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Developing a Framework for the Design and Deployment of Virtual Reality (VR) in Clinical Education

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Abstract. The emerging cost-effective and powerful standalone VR hardware is an increasingly viable supplement to traditional clinical educational modalities. These traditional approaches are effective but can be limited by the cost of simulation infrastructure, the requirement to attend at fixed times and locations and instructor availability present challenges in meeting the needs of clinicians. One barrier facing educators looking to develop bespoke VR-based solutions is the lack of guidelines around their design, development, deployment, and evaluation. Our team has produced and deployed a number of VR-based educational applications. Through reflecting on findings from surveys, interviews, observation, we summarise a range of insights into the complexity and nuances of the clinical VR design and deployment in a framework that can inform and guide educators, clinicians and developers looking to create their own VR applications for use in healthcare.

Keywords. Virtual reality, clinical, education, innovation, framework

1. Introduction

Virtual Reality (VR) is rapidly emerging as an attractive and innovative approach to address the education and training challenges that the healthcare workforce faces now and into the future. Ever decreasing costs, increasing processing power and relative ease of development and use means that VR technologies are being more widely adopted. The capability of VR to deliver immersive, interactive environments in the time and place of the user's choosing allows access to educational opportunities previously not possible. Western Sydney Local Health District (WSLHD), in collaboration with The University

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of Sydney and developer Frameless Interactive, have been designing, developing, and deploying VR based applications to supplement clinician education.

Despite the promise of VR, there remains a knowledge gap as to how VR can be successfully designed, developed, and deployed in the context of clinical education. In addition, the COVID-19 pandemic raised concerns, from the local Infection Prevention And Control (IPAC) experts, about the safe use of VR headsets as a result of the limited evidence available for the safe cleaning and transfer of VR head-mounted displays (HMDs) between individuals. In this paper we aim to address the knowledge gap by providing a practical design framework to guide the design of VR intended for clinical education. We do this through reflecting on extensive findings from a number of case studies undertaken by our team.

2. Methods

A series of mixed methods research studies were conducted on multiple iterations of the different VR based applications our team has developed. The studies used methods including semi-structured interview [1], survey [2], observation, with findings analysed through thematic analysis and descriptive quantitative data extracted from user performance. The findings from each study were then immediately incorporated into subsequent iterations of the VR applications, which were then re-evaluated to establish if the desired outcomes had been achieved. When significant new features were incorporated into the VR applications, such as verbal interactions in headset, research was conducted to evaluate the validity of the previous findings in the new context [3].

To address the concerns raised by the WSLHD IPAC team, we approached the NSW Clinical Excellence Commission (CEC), who worked with us and their broader expert Community of Practice (COP) to review current best evidence that informed the development and adoption of a resource on the cleaning and disinfection of HMDs. Here we reflect on a collection of findings from our studies [3-7].

3. Results

After reviewing the cases, we developed and refined a framework to support future clinicians, educators or developers looking to design VR-based applications for clinical education [3,6]. The Clinical Training through VR framework now consists of 11 distinct factors (as summarised in Table 1) which can be incorporated through design features to ensure user needs are addressed through VR-based applications.

Table 1. Clinical Training through Virtual Reality design framework Factors and Exemplar Statements.

Factor	Description
Advanced roles	The ability to manage tasks at an acceptable standard
Accessibility	Clarity as to how commands are given and accessed
Agency	The environment providing opportunity to control workflows autonomously and make choices that align with prior experiences, such as multitasking
Completion	Clear commencement and completion prompt to tasks
Diverse input modalities	The environment replicates natural input modalities such as issuing commands verbally
Mental models	The environment design and prompts align with how the clinical environment operates

Motion sickness	That all efforts are made to reduce the experience of motion sickness for the user so they can engage with the experience
Perceived value	The application provides an experience perceived as valuable by the user
Privacy	The application and deployment experience should maintain the user's privacy
Realistic tasks	Common clinical tasks should be available for completion in a realistic manner
Visibility	Clear visible assets aligned with environmental orientation

The findings of our ongoing research have informed development of multiple VR-based applications, which are in varying levels of deployment both locally and internationally. These VR applications (shown in Figure 1) address specifically identified areas of clinical need. The applications educate clinicians in Advanced Life Support management [4,6], Code Black management [5], Verbal de-escalation skills [3], and clinical communication skills. Our approaches to design of the virtual environment and interactivity features were determined by the needs of the specific application. These approaches included passive 360 video, interactive randomized 360 video, immersive game environments, animated interactions with decision trees and Artificial Intelligence driven conversational agents.

Figure 1. Locally developed VR based applications. Top Left: deteriorating patient, Top Right: Verbal de-escalation with AI conversational agent, Bottom Left: ALS Team Leader, bottom right: Situational awareness.

Following a collaboration with the CEC IPAC team and their associated COP, the co-authored publication of the state guidelines for the cleaning and disinfection of HMDs was possible which allowed for the safe resumption of the VR-based research studies [7,8].

4. Discussion

The broad adoption of VR in clinical education and the advantages are potentially attractive for clinicians and educators. However, at the same time the practicalities of deployment into complex healthcare systems must be taken into account. Here we discuss some key themes identified by our team during our VR based deployments.

4.1. Design

There are a multitude of healthcare-focused, VR-based applications available with more appearing on almost a daily basis [9]. One of the major shortcomings as revealed by our research, is that many of these new applications fail to implement human-centered design considerations or focus on addressing user needs beyond a potential educational experience. Based on our own work, we present the Clinical Training Through Virtual Reality Design framework providing guidance for developers of VR-based applications in a healthcare setting for clinicians [3]. Consideration of these identified needs during the design, development and deployment process ensure that the applications will adequately support clinician education.

4.2. Infection Control

The COVID-19 pandemic reinforced the importance of effective evidence-based approaches to IPAC. The nature of HMDs is that they are often shared between individuals and during use the HMD is in close proximity to the users' mucous membranes. Thus, there is a potential risk of transmission of harmful pathogens. Our research identified simple processes and considerations that can be employed to ensure that the devices can be shared safely between multiple users [7].

4.3. Connectivity

The nature of VR often requires online connectivity to fully harness the power of the technology. The applications we have developed use several online features, such as learning management systems, voice to text transcription and analysis and a direct link with an Artificial Intelligence system. Initial pilots used local hot spotting to trial the applications. Moving forward, it was identified that a scalable process with appropriate governance had to be established. Partnering with our local Digital Health Solutions team, we were able to enable the devices to securely access the hospital provided Wi-Fi with appropriate firewall and proxy settings. In our experience these partnerships were invaluable for a truly scalable solution.

4.4. Practical deployment

To deploy VR-based solutions at scale, there is a need to consider the hardware to be procured. Our applications favour the cost effective and widely used Meta Quest 2 HMD. However, with the closure of the "Oculus for Business" service the bulk purchase of headsets has become challenging because the consumer-focused web portal has a purchase limit of three devices [10]. While there are solutions available through other vendors, streamlined procurement is an important consideration.

Once the hardware has been procured, a plan and governance structure must be identified to deploy the hardware into the clinical setting. While the usability of the technology is improving, our experience is that this is still a learning curve and having "clinical champions" to facilitate the onboarding and initial use is particularly valuable for successful project outcomes and user satisfaction.

Following the deployment of the devices into the clinical setting, the ongoing support and maintenance of these devices must be considered. Our approach within WSLHD has been to use direct support from the vendors, project team and simulation services. While this approach has allowed multiple projects to be successfully deployed and completed with larger numbers of HMDs, this would not be an efficient solution in the long term. Infrastructure to support these initiatives must be planned, established, and provided with secure and ongoing funding.

5. Conclusions

The use of VR to supplement clinician education holds significant promise in overcoming the significant challenges of accessibility, scalability and flexibility that traditional educational approach are unable to address. To capitalize fully on this promise several considerations must be taken into account. Failure to adequately address user needs during the initial and ongoing design of an application can result in the applications that do not meet the specific requirements of the clinicians using them. This then results in poor adoption of the application. In addition, not addressing the practical considerations for the deployment of the VR hardware, such as IPAC requirements and practical support for the hardware, could also hinder widespread adoption and safe use of the technology even where the applications may be otherwise well received. Overall, at this stage of its development VR is not a panacea for all educational approaches nor will it address all existing challenges. Our research and that of others does, however, show that it is a new tool in our educational arsenal and when used in appropriate settings, can provide significant and hitherto unattainable benefits to both learners and educators.

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