The Immersive Learning Laboratory: employing virtual reality technology in teaching

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SELECT SESSION

C2: Interdisciplinary and cross-disciplinary engineering programs and learning environments

CONTEXT

Virtual reality (VR) technology has revolutionized educational opportunities by allowing people to experience and interact with diverse environments. Many environments in which professional engineers and scientists work are restricted from students due to safety and logistical constraints. Moreover, immersive technology can complement textbook based learning with visualization and immersion as an engaging medium. To transform the learning experience at The University of Sydney an innovative Immersive Learning Laboratory (ImmLL) was established under this project. The laboratory will enable academics to teach using immersive content based on interactive 360° videos of real environments or constructed virtual realities.

PURPOSE

The ImmLL is a new learning environment which pilots innovative teaching methods using VR to optimise the student learning experience and educational outcomes.

APPROACH

The project was split into four stages. In stage I, several of the current VR platforms were evaluated and tested in order to select the most suitable for teaching purposes. The laboratory space was also designed to maximize the learning and teaching experience. In stage II, a series of workshops were conducted to assist in training academics to develop their own learning material to use in the space. Stage III and IV are currently running with teaching sessions and an evaluation of learning experiences at the laboratory as of Semester 2 2017.

RESULTS

Technology testing was conducted with the two main brands of VR equipment; HTC Vive and Oculus Rift. Based on several criteria including user experience, quantity of content and the preference for seated experience, the Oculus Rift was selected as the preferred VR headset. The laboratory was fitted out for 26 Oculus Rift and high-performance computer units. Twenty academics from four different faculties were given training on the technology and content creation for 360° videos and virtual reality teaching. During Semester 2, the teaching and learning experiences will be evaluated. It is expected that positive and engaging learning outcomes will be found with some minor challenges around employing the new technology and user experience (motion sickness).

CONCLUSIONS

To our knowledge the ImmLL is the first laboratory of this scale for VR teaching in Australia. It is breaking new ground with an emerging technology and initial findings show promise in its ability to provide the highly engaging and motivating learning environment of the future.

Introduction

Virtual environments in 3D and simulations have been widely used in training and education to deliver abstract concepts and encourage active learning. Immersive VR enables students to visualize, experience and interact with diverse environments otherwise not accessible due to safety and logistical reasons. VR technology assists in bringing real-life working environments to classrooms, to transform the learning experiences of the future engineer and scientific workforce. Freina and Ott (2015) listed immersion, interaction and user involvement of VR technology as the three principal characteristics that have high potential to engage and motivate students. Dede (2009) also outline the potential of VR to motivate and engage students through situated learning, multiple perspectives and transfer to real-world settings.

VR technology can primarily be categorized as non-immersive and immersive. While non-immersive VR provides a virtual environment by projection on a screen or a desktop, immersive VR typically utilizes a head mounted display (HMD) and emphasizes presence – the perception of “being there” (Soukup, 2000). The use of immersive VR has been limited due to the associated high cost of hardware and technical and usability issues (Freina & Ott, 2015). However, the latest advances in immersive VR technology has made it more affordable, opening new opportunities in both research and education.

Non-immersive VR was the first step in virtual technology education and it was demonstrated to be an effective teaching method (Warburton, 2009), with the ability to improve learning outcomes (Ijaz, Bogdanovych, & Trescak, 2016). Recently, affordable VR setups such as the Oculus Rift (Oculus VR, 2017b) and HTC Vive (HTC, 2017) have overcome the challenges faced by earlier systems. There has been a noticeable growth in educational applications exploring VR, augmented reality (AR) and mixed reality systems. For example, an immersive 360-degree video for surgical education was recorded from a camera mounted on a helmet (Ros, Trives, & Lonjon, 2017). This immersive experience has allowed medical trainees to experience first-hand operating room procedure through the eyes of the lead surgeon and it was assessed as a valuable pedagogical exercise. Izard et al. (2017) demonstrated another application teaching anatomy using interactive internal virtual body exploration. The discipline of science has lead the exploration in VR teaching and engineering is starting to make advances in this space.

Construction safety education is an important part of the civil engineering curriculum. Peña and Ragan (2017) point to a lack of methods to effectively contextualize safety information in an engaging way. These authors developed an interactive VR system using real incident reports to teach construction safety. Preliminarily results suggest better student engagement with the learning environment. Immersive technologies such as AR and VR are effective tools to develop 3D visualization experiences to facilitate multidisciplinary design education (Camba, Soler, & Contero, 2017).

VR environments, 360-degree videos and AR have the potential to assist educators to teach using innovative teaching methods (Astbury, 2016). In addition, the author accentuated the vital need to train educators who can further provide immersive educational experiences and in order to successfully integrate this technology as a standard medium. Immersive technologies can not only engage regular classroom students but also has the potential for distance learning (Potkonjak et al., 2016) and are inclusive learning environments for differently abled students (Pavlik, 2017).

Purpose

The purpose of this work is to report on a pilot initiative taken by the University of Sydney to employ immersive VR technology in undergraduate and postgraduate learning. This paper discusses the approach followed to introduce immersive VR for learning, the various stages of planning and the deployment of innovative technology, the training of academics and teaching cases currently taught in the laboratory.

Approach

The pilot project was divided into four stages based on the proposed objectives and the requirement of a 12 month project timeline.

Stage I: Initial setup

In stage I, extensive testing of VR technology was performed to decide on the technology best suited for teaching and configuration of a teaching space. The aim was to select technologies that supported a range of VR experiences including 360-degree videos and constructed virtual reality environments. Based on this initial technology decision, we further evaluated both HMDs for several aspects including cost, procurement logistics, scale in terms of deployable units, technical complexity, space requirements, content availability, future VR development as well as after sales support. To support content creation, 360 cameras, including drone mountings, were also investigated.

Stage II: Training Academics and Tutors

The aim of stage II was to empower academics to develop and/or select their own educational VR content in the form of immersive 360 videos or virtual environments. Through introductory workshops, academics and tutors were given an orientation of ImmLL. The lesson plan for the sessions included training to use the VR hardware, basic configuration settings and an overview of available VR content. After experiencing both 360-degree videos and VR applications an engineering teaching case was discussed.

Developing 360 Videos

In a second workshop, the aim was to train academics in the overall workflow from recording to playing 360-degree videos. Detailed guidelines were prepared with step by step instructions on how to record, edit and play 360-degree videos using Adobe Premiere or as an independent application using the game development software Unity.

Constructed Virtual Reality Environments

The third workshop was to assist those academics who wished to build custom VR environments. This workshop focused on software tools, platforms and workflows to develop VR environments. A guideline was prepared to demonstrate how to visualize 3D models and data. Additionally, instructions were given about how to use existing VR applications to produce educational content following a simple workflow.

Stages III and IV: Teaching and Evaluation

Stage III of the project was the delivery of teaching commencing in August, 2017 (semester 2). An online booking system was created to facilitate the scheduling of tutorials from units of study where the academic had completed the workshop training. Student numbers and experiences were recorded during the semester.

Evaluation is the final stage of the project and consists of a voluntary online survey for student participants and academic teaching staff. Ethical clearance was sort through University Human Ethics Committee. This evaluation is set to be complete by the end of semester 2.

RESULTS

Stage I: Initial set-up

Two available HMDs that fitted the primary criteria were Oculus Rift with its touch controllers and HTC Vive. In stage I, Oculus Rift with touch controllers was selected after a detailed VR testing to choose the best hardware to support the learning. We found that there was a variety of content available for both platforms and both could support diverse immersive content. During testing of both technology setups, the Oculus Rift had fewer tracking issues and had a relatively lower risk of trip hazards for multiple users in a confined space. The Oculus Rift also provides a better seated experience and needs less seated space per user (approximately 1 m^2). Considering that we intended to design a space for tutorial sessions (max 20 - 24 students), the Oculus Rift was found to be the most suitable technology. This technology evaluation lead to the purchase of 26 sets of Oculus Rift HMDs, touch controllers and high-end VR PCs (Intel i7, Asus Z270 motherboard, 16 GB of RAM, 500 GB M.2 NVMe SSD, Nvidia GTX 1080 graphic card). Moreover, two 360-fly 4K cameras (360 Fly, 2017) and a 3DR drone with Kodak PIXPRO SP 360 cameras (Kodak, 2017) were purchased to produce 360-degree videos. Table 1 lists the pros and cons of the respective VR setups for use in an educational space.

Table 1: Technology selection by criteria (pro '+' con '-')

Criteria	Oculus Rift	HTC VIVE
Cost	+ AUD $900	- AUD $1400
Procurement	- Ships from USA	+ Local purchase
Number of units	+ Individual trackers mean better scalability	- Multiple units compatible with one sensor set - Sensor screening and interference
Technical set-up	+ Less cables - Tracking issues - Sitting experience	+ Tracking accuracy - Cables as a trip hazard - Standing experience
Space	< 3 m^2 (sitting ~1 m^2)	~ 4 m^2
Content platforms	+ Oculus Rift store apps + 360 videos free	+ Apps and content available + More interactive content
Future Proofing	+ A tech start-up, now Facebook owned	+ Backed by HTC
Support	- Limited	+ Support via regional offices

Immersive Learning Laboratory Space

The decision to adopt the Oculus Rift guided the design of the laboratory's physical space to support the target tutorial size for learning sessions. To facilitate both immersive teaching and content development the lab space was divided into two work zones. Two VR desks at the front were allocated for content development to enable content creation activities in parallel to teaching sessions scheduled in the lab, as depicted in Figure 1. Three height adjustable desks in the first bay were also installed for disability access.

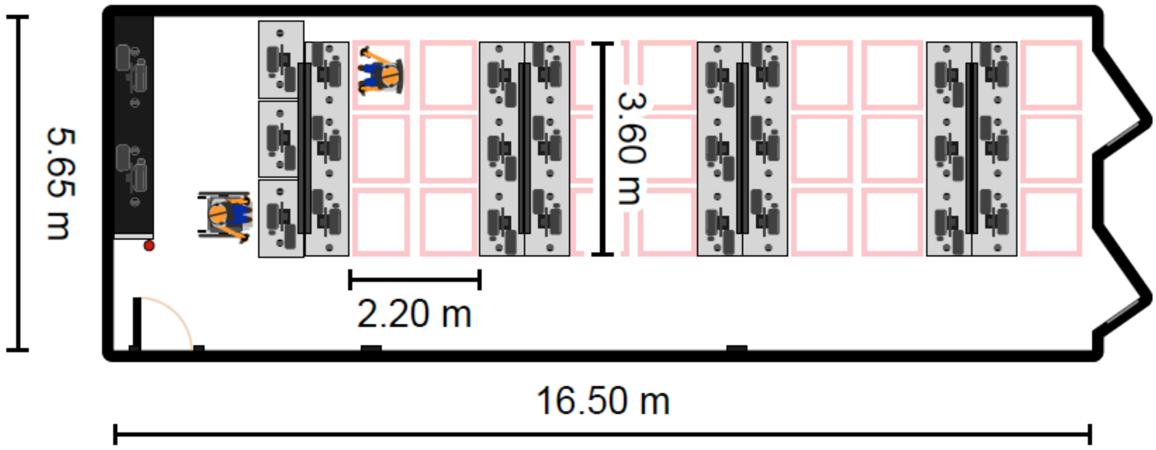

Figure 1: Floor Plan – development and teaching space. Top view with pink boxes indicating the sensor area for each computer.

Stage II: Training Academics and Tutors

In total 20 academics and 19 tutors from four faculties were trained to conduct teaching in the introductory workshops. Academics used the Oculus First Contact tutorial (Oculus VR, 2017a), Google Tilt Brush (Google, 2017b) and Google EarthVR (Google, 2017a) to familiarise themselves with the technology and its capability. Common problems experienced with academic attendance at the training was their limited time to participate in the workshops. During the workshops three out of 20 academics reported motion sickness and two out of 20 reported that the HMD was uncomfortable while wearing glasses. These reports will be compared to those reported during student use in Stage III. Academics indicated concern about the time required to produce content from design to teaching execution and the resources required. In the initial workshop, some academics showed interest to bring immersive field trips to their classes. This was one way to give experiences of real-life situations of work sites or places not easily accessible to students.

<u>360 and virtual reality content creation workshops</u>

Only seven academics attended the content creation workshops. This was a clear indicator of the concern of academics over the amount of resources required for content creation. It was not aimed for academics with these diverse backgrounds to develop unit specific material within the workshop, but rather the academics were guided to understand the amount of effort and cost involved to develop custom environments. We discussed the possibility of using existing VR educational applications and provided technical contacts to prepare their immersive teaching material.

The development support provided by this workshop was instrumental in reducing the time and cost of producing the quality immersive content. Academics were also given a hands-on experience with using 360-fly 4K (360 Fly, 2017) and a 3DR SOLO drone with Kodak PIXPRO SP 360 (Kodak, 2017) cameras. Also, attendees learnt to edit and publish a sample video for use in VR. The ImmLL technical team offered support to academics for development where requested to execute timely teaching sessions.

Stage III and IV: Teaching and Evaluation

Stage III has commenced with teaching sessions being held in the ImmLL. In semester two 2017, 11 academics from four faculties (engineering, science, architecture and arts) and six schools booked teaching sessions, as shown in Table 2. There were 19 trained tutors who assisted academics during these sessions. In total, nearly 600 students enrolled in seven subjects are expected to learn course specific tasks using the lab in 2017. A running teaching session is depicted in Figure 2.

Figure 2: A teaching session in the laboratory

Based on the experiences with academic workshops, minor motion sickness and problems with the wearing of glasses were anticipated. However, with two thirds of the teaching complete only one student reported feeling uncomfortable with a fear of heights. To date there have been no students reporting motion sickness, which is likely due to a younger generation having more experience with this type of technology. To improve the user experiences, we ensured that an ImmLL team member was available to support the first session for each subject.

During teaching, it was observed that the sensor area (marked by the pink box in figure 2), spontaneously reset. This caused the user to view content from an awkward angle, sometimes rotated 180 degrees. The exact technical cause of these spontaneous sensor area resets is not known. The solution for a teaching environment was to move the student to another unit and reset the computer, with subsequent recalibration of the sensor areas.

Table 2: Current teaching in the laboratory (not including final year thesis)

Discipline	Subjects	Students(N)	Content
Engineering & IT	CIVL2010 Environmental Engineering	240	360 videos and 3D models
	CIVL3310 Humanitarian Engineering	35	
	ENGG5103 Safety Systems and Risk	50	
	CIVL3206 Steel Structures	50	
Science	BIOL1997 From Molecules to Ecosystems	35	360 videos, 3D models and 3D VR applications
	PHSI3911 Physiology	18	
Art and Social Sciences	ARIN6904 Mobile Media and Games	180	VR/AR applications
Total	7	608	

Teaching Case I: Humanitarian Engineering

Humanitarian Engineering is offered as a third-year elective which introduces the role of engineers in development, disaster relief, remote communities as well as global sustainability. Students frequently did not have any experience firsthand of development or disaster contexts and it was a challenge to reach the desired learning outcomes through lecturers and reading material alone. Tutorials in the ImmLL were designed to increase students understanding through 360-degree videos of urban informal settlements and rural villages. JAUNT VR (Jaunt, 2017) is one application that has a wide selection of 360 degree videos, an example of which is 'Women on the move' based in Niger, West Africa. The students viewed the content and were then allocated a frame (time point) in the video to make detailed observations around a particular engineering focus (water, energy, transport or building construction) and report back to the class. Student informal feedback was that they felt that they are actually present in the 360 video and it really opened their eyes to how things really were. Engagement in class was high and students were excited to be using the new technology.

Teaching Case II: From Molecules to Ecosystems

This unit examines the function of biological organisms and their interactions with local ecosystems down to the molecular level. First year science students delve into the microscopic universe of beyond cells, to the structure and function of various biomolecules including DNA and proteins at the atomic level and gain understanding of how their interactions are crucial for homeostasis. Structural modelling of these molecules was particularly important not only in gaining an appreciation for how intermolecular forces are at play in the folding of proteins, but also to recognise key motifs in protein structures and how these contribute to the reactivity and function of protein enzymes. To improve student understanding of protein function by structural modelling of proteins using Blender and interacting with these structures in 3D space using Unity3D in the ImmLL. These tutorials additionally introduced the students to the need for digital literacy in the field of biology in the 21st century through basic exposure to 3D modelling software and game development principles. This exercise aimed not only to facilitate the retention of theoretical knowledge delivered during lectures but also to expose students to 3D modelling, game development and basic scripting.

Teaching Case III: Steel Structures

Third year undergraduate students enrolled in steel structures (civil engineering) course used immersive VR environment to investigate portal frame structure. The aim was to allow students to understand well the sense of scale by navigating around the structure as they can in person. This was more realistic experience than simply looking at the structure on a 2D screen. This sense of scale includes a realistic span to height ratio of the structure, bay spacing, section depths of all the main frame members, including beams, columns, and cross-bracing, etc., and relative sizes of all the members (relative to each other). Another main goal was to have students better understand connection design. They could see how physically the connections are formed and how everything fits together, and in a realistic scale, and again sizes relative to each other (bolts and stiffeners to main frame members). Virtual environment was built in Unity using Sketchup models where students could navigate and observe various details of the frame structure.

Conclusion

ImmLL has proved to be a successful pilot project for The University of Sydney. Academic and student verbal feedback received has clearly demonstrated that immersive VR education is perceived as an engaging teaching tool across multiple disciplines in a higher educational environment. Initial reports are positive from the 11 academics conducting teaching sessions in ImmLL who have delivered immersive learning experiences approximately 600 students enrolled in seven subjects across three different faculties, however the detailed evaluation in stage IV will give more insight. Future plans for ImmLL are to continue in its current configuration for 2018 with additional academics teaching with the technology. The University of Sydney already has plans to include VR technology in new purpose-built facilities at a larger scale.

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