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An Augmented and Mixed Reality Approach to Eye Fundus Training

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Introduction

Fundoscopic examinations are critical in the diagnosis of life and sight-threatening diseases, such as hypertension and diabetes mellitus. Although fundoscopic examinations are regarded as an invaluable skill to both general practitioners and ophthalmologists, it is still a procedure that requires extensive training to master. The difficulty associated with fundoscopy proficiency includes the lack of training time associated with current simulation and other tools. Additionally, patient and old manikin-based training add further challenges as the view of the fundus is only available to the examiner, leading to oral explanations supported by photos, illustrations, videos, multimedia, and most recently mobile applications, virtual reality, and augmented reality tools. However, such complementary tools lack realistic examiner-patient interactions, and in the case of photographs, preferred by students because of the high resolution and ease of manipulation, thus eliminating any examinee interactions. The need for realism and safer medical practices has resulted in the development of manikin simulators that allow exposing trainees to numerous scenarios while presenting learning objectives for the development of cognitive and psychomotor skills. However, manikin simulation requires a steep investment with regards to acquisition, maintenance, facilities, training, and curriculum development, that may limit access to medical educational institutions. The purpose of this research is to develop and study a complementary consumer-level tool for eye examination employing virtual and augmented reality, to elicit deliberate practice in the development of skills necessary to perform fundoscopic examinations. Our work builds upon simulation, role-playing, and games as tools to determine the most effective method of allowing trainees to develop fundoscopic examination skills in a safe and effective practice environment.

Methods

To develop the virtual and augmented reality training scenario, first, we conducted an analysis and characterization of the fundus examination, more specifically, we examined the interactions taking place to identify the inputs and outputs that will govern our system. Based on this information, we developed a virtual eye examination scenario that employs virtual and augmented reality allowing a user to approach a virtual patient while manipulating a 3D-printed or a digital version of the funduscope to examine the eye fundus and identify basic anatomical landmarks. To develop the virtual scenarios, we employed the Unity3D game engine, whereas the assets were created using 3D authoring and character creation tools such as Autodesk Maya and Adobe Fuse. For the virtual interactions, a Microsoft HoloLens Headset provided independent movement and interactions without constraints while wearing the headset. Users are able to use the HoloLens’ “left-click” gesture input that requires the user to hold their hand in the air while pointing at the object of interest, and tapping the index and thumb fingers to interact with certain virtual elements, such as an ophthalmoscope, the red reflex, and the various quadrants of the eye fundus. The augmented reality interactions responded to a 3D printed funduscope that allowed the user to interact with the eye tool by wearing a mobile virtual reality headset while looking at the marker placed in the printed funduscope in front of the headset. The 3D printed funduscope was designed to host a wireless communication Arduino board with potentiometers to adjust light and lenses, while wirelessly sending the data to the mobile device. To understand the feasibility of both approaches as potential practicing tools, we gathered usability opinions from game developers and a medical partner regarding the HoloLens and mobile augmented reality usability.

Discussion

The use of virtual and augmented reality elicits curiosity and interest amongst users, resulting in engaging experiences. However, given the work in progress nature of our current endeavors, there is still much work and research to be completed. During an informal survey of our virtual fundoscopy tool, participants expressed that the tool was easy to understand. The main concern was related to the HoloLenses’ interactions that made it difficult to use, primarily due to the limited field-of-view, and gesture input system. The augmented reality approach instead, was found more intuitive as it allowed 3D printed interactions and touch-based inputs if not wearing the virtual reality headset. Although we have only gathered informal usability perceptions that allow us to fine-tune the interactions and simulation flow, all participants have expressed interest in our approach by highlighting the potential applications in other fields. Future work will focus on the development of a framework that allows cross-platform eye examination to allow users with different computers to be part of the group examination experience.
Using physical 3D printed models and physical optical glyphs with Augmented Reality to display anatomy unavailable to medical students in a first-year lab setting

Andrea Zariwny

UX Design, Invivo Communications, Toronto, ON, Canada

1. Why is this topic timely and important?
Learning about anatomy destroyed by preservation methods is a challenge for medical students. For example, the inner ear has a complex shape, a small size (< 4mm) and it is buried in dense bone of the petrous temporal region and is often destroyed in the process. It is challenging to communicate and is often illustrated and thought to be a structure similar to a snail shell.

The development of Augmented Reality (AR) technology provides an opportunity to create a digital graphic representation of hidden, or otherwise unavailable information, and incorporate it by means of a digital device with the surrounding environment.

This technology has exciting potential for education applications but is currently not widely adopted. However, this project was used to facilitate interactive learning by combining a digital functioning real-time animation of the spiral ganglion, with an accurate anatomical illustration of the cochlea. It also provides a supplementary means of obtaining structural and functional information on this difficult anatomical subject matter by the 3D printing of the petrous bone anatomy. The theory behind this project also has potential surgical and other pedagogical applications.

2. Who is the intended audience?
Undergraduate medical and paramedical students especially those with interest in neurosurgery, ear nose and throat surgery, and audiology.

3. Why use AR in education?
   a) Augmented Reality is not a commonly used technology for educational environments.
   b) While doing my research I discovered that the development of Augmented Reality (AR) technology can provide us with an opportunity to create a digital graphic representation of hidden, or otherwise unavailable information, and incorporate it by means of a digital device with the surrounding environment.
   c) Using this technology, I could facilitate visuo-haptic learning (learning through sight and touching/moving) and provide supplementary means to information about scientific topics.

4. Description of the demo
The demo will be of an app for mobile devices that will recognize the actual anatomical illustration of the cochlea as an optical glyph and respond by superimposing the AR graphic of the spiral ganglion accurately in location and form when viewed from any angle.
The Effect of Sound on Haptic Fidelity Perception for Technical Skills Development in Virtual Simulations

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Introduction
The field of simulation is currently seeing a great effort and emphasis on the use of immersive technologies (VR/AR, and serious games, that is, video games applied specifically to learning and training, in particular), to better motivate and engage the trainee in an ethically safe and cost-effective manner. However, most applications are still focused on cognitive skill development due to various technical limitations and cost issues, as technical skills development (e.g., surgical drilling skills), require the simulation of the sense of touch in the virtual domain. High-end haptics is still in its infancy in terms of consumer-level devices, and when present, these are restricted to larger institutions that can afford the associated complex and costly hardware. Although lower-end haptic devices are available, further studies are required to guarantee their suitability for medical training and as an alternative to costly solutions that may be unavailable to various training procedures and medical students across medical institutions. The simulation of the sense of touch falls under the field of haptics, which collectively refers to machine touch and human-machine touch interactions and includes all aspects of information acquisition and object manipulation through touch by humans, machines, or a combination of the two within real, virtual, or teleoperated scenarios. Recent advances in hardware and software have resulted in the availability of a variety of haptic devices, including several at the consumer-level, and their cost is proportional to haptic fidelity (i.e., higher fidelity implies a higher price). The application of lower fidelity, consumer-level haptic devices is becoming more widespread given their reasonable cost of approximately $250 and $600 USD in contrast to higher fidelity haptic devices that can exceed a cost of $10,000 USD. However, these consumer-level, lower-end haptic devices are generally restrictive and cannot provide the higher levels of fidelity, and range of motion (degrees of freedom), often required to realistically simulate many tasks. In the real world, senses interact with one another and alter each other’s processing and ultimately perception. Prior work has examined the effect of sound on visual fidelity perception has shown a strong influence of sound on visual fidelity perception. However, very little prior work has considered multi-modal interactions with the other senses, particularly the sense of touch. Within the scope of this proposed research project, our current work is investigating whether sound can be used to increase the perception of haptic fidelity inherent in low-end consumer-level haptic devices to allow the use of such devices (coupled with the appropriate auditory cues) in applications that require higher fidelity at a fraction of the associated cost. Here we describe an experiment that examined the influence of sound on haptic fidelity perception in a virtual drilling scenario to determine whether the low fidelity haptic feedback associated with lower-end, consumer-level haptic devices can be compensated for through the use of sound.

Methods
The Unity3D game engine was used to develop the virtual drilling scenario. Haptic feedback was generated with the Novint Falcon, a consumer level ($250 US), and a low-fidelity haptic device that provides three degrees-of-freedom (3DOF) with force feedback over the three coordinate axes upon contact with virtual objects. The system receives the user’s input in the form of thrust movements towards/away from the (virtual) material being drilled and activation/deactivation of the (virtual) drill. The movement and button pressing status are sent to the haptic software which will respond accordingly based on the mechanical system (e.g., drill and material properties). The auditory stimuli consisted of five auditory sound conditions that were either non-contextual (i.e., not related to the task) or contextual (i.e., related to the task). The four non-contextual conditions consisted of: i) no sound at all, ii) white noise, iii) classical music, and iv) heavy metal music. The one contextual auditory condition consisted of i) drill sound while drilling through wood. The virtual drilling scenario was comprised of various trials that required the participants to (virtually) drill through a piece of wood. Once the task was completed, participants were presented with a dialogue box that asked them to rate the haptic fidelity (on a scale of 1-7).

Results
Although preliminary and greater work remains, the results presented here do indicate that sound can potentially influence haptic fidelity perception and more specifically, a contextual sound that matches/corresponds to the task being performed should be included. Furthermore, participants generally strongly believed that sound is an important part of the drilling process and that it can influence haptic fidelity perception; all participants felt different haptic feedback while the mechanical model remained the same for the duration of the experiment.
Development of a Head-mounted Holographic Needle Guidance System for Enhanced Ultrasound Guided Regional Anesthesia

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Introduction
The use of emerging mixed reality technology for enhancing needle-based procedures is a novel development. Currently image guided therapies are performed by simultaneously visualizing an anatomic target and needle using ultrasound (US). However, procedures that may benefit from real time image guidance, such as challenging neuraxial procedures (spinal or lumbar/thoracic epidural), are can be difficult to perform in this manner. US guidance, in the context of neuraxial procedures, typically involves pre-procedural US scanning to identify relevant anatomy, estimate the intended needle pathway, and create surface markers to help guide needle insertion points. The procedure is then carried out by the operator, recreating from memory, the location and angulation of the ultrasound as a path for the needle. Previous studies have shown that this method can reduce procedure time and needle passes, and therefore potentially reduce patient discomfort and morbidity (Chin et al., 2011). However, little is known about the accuracy with which operators replicate an ideal needle trajectory once identified by US. The Microsoft HoloLens is the first self contained, head-mounted, holographic computing device. It allows users to experience mixed reality – the combination of spatially stable holograms with the real world.

Methods
We have created software for the HoloLens which precisely registers the position of an ultrasound transducer by affixing an optical tracking marker, allowing for a spatially stable hologram to be projected into the user’s visual field depicting the ideal needle path. Operators may then use this hologram to precisely guide the needle angulation and location. We hypothesize this will reduce procedure time and the number of needle passes.

Results
Preliminary work with models of the lumber and thoracic spine has demonstrated that a range of operators (novices to experienced regional anesthesiologists) can rapidly learn to use holograms to successfully perform neuraxial anesthesia.

Conclusions
Further study is required to quantify the potential benefit of holographic guidance on procedural accuracy. While this may have wide ranging implications for many image guided therapies outside of anesthesia, a randomized control trial is planned to quantify its effect on thoracic epidural placement.
Immersive media to communicate patient stories for the purpose of enhancing empathy skills in medical education training

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Proposal

The focus of this paper is the use of immersive media to communicate patient stories for the purpose of enhancing empathy skills in medical education training. A variety of different fields and industries are drawing on immersive media technologies to evoke empathetic responses by fully immersing audiences in a story environment and helping them take on the perspective of the people whose stories are being told. These media range from 360 immersive videos, to augmented reality, to full virtual reality (VR) scenarios in which the audience experiences a first-person perspective within an interactive computer-generated environment. Since empathy is considered a core competency for physicians and has been correlated to patient satisfaction with healthcare experiences, it is important to explore potential for immersive story-telling to evoke or even enhance empathy-related skills in medical trainees, which is what the pilot study detailed in this paper aims to do. The presentation will: 1) overview secondary research on immersive media/VR and empathy; 2) outline an original research-creation pilot study on translating patient into immersive narrative videos; and 3) critically reflect on the challenges and opportunities for immersive story-telling to foster cultures of compassionate care in medicine. The paper aims to engage participants in questions around how new media and digital humanities can provide tools for medicine to understand and address the complexities and nuances of patient experience.
Immersive Virtual Reality to Reduce Procedural Pain During IV Insertion in Children in the Emergency Department: A Feasibility Pilot Study

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Introduction
Venipuncture and intravenous (IV) access continue to be the most common causes of pain and distress among children in the pediatric emergency department (ED). Distraction is a powerful tool to help decrease pain and distress in children undergoing painful procedures, including skin-breaking procedures. Virtual Reality (VR) is a unique tool for distraction in that it is immersive and integrates many sensory experiences thus capturing a greater degree of the patient’s attention. Several recent studies have shown VR to be successful in reducing acute pain (including related to skin-breaking procedures) in both adults and children 3-6. Methods: We conducted a pilot randomized control trial of children 8-17 years old undergoing IV insertion in the pediatric ED comparing an interactive virtual reality environment (KindVR aqua) and a control (video played on a tablet; current standard of care). The primary outcome was to assess the feasibility (safety, acceptability and accrual rates) of the VR intervention in ED from the perspective of children, families and the healthcare team. Our secondary aim was to explore the differences in self-reported and proxy-reported pain, distress and fear during IV insertion between the interactive VR intervention and control group.

Results
Eight patients have been enrolled in the study to date out of 40; 3 randomized to the VR intervention group and 5 to control group. Overall nursing satisfaction scores were higher for the VR intervention compared to control. In this respect, preliminary findings are that the VR was a helpful distraction, reduced children’s pain, improved nurses’ workflow, and made it easier for nurses to conduct the procedure compared to the control. Likewise, children and parents liked the VR for distraction, found it helpful, reported reduced pain, and wanted VR for the next IV compared to the control. Children in the VR intervention had greater reduction in average self-reported pain scores (reduction of 3.78 compared to 1.51 on a 0-10 pain scale).

Conclusions
Children, families and nurses reported that the intervention was acceptable in the ED setting. Nurses enjoyed the presence of the VR intervention during the IV insertion procedure and did not feel it disrupted workflow. In this pilot feasibility study, we demonstrate that VR for distraction during IV insertion is feasible in the chaotic environment of the emergency department. Our plan is to continue our enrolment in this study.
The use of virtual reality in the treatment of social anxiety disorder

Thomas Overly

Promena VR

Introduction
Most current studies of the use of virtual reality (VR) in the treatment of social anxiety disorder (SAD) have examined the differences in efficacy between standard cognitive behavioral therapy (CBT) and CBT that also has a virtual reality component used in exposure sessions. While the evidence to date is promising, there have been no studies of the variation in features, design, and delivery of the VR software used in treatment. The program used in the case study presented here as built specifically for the client based on information that he reported on his social anxiety hierarchy.

Material and methods
Case Report: A 33-year-old male diagnosed with both SAD and illness anxiety disorder presented for outpatient psychotherapy. The client participated in a psychological evaluation, followed by seven one-hour sessions of conventional CBT, and then six one-hour exposure sessions using virtual reality. Subjective units of distress (SUDS) were used to construct the client’s social anxiety hierarchy and were also used to monitor anxiety levels during all exposure sessions, where SUDS ratings were verbalized by the client throughout the exposure. Additionally, a pulse oximeter was used to monitor the client’s heart rate during all exposure sessions. For the exposure sessions a virtual conference room was built and populated with avatars that could be controlled by the therapist. The in vivo version of the VR scenario was reported to generate a greater than 70 SUDS rating. The avatars and the actions they performed were also based on client reports and included behaviors such as falling asleep, cell phones ringing, and interrupting the speaker to ask questions. During each VR session, the client presented speeches of his choice to executives seated at the conference room table.

Results
While the client’s early in-session SUDS scores were consistently greater than 70, by the final session of VR exposure, the client reported a less than 30 rating on all SUDS reports during the session. Additionally, the client reported that in vivo activities he was engaging in at the time of treatment were no longer generating SUDS ratings of greater than 30. No significant changes in heart rate were observed during VR exposure sessions.

Discussion
The customization of the program used for VR exposure in this client’s case enabled him to habituate to, and thus gain mastery over, stimuli that accurately represented the real-world challenges faced by the client. As virtual reality tools become more prevalent in the treatment of social anxiety disorder, the need for quantitative studies focused on informing the design and implementation of VR software used in treatment will also continue to grow. Given the positive results found across recent studies, further improvements in outcomes may someday make the use of virtual reality in the treatment of SAD a clinical standard.
Incorporation of Virtual Reality at University of Toronto’s Gerstein Science Information Centre

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Proposal

Virtual reality (VR), a fully computer-generated environment that gives users an immersive experience of being there, serves as an exciting instrument for knowledge acquisition and creation in the context of an academic library, in the same tradition as more familiar digital library resources, including video tutorials, virtual library tours, or online anatomy resources presented in 3D. The University of Toronto’s Gerstein Science Information Centre is in a unique position on St. George campus to attract a wide array of potential VR users and content creators, and create the conditions that would encourage fruitful and creative cross-disciplinary collaborations. In Fall 2017, a two-tier VR service was launched at Gerstein. Students new to VR can get their feet wet borrowing a 360 camera and Google Cardboards for a 5-day loan period. Those more experienced (or adventurous!) can spend time in our "room-scale" VR studio experimenting with Unity and an HTC Vive. All at no extra cost to students, staff, and faculty at the University of Toronto. By providing this technology at Gerstein as well as the training to support VR captures and other endeavors, we support our patrons’ experimentation with this new technology in a low-stakes environment and creation of immersive experiences associated with their research projects. Whether this comes in the form of 3D visualizations of engineering designs, renderings of an archaeological site, or simulations of real therapeutic or laboratory environments, we can support our patrons’ creativity and knowledge creation in an environment that encourages interdisciplinary learning, collaboration, and innovation. In this presentation, Erica Lenton, Gerstein librarian, and Mike Spears, manager at the Mobile Application Development Lab at Gerstein, will explain how libraries broadly are supporting VR research and content creation, how our service was developed and how it’s going 6 months in, and what the future may hold for VR services in academic libraries.
Alleviating pre-operative anxiety through patient education with innovative 360° immersive virtual reality

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Introduction
The prevalence of pre-operative anxiety is estimated as being as high as 80% in surgical populations. Currently, peri-operative clinical trials have revealed that pre-operative anxiety is associated with reduced short-term post-operative recovery, poor functional outcomes, increased pain scores, wound infections, increased length of stay and even mortality. The greatest anxiety has been linked with the fear of the unknown, specifically the process of physically being taken to the operating room. Strategies such as implementation of the pre-anesthetic clinic (PAC), the use of videos of what to expect leading up to surgery, calming music, and pharmacological treatments have been costly or with mixed effects. Through immersive 3D VR simulation, patients can ‘experience’ the journey of being prepped for surgery and transferred to the OR. A patient can learn about their pre-operative experience in an engaging/active manner by having the perception of being physically present in the pre-operative experience days or weeks prior to their procedure date. We have constructed and are evaluating an immersive 3D simulation to familiarize patients with the pre-operative experience, to investigate whether:

1. immersive 3D virtual reality patient education video can reduce pre-operative anxiety
2. how 3D video compares to current practice of 2D video

This randomized prospective trial will create an innovative virtual reality educational tool geared towards patients. It will potentially increase patient engagement with the hospital and alleviate anxiety leading to decreased morbidity post-operatively.

Methods
100 patients undergoing procedures were gathered for this assessment. Patients were randomly assigned to a VR or 2D group for their pre-assessment clinic (minimum one week prior to surgery to a maximum of two weeks). The primary outcome was to track anxiety levels through 3 stages of the patient’s care: pre-intervention, post-intervention, prior to anesthesia. Anxiety was measured using previously validated (in the realm of assessing peri-operative anxiety) Visual Analog Anxiety Scale (VAS). Patients indicated their anxiety levels using the VAS at their assessment appointment in the PAC (before and after physically watching the video) and once again and on the day of their surgery, immediately after they enter the operating room. As secondary outcomes, this study will also compare patient self-reported usability and satisfaction, as well as heart rate (HR) and MAP measurements between the two groups.

Results
Females randomized to VR experienced a higher anxiety score than males at all stages of the study. Both study interventions (2D and VR) decreased anxiety level immediately, however anxiety level returned to baseline (prior to intervention) on the day of surgery in the OR before anesthesia for males randomized to 2D and females in both groups. Interestingly, anxiety level inside the OR for males randomized to the VR group increased beyond baseline level. Both male and female experienced an increase in their heart rate (bpm) prior to anesthesia. This increase was more pronounced in male randomized to the VR group however this change was not significant. Females randomized to VR experienced a significant decrease in mean arterial pressure (MAP) prior to surgery. Alternatively, the male population in this VR group showed no significant changes in the MAP despite an increase in their VAS score. Males randomized to 2D showed a slight decrease in MAP prior to surgery, however this was not statistically significant.

Discussion
Our preliminary results show that anxiety level in patients decreased immediately after watching the video indicating that VR may have a bolus effect. We also demonstrate that there is a gender-specific reaction to immersive VR
The efficacy of immersive 360-degree video in improving spatial orientation among medical students

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Proposal
The recent emergence and commercialization of immersive virtual reality (VR) shows great promise in its application to medical education. While several surgical, critical care and procedural ‘virtual reality simulators’ are described, only a limited number of these are truly immersive. Furthermore, among the few studies that do describe immersive VR simulators for medical training, very few have explored the modality from a pedagogical perspective. We hope to better understand the utility of an immersive environment for learning through this proposed prospective randomized controlled trial. We will study this concept by looking at a common, and often anxiety provoking, problem faced by medical students – navigating unfamiliar hospital environments at the start of a new clinical rotation. 40 first and second-year medical students from the University of Toronto will be randomized and shown navigation videos of Sunnybrook Health Sciences Centre in either VR or 2D formats. The VR content will be viewed as 360-degree videos, where the viewer wears a headset that creates a sense of immersion and realism. After watching each format, the students will be assigned a navigation task in the hospital and their respective spatial orientation performance will be compared. Objective measures to assess participants’ performance will include time and distance travelled, and number of errors before completing each navigation task. A subjective questionnaire will also be administered to assess learner satisfaction from the two video formats. It is hypothesized that the realism and immersiveness of 360-degree videos will confer a sense of presence, improve sense of direction with better way-finding skills, and decrease anxiety associated with navigating an unknown environment. To date, there is no study reported comparing 2D with 360-degree video on way-finding and orientation. Furthermore, this study will be one of the few to explore the effectiveness of learning in a VR environment through 360-degree videos when compared to traditional 2D videos. Rigorous evaluation of immersive virtual reality from a pedagogical perspective is crucial before we invest resources in further developing this technology for medical education.
Microsoft HoloLens – Bringing Virtual and Augmented Reality to the Operating Room

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Introduction
The advancement of technology and innovation in medicine has drastically grown in both the scientific and mainstream media world. From tissue engineering to 3D printing, medicine is quickly evolving to the needs of society. In particular, the field of reality manipulation (virtual, augmented, and mixed reality) has garnished much attention for its potential to improve efficiency within the healthcare, especially in the operating room (OR). As of now, image guided procedures in the OR are spatially and technically challenging as users must balance their view on an imaging screen (eg. ultrasound), the patient/working space, and other key monitors such as the vitals machine. Here, we suggest a potential solution using reality manipulation. Currently, there is no research that has validated a function for reality manipulation in the OR.

Purpose
The purpose of this project is to demonstrate the effectiveness of mixed reality (blending virtual and augmented reality) during image guided procedures in the OR.

Methods
We integrated an ultrasound machine and an OR vitals machine into two simultaneous holographic screens through the Microsoft HoloLens via a secured network conducted over a signal transducer (Epiphan VGADVI Broadcaster).

Results
Real time streaming of an ultrasound and a patient's vitals were projected into space through the Microsoft HoloLens. There was a time lag of seconds between the ultrasound/vitals and the respective projections. Screen manipulation was possible to adjust the size and location of each screen separately to suit the user's preference.

Discussion
In this preliminary project, we demonstrated the potential for a functional purpose (image guided procedures) of mixed reality in the operating room. Future works will track efficacy and feasibility to operate with the Microsoft HoloLens.
Can VR simulations be a low-cost and effective education tool for training residents and medical students?

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Introduction
Modern anesthesia education requires effective, efficient and low-cost advances in education. Modalities such as full body mannequin simulations are currently being used but are costly, largely inaccessible and require a great deal of personnel support. A possible solution to this educational dilemma is the creation of immersive virtual reality (VR) curriculums. Unlike mannequin-based simulations, virtual environments can be accessible from anywhere at anytime, require fewer resources and have assessment metrics integrated. There is growing appreciation for the value of VR leading to rapid technological advancements and reduction of costs further increasing the accessibility. For example, new head mounted displays (HMDs) and 360-degree cameras have made it simpler to increase the degree of immersion within the VR experience than previously possible, allowing for the creation of any environment/context. These technological advancements have led researchers to consider extending and broadening use of VR into clinically relevant educational contexts. As an educational modality (unlike gaming or simply experiencing an event for example) many of the learning mechanisms and boundaries for learning and/or assessment require further research. As such, this study will endeavor to be the first to create virtual reality simulations founded on sound learning theories.

Purpose
To investigate whether:
1) Immersive VR crisis scenarios can reduce the practice time required for acquisition of competencies;
2) VR is non-inferior to traditional full-size body mannequin for assessment of technical and non-technical competencies;
3) To identify factors that enhance or limit learning from VR simulation.

We hypothesize that a VR-based simulation tool will be an effective modality for clinical practice and will be equal to traditional mannequin-based simulation for assessment of competencies.

Methods
We have designed a novel interactive and immersive full-size trauma bay with an adult patient and healthcare professionals. Fifty anesthesia residents will undertake cognitive decision-making steps in managing a patient with an airway injury and proceed with an awake fibre optic intubation. Feedback and evaluation algorithms are integrated into the program. Participants will receive a didactic training session on airway trauma, then manage two scenarios (one using immersive VR and one using traditional full size mannequin simulation, sequence will be randomized). Performance will then be assessed using in-situ airway trauma simulation scenarios 4-6 weeks later. We will assess the number of practice sessions medical students require to achieve readiness/saturation of learning in managing airway injury in trauma patients and performance on the trauma airway injury in-situ simulation scenario will be evaluated using a) airway injury checklist of core decision making steps and b) Ottawa Global Rating Scale for non-technical skills. Data will be analyzed for between group and modality differences. We will also conduct questionnaires to rule out confounding factors such as previous simulation, airway injury management, and VR experience.

Discussion
VR technology is increasing in popularity with a great increase in the level of customizability and immersion being achievable. By demonstrating its effectiveness as an educational strategy and through creation of a platform of immersive VR scenarios, we will set the foundation for creating custom curriculums and assessment frameworks that are cost effective, reproducible and accessible.