Designing Virtual Reality Environments for Paramedic Education: MESH360

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Abstract: This paper outlines the first two stages of a design-based research project that aims to develop more authentic critical care educational simulation experiences and learner-centred pedagogies in paramedicine education. The first two stages involve the exploration of mobile virtual reality (VR) to enhance the learning environment, and the design of prototype solutions for designing immersive scenarios and 360-degree video enhanced critical care simulations. Thus far we have identified a set of design principles that will guide the implementation of the project. These design principles will be modified in light of the subsequent project evaluation stages.

Keywords: Virtual Reality, Simulation, Paramedicine education, Heutagogy

Introduction

The aim of the Multiple Environment Simulation Hub (mesh) project is to explore the use of virtual reality (VR) to enhance paramedicine education through the development of more authentic simulation scenarios and exercises. Thus we have named the project Mesh360. As an essentially mobile profession of first responders to emergencies on location, Paramedicine can benefit from mobile technologies that enable communication, link to remote medical knowledge databases, record on the scene experiences, simulate hazardous environments, and use mobile piloted drones for quickly exploring inaccessible crash and disaster scenes. The use of VR for medical and critical care training has been established for over a decade (Hsu et al., 2013) as a means to simulate hazardous environments and provide students with problem based learning scenarios. VR in medical education ranges from dedicated simulation programs through to virtual environments in second life (Conradi et al., 2009). A comparative study by Cone et al., (Cone, Serra, & Kurland, 2011) indicated the efficacy of VR as a platform for paramedic student education. The main challenges of VR in medical education are the development costs, and user familiarity with the VR-based applications (Conradi et al., 2009; Hsu et al., 2013). A focus upon student-generated mobile VR and social media can address these issues. Medical education is already engaging with mobile social media through such avenues as the #foamed (https://twitter.com/hashtag/FOAMed?src=hash) Twitter hashtag (free open access medical education), and the annual SMACC (Social Media and Critical Care) Conference (http://www.smacc.net.au/about-us/welcome/) first held in 2013 now attracting over 2000 attendees.

To ensure that the project is founded in pedagogical goals rather than technology focused we have established a community of practice of Paramedicine lecturers and academic advisors to base the project within an educational design research methodology. This begins with the observations of student threshold concepts that limit the effectiveness of critical care simulations, and is followed by ideation and prototyping of technology-enhanced solutions. The following stages of the project will explore mobile VR as a simple approach for paramedicine students to create, share and critique real world experiences linked to the geographical context that simulated environments tend to decontextualise. Clearly one of the main challenges of such an approach to student-generated VR content revolves around the ethical issues of patient anonymity and confidentiality, however critical care often occurs in very visible public contexts, and learning to deal with this aspect of critical care is essential. Later stages of the project will explore these issues.

Literature review

The context of the project is a three-year degree in Paramedicine or critical care education in a New Zealand University. The course focuses upon preparation of students for participation within the critical care profession, and thus ontological pedagogies that connect knowing, doing, and being as students reconceptualise their role from learner to active participant within a professional community in a rapidly changing world.

> A genuine higher education cannot content itself with a project either of knowledge or of skills, or even of both. It has to do with *being*, for it is being that is fundamentally challenged in and by a world of supercomplexity. Neither knowledge nor skills can furnish the wherewithal to form persons adequate to such a situation: on the one hand, knowledge will not just be out of date, but will always be insufficient to describe the novel and unstable situations that present themselves; on the other hand, skills are always addressed to known situations, and cannot be addressed to unforeseen (and unforeseeable) situations. So (human) being itself has to come into view, for the fundamental problem now becomes: how is one to live amid supercomplexity? (Barnett, 2009)

Globally emergency services are being transformed by the ubiquity of mobile social media (Lyon, 2013; Szczerba, 2014; UNESCO, 2013). Virtual Reality (VR) exists on an experiential continuum from direct real world environments to experiencing an immersive simulated environment. Fitzgerald et al., (2013) represent this continuum from Reality to Virtual Reality as a mixed reality approach.

Virtual reality involves the use of a computer to create an interactive immersive experience via some form of head mounted display (HMD) unit, such that the user feels part of the virtual or simulated environment. The development of virtual reality within education is not a new phenomenon, but part of a relatively long history of educational technology development from desktop computing to mobile computing. VR encompasses educational games, simulation and virtual worlds, and has been shown to be "effective in improving learning outcome gains" (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014, p. 29). However, VR content has been costly and difficult to develop and deliver (Merchant et al., 2014). The ubiquity of student ownership of smartphones (Dahlstrom, Brooks, Grajek, & Reeves, 2015; International Telecommunication Union, 2015) that are essentially high powered computers with small yet high definition screens has created a new era of potential for student generated VR in education. "The differences between modern VR compared to the concept of VR presented two decades ago is that the technology is finally at the stage where it can be adapted to any mobile phone" (Hussein & Natterdal, 2015, p. 1). This is best illustrated by the introduction of Google Cardboard (2014) and the consumer version of the Samsung Gear VR headset (2015). Both of these VR HMD's are powered by a user's smartphone with low cost or free mobile VR apps, rather than a dedicated built-in computer and display unit. This keeps the cost down and enables a student's investment in their smartphone to fulfill a wide range of functions beyond being used as a VR headset. The Samsung Gear VR unit is designed to be compatible with the latest Samsung Galaxy smartphones, while Google Cardboard (and third party variants) supports a wide range of Android smartphones, Apple iPhones, and to a more limited extent Windows mobile phones. Simple forms of user-generated VR content include 360 degree or spherical panoramic images, and 360-degree videos. These 360-degree content experiences provide an entry level VR experience. Interactive simulation room environments involve a deeper level of VR production and viewing, but can be relatively cost-effectively designed using 360-degree video cameras, and editing software that splits the 360 video into three or four sections for display by multiple projectors on the walls of a room.

Theoretical foundations:

The project is founded upon networked, ambient/experiential, and student-centred pedagogies that support the development of student reconceptions of being as they prepare for participation within the paramedicine profession. Examples of networked, ambient/experiential and student-centred pedagogies include social constructivism (Vygotsky, 1978), mixed reality learning (Pachler, Bachmair, & Cook, 2010), connectivism (Siemens, 2004), rhizomatic learning (Cormier, 2008), and heutagogy (Hase & Kenyon, 2001). The ability to share geotagged user generated VR content enables connectivist pedagogies, connecting teams of students from various global cohorts. The design of an ecology of resources comprised of a collection of integrated mobile social media platforms such as Google Street View, Google Maps, 360 degree video channels on YouTube and Google Cardboard linked or curated via Google Plus Communities enables a rhizomatic learning environment (Aguayo, Cochrane, & Narayan, 2016; Cochrane, 2016).

Learner generated content in medical education
Luckin et al., (2010) and Pachler et al., (2010) argue that one of the key affordances of mobile learning is the ability to enable learner-generated content and learner-generated contexts. In medical education developing students' critical clinical analysis skills is highly important. Moving beyond text book information and scenarios to enable students to develop and critique authentic contexts for diagnosis is critical. This is the aim of clinical placement and simulations, however critical analysis and linking theory to practice can be achieved through

designing learning experiences around problem based learning and learner generated content and contexts, leading to the development of student critical analysis skills. Examples of authentic mobile clinical analysis projects in the literature include: (Conradi et al., 2009; Eysenbach, 2008; Ming-Zher, Swenson, & Picard, 2010; Scott, Nerminathan, Alexander, Phelps, & Harrison, 2015; Smordal & Gregory, 2003).

Simulation and VR
The foundation of modern Virtual Reality began in the 1960s with a product called the Sensorama. This apparatus projected images, vibration, sound, smell and wind to provide a series of immersive experiences (Hamit, 1993). Virtual Reality immersive environments in today's world have built on this with a proliferation of available computing-supported visual and auditory experiences. Critical awareness (CA) within paramedicine is an important skill that is very difficult to teach in a classroom. As Norri-Sederholm et al. (2014) argue it is critical within prehospital care for the clinician to have the right information when creating a treatment or management plan at a scene. Guhde (2011) highlights that a simulated experience has its best learning when students are able to role-play, react, and make decisions with as little input from instructors as possible. For many years Paramedicine has used a manikin simulation based strategy for its healthcare education. Not only does this strategy allow a standardised and consistent replication of patient condition but also allows the student to demonstrate procedures, decision making and critical thinking (Jeffries, 2005). It does not however provide a simulation of the environments that the Paramedic may encounter within their daily practice. Currently, a simulation environment within an education setting is often static, non-changeable and to an extent routine. Whilst it is still possible to provide the student with a clinically relevant training, it does not provide the environmental challenge that is unique to Paramedicine. Practice simulation in acute and pre-hospital care settings is a growing area of interest for clinicians and health educationalists, and there is much evidence to support its use (Pike & O'Donnell, 2010).

Design principles
We have identified several design principles throughout the body of mobile learning and educational technology literature that support the key graduate outcomes of the course (Cochrane & Narayan, 2015; A. Herrington, Herrington, & Mantei, 2009; Laurillard, 2012; Leinonen & Durall, 2014). Activity theory is one of the most common theoretical frameworks used to inform mobile learning research and practice, however, Pachler et al., (2010) argue that it is difficult to operationalise and is more suitable as an analytical tool than a pedagogical design tool. Bannan et al., (2015) argue that design based research is an appropriate methodology for grounding mobile learning projects and research. Throughout the design and implementation of over 40 projects, we have found that supporting the development of innovative pedagogies through the integration of educational technology projects via the establishment of a community of practice is key to the success of such projects (Cochrane, 2014). Hase and Kenyon (2007) argue the case for using heutagogy (student-determined learning) as a guiding pedagogical framework to go beyond developing student competency to building student capacity to deal with real world problems. In the messy arena of clinical diagnosis, the ability to think beyond familiar scenarios and to work effectively in teams is critical. Herrington et al., (2009) argue that any educational technology intervention should be designed around the authentic use of the technology. St John-Matthews (2016) argues for the need to integrate collaboration and team-work into student project activities via harnessing social media to network and share research.

Methodology

The project is founded upon a qualitative design-based research methodology (Amiel & Reeves, 2008). The project is supported by: a community of practice that meets weekly face-to-face consisting of a group of like-minded paramedicine lecturers an academic advisor and a research and technology facilitator, an online project discussion forum (Google Plus Community), an online collaborative documentation archive (via Google Docs), a WordPress site that acts as a project social media hub, and a project social media hashtag (#mesh360) for curating the VR panoramas, 360 videos and other mobile social media contents and outputs. Data Collection processes will include: a record of researcher and lecturer collaborative design of new assessment activities and processes via shared Google Docs, collation of researcher and lecturer brainstorming and sharing processes via the public (but participation by invitation only) Google Plus Community, Face-to-face and video conferenced semi-structured interviews, collation of mobile social media via a project hashtag, and online surveys. Participant social media usage will be analysed via visual conversational analysis tools such as TAGSExplorer (Hawksey, 2011) for Twitter. Other social media usage analytics such as Google Street View and YouTube views and peer ratings will provide analysis of the geographic reach and impact of the project artefacts. Stage three of the project will involve student data analysis that will occur after the exam board has finalised all academic grades, with the data analysed by the researchers for themes that indicate the impact upon student learning and the development of professional digital literacies. All participant data will be anonymised.

Research questions

Our research questions focus upon using mobile VR to enable new pedagogies that redefine the role of the teacher, the learner, and of the learning context:
- How can we use our identified design principles to utilise a mash up of mobile social media as a simple framework to design learner-generated authentic learning environments and stimulate student critical awareness of practice risks via VR environments?
- How can we enhance clinical simulation environments using interactive 360 degree videos to more authentically reflect real world scenarios?

Project participants

Within the first phases of the project the project participants include three paramedicine lecturers, an academic advisor as pedagogical and technological support, and a research and VR production facilitator. In the implementation and evaluation stages of the project participants will include the current cohort of paramedicine students.

Guiding design principles

Design principles were identified through the literature on designing authentic learning and scaffolding innovative pedagogies. These include:
- Basing the project within a design-based research methodology
- Supporting the project through the establishment of a community of practice
- Using heutagogy (student-determined learning) as a guiding pedagogical framework
- Designing around the authentic use of mobile devices and VR
- Integrate collaboration and team-work into the project activities

There are four key stages of the project:

1. Establishment of a project community of practice and development of theoretical mobile VR solutions to stimulate critical and analytic problem awareness and analysis
2. Testing of mobile VR solutions in practice through simulations and development of design principles
3. Development of an enhanced VR simulation room environment
4. Design of student-generated mobile VR scenarios

Data collection strategies

A generic mobile VR ecology of resources can consist of a collage of mobile social media tools that facilitate five key elements: (1) a student team hub, (2) a mobile VR content creation workflow, (3) a cloud-based VR content host, (4) VR content publication and sharing via social networks (SNS), and (5) a smartphone-driven head mounted display. The goal of the framework is to enable the explicit design of learning experiences around new pedagogies such as rhizomatic learning, social constructivism, heutagogy, authentic and ambient learning, and connectivism, via participant-active VR. Table 1 illustrates the crossover between educational design research, learning design, design-thinking, and the relationship with theory, practice, and mobile learning across each of the four stages.

Table 1: DBR framework

Methodology: (Educational) Design-Based Research	Stage 1	Stage 2	Stage 3	Stage 4
4 stages of learning design	Informed Exploration	Enactment	Evaluation: Local Impact	Evaluation: Broader Impact
Connecting theory and practice	Theory	Practice	Participant Feedback	Critical Reflection
Intersection with mobile learning	MSM Framework informing curriculum redesign	Rhizomatic Learning: Developing an EOR Designing Triggering Events	Participant Feedback	Peer reviewed feedback via SOTEL
Design Thinking	Observe & Define	Ideate & Prototype	Iterative Testing & improvement	Wider testing

While the data collection stages will be most relevant in the evaluation stages of the project this paper outlines the first two stages of the Mesh360 EDR research project where we co-define the project problem and requirements, and develop prototype solutions based on existing design principles and technological innovation.

Mesh360 Project Implementation

The aim of this project is to utilise the potential of virtual reality by providing a learning environment for novice Paramedicine students to try, fail and learn without real-life consequences. We aim to provide an environment that can develop an understanding and critical analysis of the complexity of pre-hospital paramedic practice. Due to the nature of the wide and dynamic working environment that a Paramedic might encounter it is important to provide an imitation of some real thing, state of affairs, or process for the practice of problem solving, skills and judgement. It is important that all components of a teaching system, especially the teaching methods used and the assessment tasks, are aligned with the learning activities assumed in the intended outcomes. In order to ask this of our paramedic students we are required to provide the correct working environment and the correct medical training. The Mesh360 project consists of three identified elements: (1) pre simulation VR scenarios to develop student critical awareness of real world issues – simulating arriving at a critical care incident and risk evaluation before patient treatment upon entering the simulation room (2) an enhanced 360 degree interactive simulation training room to reflect the impact of a variety of environments on Paramedic performance (3) integration of the use of mobile social media into the curriculum to facilitate student-generated content and authentic simulation contexts as more authentic assessment activities. The portion of the framework for supporting user-generated VR content is illustrated in figure 1.
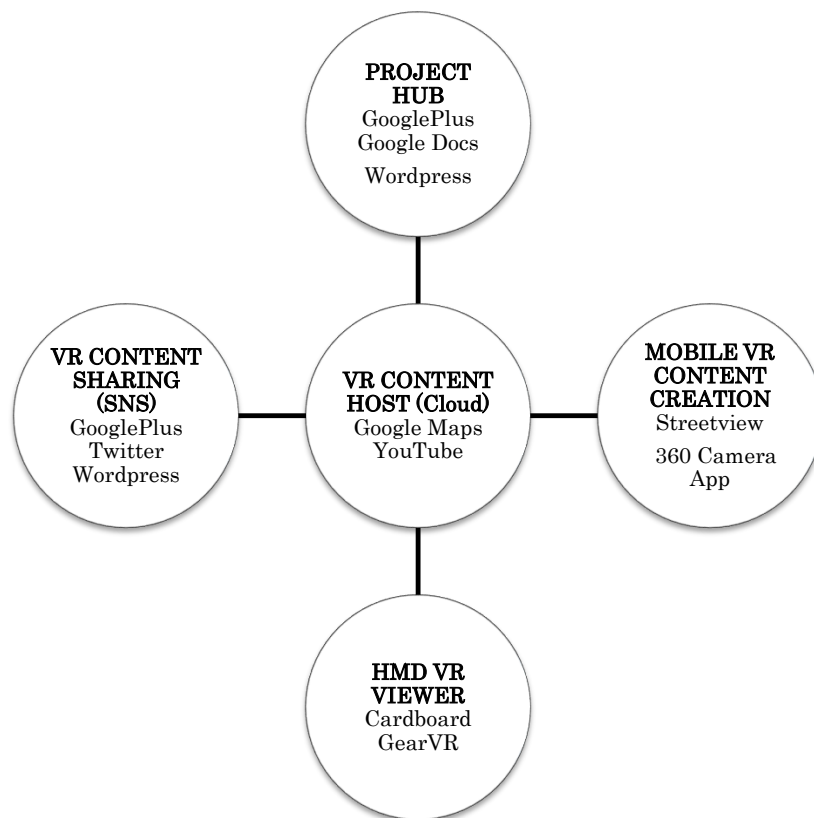

Figure 1: Mobile VR EOR

Figure 1 illustrates the use of a collection of mobile social media and social networks to support the creation and sharing of user-generated mobile VR as part of the overall Mesh360 project. Cormier (2008) refers to the design of a collection of tools to support learning as an ecology of resources (EOR). In our case the ecology of resources utilised to support the mesh360 project include:

- Individual WordPress blogs as project journals
- A team WordPress blog for publicizing project outputs http://mesh360.wordpress.com
- A shared Google Drive folder for project documentation, collaborative research writing, and collaborative curriculum brainstorming and redesign
- A Google Plus Community
- A project YouTube Channel
- A social media hashtag #mesh360

The mobile VR ecology of resources provides both a collage of community building and nurturing tools for the project, and will provide a rich source of participant-generated artefacts and reflections from both lecturers and students. In choosing platforms for each element of the framework we have focused upon selecting cross-platform tools that enable a student BYOD approach and interconnect easily. A simple and flexible delivery platform for student-generated mobile VR content is key – and this is why we have chosen Google Maps and YouTube as suitable mobile VR content hosts that do not require any specialised institutional web server, minimises the project IT infrastructure, and provides the opportunity for either private or global collaboration.

Pre simulation VR scenarios

Typically, when a paramedic is responding to a job there is a period of time in the response to the job where they can start to formulate a plan based on the information at hand. Bringing this into a simulation program is difficult as students are usually in clinical rooms with a manikin and not able to visualise or experience the broader scene. Given that paramedic's work in an ever changing environment and gain information from the environment they are in it is important to give the student the different prompts that one can gain from the environment they are in.

The project aims to give the student a 360-degree immersive view of the scene before the scenario to allow the student a period of time to take prompts from the scene and formulate a plan of action. Therefore, allowing students to gain information from the environment to make informed decisions during the simulation. Typically, when doing manikin-based simulations the instructor will feed information to the student verbally. Although this works, it can interfere with the students' train of thoughts and interrupt their learning. By engaging in a 360-degree VR experience the student has a learning environment they can experience and learn from as they explore the scene for answers as an on road paramedic does. Enabling the student to be able to experience the environment and make decisions or plans without being interrupted, for example see our first attempt at making an ambulance VR experience at https://youtu.be/7bUDlWQX6OQ that can be viewed using a smartphone and a HMD.

It is hoped that as a result of this project students will learn to use the environment they work in as a chance to get information and therefore help with their critical decision making in the treatment of their patient's.

Enhanced 360-degree interactive simulation environment

The project aims to develop authentic interactive simulation environments for student training and assessment. To put this in context, a Paramedic may be called to a car crash with multiple victims, a Fire, a drowning in a pool, building site trauma or an elderly person's home address. The diversity is endless yet our current simulation environment stays the same. The inability to change the environment within current Paramedic programs means that the student Paramedic will not develop an understanding of the importance of context-sensitiveness around critical aspects such as sound, visual clues, and safety. The implications of external stimulus so often found in a real world environment are required to develop a critical awareness and understanding of a real world influence. This project acknowledges that education is about creating the conditions in which people can learn and is looking to enhance this experience by way of technology.

The immersive Virtual world is at the frontier of innovation in medical education and our aim is to utilise a 360 video capture and content production workflow and use an immersive three wall room projector system to replicate a multitude of environments that a student can experience when attempting a medical based scenario. The concept is similar to that developed by Immersive Interactive Ltd (http://immersive.co.uk/) with a screenshot shown in Figure 2, but custom designed specifically for our Paramedicine context.

Figure 2. Simulation room concept by Immersive Interactive Ltd (https://youtu.be/Rmb1q-Ckghw?t=26s)

The systems currently being considered utilise infrared technology for interaction with the projected image. The interaction will include additional pertinent information that may enhance decision making strategies and further develop problem solving skills. An example of this will be that the student paramedic will interact with the screen to investigate medical records or medications. This information is often essential in the real world environment to determine risk and medical management of the patient. In addition to the interactive capabilities of this system, sound will complement the projected image and provide additional stimulus to the environment.

Integration of mobile social media within the curriculum

Education traditionally has been delivered face to face, yet in recent years online and mobile learning have allowed more flexibility, for students to study at their own time and pace, as well as in collaboration with their peers. Lecturers can engage a wider class without having students in the physical classroom. Designing effective online learning involves creating an environment that facilitates interaction, collaboration and feedback from their tutors. Poorly designed online learning environments can stifle students' progress and provide limited avenues for interaction.

Classrooms provide the ideal traditional environment to interact and get real time feedback within social dynamics, allowing students to take ownership of their education and learn in a streamlined manner. This project aims to increase students' immersion in their learning environment by creating a blend of digital and face-to-face interaction utilizing virtual reality and mobile social media. Lectures will be redesigned to become more interactive and collaborative experiences, with real world scenarios and demonstrations streamed for remote participants recorded with a 360 video camera in real time and archived for later viewing and critique. Course content will be redesigned to focus upon collaborative student-generated content, shared via the networked connectivity of students' own devices. This will facilitate discussion and collaboration between the on-campus students and remote students, as well as provide opportunities for input from experts around the globe via social network sites (SNS) such as Twitter (see for example #foamed), Google Plus Communities, and live-streamed video conferencing (such as Hangouts on air). This course redesign will allow a refocus upon social learning to occur, facilitating team-work and providing active participation within the global professional network of the critical care community.

This needs to be undertaken in a way that does not incur a considerable cost for the student by utilizing a BYOD approach with a low-cost head-mounted display (HMD) to view any VR content. The aim is to provide interactive learning experiences that students can replay at any time and not have to read through extensive notes to gain a similar level of understanding. Virtual reality in the classroom aims to provide the best of the real world and mobile learning, to obtain an enhanced education experience.

Discussion

One of the goals of this project to provide a facility that offers pre- and post-graduation paramedics the opportunity to experience a range of scenarios in a 'real life' but secure and safe environment. Paramedics' scope of practice, in pre-hospital and out-of-hospital environments, requires a comprehensive understanding and application of a range of clinical procedures. These procedures require paramedics to work autonomously or as part of multidisciplinary teams, and to take a multi system-based approach to managing patients' conditions. This project enables students to apply theory to practice in complex situations, such as managing patients injured in road traffic collisions.

Mesh360 simulation is a practical, 'real life', safe working environment in which student paramedics, and other healthcare students, can experience aspects of pre-hospital care and contextualise their theoretical studies. The Mesh360 facility will be used by student paramedics who are undertaking the undergraduate paramedic science foundation degree programme or the BHSc paramedic science degree programme. The facility enables these students to apply their theoretical knowledge and understanding to the management of patients with multiple conditions or injury. Currently student paramedics attend practical teaching sessions that are based on objective structured clinical examination (OSCE) scenarios that involve patient assessment, patient management and patient extrication. Experienced paramedic lecturers from the Auckland University of Technology (AUT) school of health and environmental science use their wealth of operational knowledge to create multiple scenarios, ranging from single patient encounters to multiple patient encounters following complex accidents, and encourage exploration and learning from each scenario via an immersive experience. Skills training and theoretical developments are redundant if they do not improve patients' prognoses and outcomes. It is hoped that the Mesh360 simulation facility will enhance a student's learning experience and equip them with the knowledge, skill and understanding required to work in complex, sometimes hostile, and uncertain environments.

It is envisaged that the Mesh360 facility will further support student paramedics' education through mutually beneficial collaboration with agencies such as the fire and rescue service, the police and specialist hazardous area response teams. In addition, it is hoped that this facility will be utilised as an inter-school training arena for all health disciplines within the University.

Project Community of Practice and Refinement of the design principles

Throughout the initial stages of the project we have attempted to use our identified design principles to guide the project:
• Basing the project within a design-based research methodology
• Supporting the project through the establishment of a community of practice
• Using heutagogy (student-determined learning) as a guiding pedagogical framework
• Designing around the authentic use of mobile devices and VR
• Integrate collaboration and team-work into the project activities

The design-based research methodology forms the foundational link between the iterative project stages (Table 1). The establishment of the Community of Practice supported by online collaborative platforms and weekly face-to-face meetings has allowed for the facilitated implementation and running of the design-based research methodology agenda in addressing mobile VR in Paramedicine. In particular, the analysis of practical problems and development of design principles through constant testing and refinement of prototype solutions in authentic practice is enhanced by the ongoing collaborative and co-creative structure of the Community of Practice and its associated ecology of resources. This has also permitted the rapid adaptation to the constantly changing nature of available mobile VR technological affordances. As an example, since the start of the Mesh360 project in early 2016 we went from no access to 360 cameras in New Zealand nor online, to access to a range of them and associated creation and production software and sharing platforms. Social media sharing of prototype mobile VR solutions allows for quick and responsive feedback from the Community of Practice, which in turn nurtures itself from the constant drive of technological innovation around emerging and more sophisticated mobile VR content creation platforms, for example from Google Streetview and YouTube #360 to Pano2VR, Seekbeak, WondaVR and Thinglink. Integration of heutagogy as a guiding pedagogical framework has been possible in part due to the practitioners addressing their own needs within their educational contexts through mobile VR technology. By addressing their authentic needs in context the Mesh360 practitioners have led the development of their own prototype solutions and learning environments with the facilitation of the Mesh360 Community of Practice, resulting in the design of a unique solution to the identified pedagogical limitations of prior approaches to paramedicine education.

Project implementation and evaluation stages

The establishment of the Mesh360 Community of Practice and initial development of theoretical VR solutions (stage 1 and 2) have shown positive outcomes allowing for the emergence of a set of prototype solutions currently being tested in practice. These outcomes and prototype set of solutions will inform the next steps in the design-based research project (stage 3 and 4), involving the implementation of prototype VR scenarios and testing of a prototype 360 degree enhanced manikin simulation room. Student feedback on these prototypes will inform further design iterations, and we aim to gather wider peer feedback via conference presentations and peer-reviewed publication of our results. This set of feedback and evaluation instances will permit the development of a final set of design principles for the implementation and use of mobile VR technology and associated affordances in the provision of transformative and enhanced learning experiences in paramedicine education.

The potential of VR in education

Our research questions focus upon using mobile VR to enable new pedagogies that redefine the role of the teacher, the learner, and of the learning context. At this stage of the project we are excited about the possibilities and have defined our objectives and scope of the project. By focusing upon a BYOD approach to learner-generated VR we are keeping the financial investment in the project to the students to a minimum. However, there is a significant cost to the institution in establishing the assessed pre simulation VR scenarios and the enhanced interactive manikin simulation environment. We believe the investment will be worthwhile, in both terms of value for money in the enhanced learning experience, and in terms of the benefits of the professional development of the lecturers. We are also hopeful that our experiences will be useful in other educational contexts and discipline areas, who can design their own VR enhanced learning environments based upon our developing design-based research model supported by a sustained community of practice.

Conclusions

This paper presents a work in progress, reporting on the first two stages of a design-based research project exploring mobile VR and 360-degree video enhanced simulation environments for authentic paramedicine education scenarios. The goal of these enhanced learning environments is the development of student critical thinking and analysis skills in the life-and-death pressure situations a critical care professional must face daily. Preparing our students to have the capability to work within these environments requires a more authentic approach to education than a traditional classroom and clinical simulation environment. Keeping us on track within the project scope and goals is our foundational design-based research methodology and a commitment to heutagogy as a guiding pedagogy. In the next stage of the project we will move beyond ideation and prototyping to the design, implementation, and evaluation of mobile VR and enhanced simulation learning experiences.

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