Helping Hands: Using Augmented Reality to Provide Remote Guidance to Health Professionals

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Abstract. Access to expert practitioners or geographic distance can compound the capacity for appropriate supervision of health professionals in the workplace. Guidance and support of clinicians and students to undertake new or infrequent procedures can be resource intensive. The *Helping Hands* remote augmented reality system is an innovation to support the development of, and oversee the acquisition of procedural skills through remote learning and teaching supervision while in clinical practice. *Helping Hands* is a wearable, portable, hands-free, low cost system comprised of two networked laptops, a head-mounted display worn by the recipient and a display screen used remotely by the instructor. Hand hygiene was used as the test procedure as it is a foundation skill learned by all health profession students. The technology supports unmediated remote gesture guidance by augmenting the object with the *Helping Hands* of a health professional. A laboratory-based study and field trial tested usability and feasibility of the remote guidance system. The study found the *Helping Hands* system did not compromise learning outcomes. This innovation has the potential to transform remote learning and teaching supervision by enabling health professionals and students opportunities to develop and improve their procedural performance at the workplace.

Keywords. Augmented reality, health professional, learning and teaching, procedure, rural and remote, student, usability

Introduction

In health, augmented reality (AR) systems have been successfully used to prepare medical, nursing, allied health professionals and students in a variety of procedural skills [1-5]. Within health curricula, the proficiency of procedural skills begins with learning theoretical underpinnings in the classroom and understanding context for its application. Students then practice in a safe, controlled environment such as a simulation laboratory. Students apply these new skills under supervision whilst undertaking clinical practice. Performing new procedures can be highly stressful for clinicians and students who may feel nervous or overwhelmed by the experience, and often fearful of making a mistake that may cause harm to the patient [6]. Continued guidance and support is necessary, and the application of AR has potential to support learners remotely in the workplace [7, 8].

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This project expanded an existing tele-assistance guidance system developed to address the remote guidance needs on physical task performance [9]. The technology augmented the learner's workspace with the presence of the unmediated, guiding gestures of a remote instructor. This tool enabled video image overlay of the learner's activity (procedure) space with the instructor's hand movements. The instructor visualised the learners' performance of the procedure in real-time and was able to superimpose their hand movements on the learner's field of vision. The learner visualised the instructor's overlaid hands which enabled correction and completion of the procedure. The aim of this project was to test the hypothesis there was no difference between groups that received usual procedural instruction and those who received remote guidance. A laboratory-based usability study and feasibility field trial tested the AR remote guidance system.

1. Material and methods

The project involved the customisation and piloting of the application of a wearable tele-assistance system to enable health profession students to learn and practice clinical procedures with real-time, virtual guidance provided by an instructor located remotely at another site. The project occurred in three stages: determination of the user requirements; usability trial and feasibility field trial. Ethics approval was received from the Tasmanian Health and Medical Human Research Ethics Committee prior to implementation of the project (H0015041).

1.1. The Helping Hands system

The *Helping Hands* technology is comprised of two laptops and additional off-the-shelf hardware connected through WiFi/Internet or 3G communication network. The learner wears a head mounted display (HMD) unit whilst conducting a procedure. The procedure is captured by USB camera on the HMD unit. The HMD USB microphone and headphones permit verbal communication with the instructor. The unit also has a near-eye display (Vuzix Wrap 1200DX, https://www.vuzix.com/Products/LegacyProduct/4) on which the learner can see the image sent from the instructor. The instructor looks at a large display screen, which displays the real-time image of the procedure from the learner's HMD unit. A USB camera mounted on a support arm over the display screen captures the instructor's hand gestures, and these are transmitted to the learner's near-eye display in the real-time. The instructor also wears USB headset that allows for transfer of voice information between the instructor and the learner.

The software package for the system was developed under Microsoft Windows 8.1 (64 bit) environment using a mix of proprietary and open source products. *Qt* IDE environment (https://www.qt.io/) was used for user interface development and all C++ coding. The *gstreamer* library (https://gstreamer.freedesktop.org/) was used for the media streaming of the application and, *OpenCV* library (http://opencv.org/) was used for the development of "computer vision" parts of the application, mainly for the capture of the webcams and segmentation of the images. Finally, *Microsoft Visual Studio* (https://www.visualstudio.com/) was used to compile the source code and produce the final executable file. All these software packages are either open source or are free to use for small scale development.

The aim was to produce source code that was compatible with Microsoft Windows 8.1 as the default hardware environment. However, due to portability of tools and libraries used, the actual source code should be portable between various platforms, including Microsoft Windows, Apple OSX and Linux versions.

The findings from each step informed subsequent stages. Stage 1 determined the technical requirements of the system including brightness, contrast of the images, depth perception, field of vision, potential pixilation and connectivity. A reference group comprised of health professionals, technical engineers, current health profession students, recent graduates and academic instructors was convened to test the technology and provide written and focus group feedback regarding strengths and weaknesses of the design and use of the technology [10]. The aim of the usability trial (Stage 2) was to explore whether learning outcomes were compromised by the use of the *Helping Hands* as a method of instruction. Hand hygiene is a foundation skill learned by all health profession students and was used as the test procedure in the project [10]. Novice undergraduate nurses were recruited for this trial.

The third stage of the project tested the feasibility of the technology for remote guidance within the workplace. Two sites remote from the instructor (over 100 kilometres), were used to trial the technology and assess the educational outcomes of using this method of instruction. Recruitment of paramedic and nursing students was undertaken. On completion of the procedure, they provided written feedback about the equipment and ease of use [10].

2. Results

2.1. Stage 1User requirements

The purpose of the reference group workshops was to gain written and verbal feedback about the *Helping Hand*s system and its use for remote procedural guidance for clinicians and students. Advantages and disadvantages were considered and improvements to the AR system were undertaken in response to user feedback [10]. Improvements included lengthening of the cords to accommodate a range of height of users reinforcing the cord connections and placing equipment in a shoulder bag which improved sturdiness of the learner system.

2.2. Stage 2 Usability trial

Completed surveys from users indicated the system were positive. Students reported the system was easy to learn to use and visual instruction was easy to follow [10]. From the feedback gathered from the reference group workshops and the usability trial, further technical improvements and modifications to improve the user interface were made to the *Helping Hands* system. These included changes to the placement of the microphone and inclusion of only one ear piece for the headphone that promoted easier verbal communication with the instructor.
Repositioning of the student's unit near-eye display was also undertaken (Figure 1).
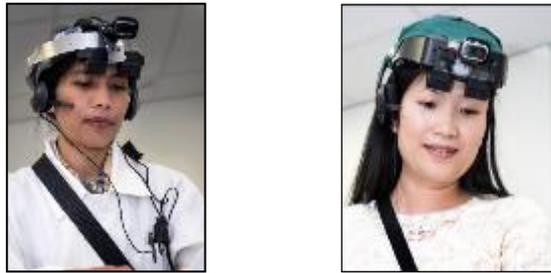
Figure 1   Changes to head mounted display prior to feasibility study

2.3. Feasibility Study

The feasibility of the *Helping Hands* system was trialed in two different patient care areas to test remote instruction, ensuring that patient safety and ethical standards were maintained. One site was 100 kilometres and the second was almost 1000 kilometres remote from the instructor set-up. Both feasibility testing sites used an equipment user protocol [10].

Although there was a low number of respondents in this feasibility study (n=17), feedback from both sites was positive:

"Great experience, can see the merits and usefulness of such technology" and *"Very cool technology, can be very useful for guidance or reassurance, easy to understand"*.

The findings indicated respondents were satisfied with the quality of audio and visual display of the technology for use as an educational tool to replace direct supervision. Although due to local conditions, connectivity varied and feedback focused on the priorities of each location. Connectivity at the distant site was superior to the capacity of the nearer site. Feedback from the distant site was more encouraging as the Internet connection was more reliable and faster than at the other site. Students could focus on the task of hand hygiene instruction using *Helping Hands*, whereas participants at the nearer site did encounter lag in audio and some pixilation that reduced the quality of images received from the instructor 100 kilometres away:

"Fine, instructor was clear and direct. I tried hard to improve the aspects that I could in regards to tech. If minimisation streamlining of headset were possible, that would be ideal in the future" and *"Quickly, same as if person was with me. Did not interrupt activity"*.

Feedback where connectivity was reliable indicated minor adaptations could improve the head mounted display and user experience.

"Delay/cut off connections could be critical in some contexts. Difficult to monitor on visual performance particularly whether it's visible on the other end due to over lay of instructor's hands".

Bulkiness and lack of adjustability to accommodate a range of head sizes impacted on audibility. Issues with infection control in terms of keeping the equipment clean and enabling timely preparation for use were raised. Screen size was also a concern for some users. Student comments indicated they were receptive to using this type of educational tool and were quite excited about the potential possibilities for its use:

"Applications in rural/remote settings for completion of procedures where instructor can't be physically present. Good for demonstrations for visual learners.

Instant feedback on correct/incorrect method" and "It was great being able to share vision. It made giving instructions much easier than if there was no visual input. It gives the person on the other end a really clear idea of the movements, the leaner was making and how to adjust them in real time".

On consideration of using with patients, students indicated that they could foresee no issues if the technology was explained prior to beginning any procedure:

"Could be positive or negative. Positive - patient can be assured proper practices are being undertaken. Negative - may think clinicians/student isn't fully informed about the procedure".

Students realised the value of access to this technology when requiring specific instructions, advanced skills or are geographically isolated from expert tuition:

"I think this is an amazing opportunity for technological advancement in the medical field. I support it and would be very pleased to see the use of this in the future".

3. Discussion

The results of the surveys showed *Helping Hands* was readily acceptable by end-users, who agreed it was easy to understand and use. Where Internet enabled networks were available, the *Helping Hands* technology was able to augment current student preparation, and potentially provide an alternate strategy for accessing trained health profession personnel. This remote access enables timeliness, utilisation of expertise and support where patient health outcomes could be reduced if instruction or supervision were unavailable.

Helping Hands is a wearable solution that addresses the need for a hands-free, portable, remote audio and visual guidance system. The application of this technology in learning and teaching scenarios represents a significant step in simulated learning. The project has application across a range of healthcare settings with a considerable benefit in learning environments where staffing levels are lower and in those where students may find access to an on-site instructor more difficult, such as in rural and remote areas. It has also the potential to change the meaning of direct and indirect supervision as defined by some of the National Boards registered with the Australian Health Practitioner Regulation Agency [11, 12].

The technology developed by this project allows procedural experts to share their skills and expertise with one or more novices without the need to be in the same physical location as the learner. In a broader context, the technology has potential for use in many other healthcare situations such as emergency childbirth, road trauma, expeditionary medicine and remote area nursing, where front-line health professionals may need to call upon a distant procedural expert. The technology also has potential for use in clinical situations necessitating a high level of biosecurity such as those found in bio-containment patient care units, or during the treatment of highly contagious diseases (i.e. Ebola). The technology also has potential for non-healthcare uses where remote instruction is required. The *Helping Hands* innovation has the potential to transform health profession supervision and therefore has the capacity to transform practice.

Future refinements to *Helping Hands* would be to increase the portability of the learner's unit and resolution of wireless connectivity issues. The project team anticipate that these could be overcome by adapting current off-the-shelf technology, such as a

smartphone using Skype in collaboration with commercial product design experts. Further development and testing of the technology, protocols and their impact on learning on different groups and settings needs to be undertaken to further develop the technology.

4. Conclusion

Determining user requirements, testing usability and feasibility of the innovation of *Helping Hands* has demonstrated this technology has potential to provide timely access to remote procedural instruction that was previously unavailable. Furthermore, educational outcomes were not comprised by this novel method of instruction. Feedback from participants indicated use of the technology was not viewed as a barrier to their learning.   Respondents indicated they believed patients would accept deployment of the system if its use was explained to them. The system could then be of benefit by guiding a clinician or student in a new or rare procedure, and enable improvement in health outcomes of patients.   Employment of more complex procedures will enable further refinement and evaluation of the technology for use remotely in healthcare settings.

References

[1]. S. M. Botden, I. H. de Hingh, J. J. Jakimowicz. Suturing training in Augmented Reality: gaining proficiency in suturing skills faster. *Surgical Endoscopy* **23** (2009) (9), 2131-7.
[2]. K. A. Ericsson. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Academic Medicine* **79** (2004) (10), S70-S81.
[3]. A. Feifer, A. Al-Ammari, E. Kovac, J. Delisle, S. Carrier, M. Anidjar. Randomized controlled trial of virtual reality and hybrid simulation for robotic surgical training. *BJU international* **108** (2011) (10), 1652-6.
[4]. C. Mather, *Human interface technology*: Enhancing tertiary nursing education to ensure workplace readiness. INTED; 2010.
[5]. S. Nilsson, B. Johansson, editors. Acceptance of augmented reality instructions in a real work setting. CHI'08 extended abstracts on Human factors in computing systems; 2008, New York, NY, USA,: ACM; 2008.
[6]. M. Pulido-Martos, J. M. Augusto-Landa, E. Lopez-Zafra. Sources of stress in nursing students: a systematic review of quantitative studies. International *Nursing Review* **59** (2012) (1), 15-25.
[7]. K. Lee. Augmented reality in education and training. *TechTrends* **56** (2012) (2), 13-21.
[8]. S. Yuen, G. Yaoyuneyong, E. Johnson. Augmented reality: An overview and five directions for AR in education. *Journal of Educational Technology Development and Exchange* **4** (2011) (1), 119-40.
[9]. L. Alem, W. Huang, F. Tecchia. Supporting the changing roles of maintenance operators in mining: A human factors perspective. *Ergonomics Open Journal* **4** (2011), 81-92.
[10]. T. Barnett, W. Huang, C. Mather. *Helping Hands: an innovative tele-assistance system for clinical skill development with health science students.* In: Australian Government Office for Learning and Teaching, editor. Canberra, Australia: Australian Government; 2016.
[11]. NMBA (Nursing and Midwifery Board of Australia). *Supervision Guidelines for Nursing and Midwifery*.2015; http://webcache.googleusercontent.com/search?q=cache:90fIMeLwZj8J:www.nursingmidwiferyboard. gov.au/documents/default.aspx%3Frecord%3DWD15%252F17456%26dbid%3DAP%26chksum%3Do x7ZntCqE9A3Gxd2R8g8TA%253D%253D+&cd=3&hl=en&ct=clnk&gl=au&client=firefox-b-ab. Accessed 3 March 2017.
[12].Medical Board of Australia (MBA). *Good Medical Conduct: A code of conduct for doctors in Australia. 2014*; http://www.medicalboard.gov.au/Codes-Guidelines-Policies.aspx. Accessed 3 March 2017 2017.