel but not looking outside. Furthermore, the Oculus Rift device is currently under development; thus, the resolution 640x800 pixels per eye, which is lower than in the final, consumer-focused version.

The participants were asked to partake in seven short experiments, each with a varying form of immersion; i.e., being in control or on the passenger seat, and having 3D on a traditional monitor or using the Oculus Rift. After each scenario, short interviews were conducted using a schedule as a general guide to ensure consistency over the interviews and to reach the main objectives of the research as well as the objectives for each scenario. This structuring ensures that the interviews remained focused on the exploration of phenomena of interest. The schedule was used to initiate questions and discussions, allowing the participants to express their own concepts, interpretations, and perceptions about immersion. Open-ended questions and Likert-type scales with five levels were used to rate the scenario (in terms of *realistic, useable, interesting, engaging, and compelling)* with seven levels of agreement from strongly disagree to strongly agree. Observations were made about participants’ gestures and comments during the scenarios. The six scenarios and their primary objectives used in these experiments are described in the following overview:

1. [SL]: Second Life (http://secondlife.com) was used with a general keyboard on a standard, 2D monitor. The participants were asked to move towards a forklift, sit on the driver seat, and drive around a warehouse. The exercise included a short introduction to controlling movements prior to the experiment.
2. [ORHouse]: An Oculus Rift scenario (the ‘House’, self-controlled by the participant, see http://sixense.com/sixensetuscanydemo with integration of Razor Hydra). This example is comparable to the Second Life experience, but perceived using the VR-device (real 3D visualisation). Note that the early development stage of the Oculus Rift means there is a limited number of available scenarios; therefore, we had to find an alternative to match the Second Life experience. Focusing on the experience of 3D itself, the shift from warehouse to a resident house is not relevant here.
3. [ORCoaster]: The Oculus Roller Coaster scenario (movement is controlled by computer and the participant has the option to look in all directions including downwards; https://s3.amazonaws.com/RiftCoaster/UDKInstall-RiftCoaster.exe). This scenario was chosen to demonstrate a larger virtual 3D space, test whether the participants react to the virtual roller coaster track by moving their bodies in response to the perceived motion, and the entertainment and fun factor. We asked the participants to express their impression of the atmosphere (visual and audio), realism, and their well-being.
4. [CAR]: Car driving simulation on a normal monitor (self-driving); http://www.decane.net/game/oculus-rift/riftracer. The simulation is located in a small virtual city, where the participant was asked to drive for a short distance to experience the visual presentation on the monitor. We used this experience as a reference point for scenario 5.
5. [ORCarSelf]: An Oculus Rift Driving Simulator (self-driving by the participant). This example mirrors the Scenario 2, but was perceived using Oculus Rift (real 3D visualisation).
6. [ORCarDriven]: An Oculus Rift Driving Simulator (driven by the experimenter). This example mirrors Scenario 3, but is perceived using the VR-device (3D visualisation). It is designed to verify the impact of not

being in control.

During the experiment, only the participant and organiser were in the room to minimise the disturbance as voices from outside of the virtual space would decrease the effect of immersion. The participants are asked to restrict the time spent in each scenario but are not rushed through the experiment so they have adequate time to adapt and explore the space. The average planned time for each scenario in the experiment was six minutes including the interviews; a total of approximately 40 minutes per participant.

We conducted the interview questions, questionnaire, and notes about their gestures and comments while the participants were in the VR scenarios or at the completion of each experiment. The questionnaire segment relating to Second Life was administered following the segment of Second Life-based scenarios and similarly the questionnaire segment relating to Oculus Rift was administered following the segment of Oculus Rift-based scenarios. A small sample size has been used and it is important to note that data from the questionnaire are not intended to be used for inferential statistics but only to provide an approximate quantitative guide to the experiences, which is supplemented by the interviews; thus, the small sample size is reasonable given the early stages of this research stream. While the indicative nature of the results is still given, it is not sufficient to identify the influence of specific factors like past experience with emerging technology, gaming, or virtual worlds. The participants represent a wide spectrum of influential factors (e.g. gaming, virtual worlds, affinity for technology) to generate suggestions for the ongoing research in this area.

Discussions of results

The results represent a preliminary study to evaluate the potential of an emerging VR technology. The participants elected to partake in the experiments; therefore, we anticipated a higher affinity for new technology than we would have by a random selection from the cohort. On a five-point Likert-type scale (from 1=no to 5=extensive), the participants were asked about their gaming (M=2.85, SD=1.46) and virtual world (M=2.23, SD=1.23) experience (correlation is 0.39). All participants had heard of head-mounted devices and only two were not aware of other VR-devices; e.g., haptic VR gloves. A seven-point Likert-type scale questionnaire was used (from 1= strongly disagree; 4=neutral; 7=strongly agree) and each participant was asked how strongly they agreed with the statement: “The [Second Life or Oculus Rift] scenario was highly” realistic, useable, interesting, engaging, and compelling. In each case, there was a significant difference with participants favouring Oculus Rift rendered scenarios. In all cases there was also greater convergence (most participants rating it as Agree or Strongly Agree each time), reflected in the lower standard deviations (see Table 1). One participant insisted on reducing his high ranking of Second Life by two-points after the experience with the Oculus Rift scenarios, mentioning that not knowing the technical options caused an overestimation favourable to Second Life. Paired t-tests were conducted to compare whether there was a difference between whether the cohort believed that Second Life and Oculus Rift scenarios were different in terms of realistic, usable, interesting, engaging, and compelling. There was a statistically significant difference in all cases indicating the cohort strongly believed the Oculus Rift scenarios were better; these scenarios were perceived to be more realistic, usable, interesting, and compelling than scenarios presented in Second Life. There was greater convergence (i.e., a lower standard deviation) for the Oculus Rift scenarios (Table 1).

Table 1: Second Life (SL) compared to Oculus Rift (OR) use in scenarios

	SL	OR	t(12)	p
Realistic	M=5.3, SD=1.25	M=6.8, SD=0.44	5.0257	0.00015
Usable	M=4.08, SD=1.75	M=6.8, SD=0.38	5.3176	0.0000
Interesting	M=5.3, SD=1.25	M=6.8, SD=0.38	4.3818	0.00045
Engaging	M=4.7, SD=1.32	M=6.8, SD=0.38	5.5268	0.0000
Compelling	M=4.7, SD=1.25	M=6.7, SD=0.48	5.3258	0.0000

The Second Life scenario [SL] started from the first person perspective in the warehouse; participants were asked to move and look around and to use the forklift. In accordance to their experience with either virtual worlds or 3D games, we observed the expected aptitude in handling the mouse and keyboard for navigation. Nine out of 13 (69%) demonstrated accuracy in navigation (i.e., not running into objects and arriving at the expected destination); the others overreacted demonstrating poor control of the avatar. There was no significant correlation between gaming experience and the participants' capability to move around in Second Life.

For scenario [ORHome] and [ORCoaster], the participant put on the Oculus Rift HMD. While we had not invested time to make nuanced adjustments of the device for a perfect fit (e.g., adjusting straps, distance to the eyes, and distance between eyes), most found the device comfortable and lightweight. We asked them to keep their eyes closed until the scene was completely loaded. All participants showed clear indication of surprise, excitement, and fascination. This was demonstrated with their verbal expressions, including: "oh my god", "this is crazy", "impressed, this is real good", "Wow, this is new, never had an experience like this". There were many comments like "WOW", "freaky and lots of laughing. (Note, that the intonation of these words indicated extreme excitement, which cannot be captured in text). The best comparison of Second Life and Oculus Rift was "it is like expecting 3rd person view, but being 1st person experience; far more real than any monitor ever can be." Besides two participants with background in 3D games, everyone started with very small and careful head movements. Feedback indicated that it required a moment to overcome the overwhelming sensation and confusion. There was also a tendency to maintain the familiar perspective of looking straightforward onto a monitor while working with monitor, reducing the field of experience to merely the part that would be visible on a monitor. Noticeably, one experienced gamer intensively used the head movement as long as he did not include the mouse for changing the direction of view as it is done in games. As indicated by the quantitative data in Table 2, all participants felt detached from the real world and *believed* themselves to be at a different location; the sensation was "mind blowing" and better than their expectations after hearing and reading about it. Some participants pointed out that they can feel immersed even just using monitors, but often drop out as soon as they turn their head; react to noises, or notice movements and lights in their field of view. This 'drop out effect' is not apparent with the Oculus Rift. The immersion was further increased through standing and not touching objects or using the keyboard; both would conflict with the visual experience and cause detachment from the virtual space.

The experience of walking through the house [ORHouse] was intense for all participants as this was the first scenario. While the design was not intending to stress the user, some found it irritating to walk down stairs without feeling the movement on their body. It was pointed out by five participants (38%) that small visual features increased the realism; e.g., fire crackling in the fireplace, sun glare, and butterflies and leaves flying in the air. The most interesting observation in this introductory scenario was how the participants used their hands and how they moved around. While most did not involve the arms and hands, four participants (30.7%) *tried* to reach out for objects and to check their presence by tapping their physical body (note that the virtual body is not visible in the scenarios). It was also obvious that all participants assumed objects in the scenario to be solid and navigated around them carefully and generally did not bump into them.

The roller coaster scenario [ORCoaster] elicited the most intense emotions and feedback (Figure 4). One participant stopped this scenario partway through as they felt uncomfortable; thus, the number of participants was reduced to 12. The participants were asked to remain standing, as we wanted to amplify the anticipated movements that might occur as a response from the visualisation of the track. However, one participant was excluded at the start when we paused the ride for them to sit down: "I cannot stand [upright], that would make me pass out." We stayed nearby to catch the participant in case they became physically over-balanced. The roller coaster started immediately; yet we did not place the headphone on the participant heads in the beginning, but waited at least 10 seconds for a comment like "realism would be better with sound." In all cases, we placed the headset on the ears of the participants after a while and pretended that we forgot about it. The roller coaster itself takes place in a fantasy castle, has high altitudes, and a jump at the end. With all but one participant we could infer where on the track they were at any time simply by observing their matched physical movements. One participant felt so present that it almost caused them to lose their balance (at an unexpected curve just as the ride appeared to be over). Further observations include (note that the frequency may be low as some participants did not report accurately): Sweating (4, 33.3%), strong tension (2, 16.6%), heavy breathing (1, 8.3%), heart beat going up (4, 33.3%), strong movements (7,58.3%), trying to hold to something in the real world (7, 58.3%), closed their eyes (2, 16.6%).

All participants agreed that the roller coaster was extremely real ("very real, almost perfect", "I really want to be there, where is it"); this is despite the fantasy setting and the low-level of graphics on the early model that is still under development, far below most users' computer monitor displays). The roller coaster "really surprised how the brain and balance sense are fooled although the picture was not 100% real [and I am not really riding on one]."

The driving simulation placed the participants in a familiar scenario, where they had control over a motor vehicle and took it for a drive [ORCarSelf]; this differed from the roller coaster scenario where they sat passively and could only change their visual perspective. All participants (12, as one skipped this part of the experiment as they felt mildly dizzy following the roller coaster) considered the simulation "very real", despite the low-level graphics display. Two had to stop the driving experiment early as they almost immediately felt some motion sickness; see below. The remaining nine participants enjoyed the simulation, especially as they felt safe to experiment with speeds and crashes. The immersion was high despite there being no steering wheel and only keyboard keys to control the vehicle. We noticed no difference between self-driving [ORCarSelf] and being driven [ORCarDriven]; mainly, this resulted from the fact that they did not look around the environment but instead in the direction of driving. One participant moved the arm to the side while driving backwards, this physical movement was unnecessary but replicated real-world behaviour. Despite the positive experience by all participants, we recorded some suggestions for improvements as well as negative comments about hardware, dizziness, and usage. The current version of the Oculus Rift is a developer kit and the final consumer version will incorporate many improvements including improved image resolution, reduced weight, and an improved design. The resolution was of no concern in the beginning (9 participants (70%) mentioned the low resolution but did not mind as "the experience is just too intensive to care at all") but later noticed whenever the movement was slow as they could examine specific details around them. Therefore, the roller coaster was perceived as higher quality than the house due to the relative difference in speed of movements. Another disadvantage of the low resolution is the tiring effect on the eyes. None of the participants could imagine using the Oculus Rift for several hours without a break.

The cables connecting the HMD to the computers proved the most significant limitations to freedom of movement. While we attempt to arrange the cable so it would not interfere with participants' movement, the radius as well as distance was very restrictive. Four participants (31%) became entangled in the cable while doing full turn. Dizziness and a sensation of 'still moving' after removing the Oculus Rift or feeling queasy in the stomach occurred in 77% of the cases, with only one participant with strong 3D gaming experience reporting absolutely no subsequent sensations. All participants had anticipated these feelings and agreed that this would not influence their affinity to continue or to use the device in the future; 62% explicitly mentioned they would become accustomed to the new experience. Two participants related the sensation to the speed of movement, while three were unable to partake in all experiments but the car driving. Afterwards, one participant mentioned that despite their love of high-adrenaline activities the participant has only ever felt motion sickness in cars; this phenomenon also occurred in the virtual space with the sensations of motion sickness only occurring with the driving simulation. The effect is partially affected by the display as their reaction time is low and can cause blurry effects on moving while there is exclusion of sensory information from physiological balance sensors; like the reverse effect of getting seasick on vessels.

The participants can see a strong potential for applications using the Oculus Rift (or future HMDs of similar quality) in education, training, entertainment, and tourism (order indicates the relevance stated by participants). It would be valuable for "places you could not go otherwise", which could be real locations like South Pole or the moon, or impossible places like the human body or within a computer processor. In addition, the same scenario on a monitor cannot have the immersive effect; the restricted 2D window into the virtual environment causes too many conflicts with the perception. Nine participants (70%) investigated scenarios with more care and seriousness; despite the knowledge that it is a game-like environment and they were not in eminent danger. 77% believe that using the Oculus Rift for an induction to an industry site (e.g., demonstrating possible incidents that can occur on this site that may lead to injury) would create greater awareness and thus more care while being in the real environment. Two participants pointed out the advantage for "hazard perception tests" to create an improved understanding rather than using an abstract context; having the Oculus Rift would result in "motivation to identify all risks to look out for later at the location." The majority of participants mentioned that it would add value to the classroom.

While the Oculus Rift covers vision (output) and head movement (input) to immerse the user and cause a detachment from the real world, the participants noticed a crucial problem with the current setup: it does not entirely eliminate external distraction. Some distraction was as simple as not having direct communication but the lack of 3D sound within the virtual space. This could be rectified using virtual mobile devices or speakers integrated with the environment but placed physically around the user. Further space to move and the entanglement with cables can be overcome by hanging the cables from above the user as is done in most VR Caves, or by using mobile computers attached to the user as done with several augmented reality prototypes; even though walking is limited as the real space is usually exceeded by the virtual space. Some participants *realised* their ghostly appearance (i.e., it is not possible to perceive their virtual body), which can be overcome in conjunction with other technologies like Kinect or VR gloves. Nevertheless, the advantage of the Oculus Rift is its simplicity and fit with the consumer market; adding more technology and increasing the software complexity may be counterproductive and lead to replication of existing approaches; e.g., Caves. The open source community is currently exploring the HMD technology and is continuously extending the authenticity and immersive experience. Thus, razor mouse integration allows replacing mouse and keyboard with virtual hands that can interact or play instruments, attached IR (infra-red) cameras create night goggles, and Kinect is used to map objects and users in the virtual space. Participants knowledgeable with Second Life emphasised the emptiness of this virtual space; neither other avatars nor bots enrich the virtual space and therefore causing a quick boredom in exploring further on. Even the best roller coaster becomes dull after riding it too often and without interaction with other users.

Finally, two female participants noted the risk they felt of the possibility of being engaged in the VR world while being unaware of the activities and behaviours of bystanders in the physical space. Using VR devices requires a protected space and trust in the people nearby; especially as any sudden interference can cause intense reactions. The participants prefer to have a signal in the virtual space that someone from the real world wants to communicate.

Scenario for vocational training

As part of the project nDiVE (www.ndive-project.com) we are developing an authentic skill-learning and -training environment to prepare, develop, and evaluate learners' skill acquisition and readiness for their professional career. Major objectives are to improve student engagement and motivation by establishing authentic scenarios and creating distinct skills training lessons and also confronting them with life-threating situations that can occur in their future professional life. Early studies in Second Life demonstrated the advantage of 3D to understand complex systems; however, we were not able to create extreme situations in this preliminary research. The experiments conducted for this publication demonstrated the effectiveness of the Oculus Rift to immerse and affect the real-world human being (heartbeat or sweat). The currently developed container terminal (using Unity) combines the educational component of the processes with the included challenge to identify risk areas that can harm human life and cause major accidents. For example, it requires experience to understand the mass of containers or the force that can be created by straddle carriers; something educational institutions cannot provide effectively through theory, studying simulations, or by conducting site visits (later it can explain the process, but accidents or incorrect processes are not easily demonstrated. The suggested training environment implements different risk areas like road crossing, distraction of attention by noise, lifting not secured containers, and erroneous positioning of containers. Using the Oculus Rift, the learner would be fully immersed in the scenario; including the particular sounds. The 3D component would demonstrate the size of containers and the equipment to be used for transport. To be allowed on a terminal, it is important to learn about safety and dangerous situations/locations during induction. If a container bridge lifts a container, the area below must be secured as a broken container door can cause objects to fall out. Compared to Second Life, the true immersion using the Oculus allows users to better comprehend the sizes of objects, making the situation of objects falling onto them more terrifying. The situation is intensified by having the loud sound of the door blasting open, therefore forcing the immersed learner to look in this direction (automatism). Based on their current position, the result is either just a scare or virtual death. The other risk areas would be similar; e.g., not paying attention at a road crossing could cause an accident with a passing straddle carrier. Note that the environment is developed and will be part of the final submission.

Conclusions

Our own experience and the analysis of the interviews indicate that the inclusion of virtual worlds using traditional 2D technology is accepted among the users, increases the authenticity of the learning environment, and provides *kind of* an immersive experience. Second Life is considered useful for observing objects, avatars, and achieving an understanding of the context; with a focus on shared presence, communication, and socialising. On the other hand, realism and the feeling of really being present at virtual locations are limited; distractions from real surroundings followed by a mere turn of the head are enough to disconnect from the illusion, crashing one back into reality.

Development of virtual presence technology has raced ahead over the last couple of years, moving from high-end prototypes and research environments towards consumer products that may finally allow instructional designers and educators to consider adoption of this approach in classroom environments. Safe, secure, sensible site visits can become virtually real while experienced in a classroom; distance education becomes virtually close; disabilities disappear and dreams transition into virtual reality. Our research provides strong indication that users find the immersion of the HMD to be greater, taking their surroundings more seriously (i.e., less likely to bump into objects and approaching dangerous situations with greater care); this has implications for health and safety training as users will take the training seriously and what they learn will be more likely to be internalised. It is also valuable to workplace inductions, where the high level of congruence between the virtual space and physical space allows greater transfer of learning while the induction may occur in a safe environment.

Why is this important when a cave provides a similar experience? We believe that it is important, as this is a consumer-focused setup that will be easy to use/install/operate and affordable to setup. The investment and supporting infrastructural requirements are orders of magnitude lower than for a cage, yet the level of immersion experienced by our experimental participants was very high. Our participants experienced significant immersion at very little cost in equipment or expertise. Future research may compare the Oculus Rift HMD to a cave setup for a more rigorous examination; such an experiment fell outside of our scope in this project. Technology like the Oculus Rift feeds our belief that we are getting a step closer to creating a truly immersive learning space that is both low-cost and widely accessible but which will engage and enthral students enough that they can immerse themselves in the illusion of being elsewhere. Educators can use this mindset as they move towards increasingly authentic learning environments and scenarios (in virtual worlds); supported by technologies such as the Oculus Rift.

Much work still needs to be undertaken to enable us to approach an experience as fluid as that on the ‘holodeck’ from Star Trek; where verbal commands, true 3D imagery, the ability to sense objects, and a (seemingly) unlimited range of motion allows all manner of immersive simulations to occur. Much work must still be undertaken to improve user interfaces. As this is undertaken, we will undoubtedly discover further applications in entertainment and education for immersive virtual reality. Is the Oculus Rift HMD the solution to the problems of the inability to maintain the illusion of the virtual reality environment, which reduce the effectiveness of training and how seriously people take the training scenarios in these environments? Our research indicates that it is not the perfect solution, but the experience it affords significantly exceeds those offered by other proposed solutions and does so at a price point that makes it affordable for all institutions, educators, and trainers.

Do we need this kind of immersion? Yes and no. When we meet for some chatting and/or talking, the use of avatars is better than just voice; i.e., as gestures can be used. If we want to feel in the space, there is no way around but to use new devices like Oculus Rift. Compared to any other form of improving the immersive feeling, the Oculus Rift is a large leap forward that will be difficult to backtrack from, once experienced, and it is affordable and easily used so that it may be adopted on a wide scale. Yet, it is important to emphasise that vision is only one, even though strong, aspect in creating immersion; and the use of head-mounted technology needs to be accompanied with, among others, (authentic) task design, sound pedagogy, and informative feedback. The Oculus Rift may be capable to blend us with virtual spaces, but in the end it is only a monitor to be used as one tool of many to tell a story.

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Contact author: Torsten Reiners, t.reiners@curtin.edu.au; Lincoln Wood, Lincoln.Wood@aut.ac.nz; Sue Gregory, sue.gregory@une.edu.au

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