Extended Reality in Educating the Next Generation of Health Professionals

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ABSTRACT

COVID-19 has severely impacted health professions education and assessment has mostly shifted online. Major challenges remain especially about teaching-learning and assessment of clinical skills. Interacting with an individual online does not provide the range of information provided by an in-person meeting. There have been dramatic advances in computers and the internet in the last 60 years. Extended reality (XR) is all real- and virtual-combined environments and human-computer interactions generated by computers and wearable devices. The future physical world is likely to face multiple challenges. It is likely that human interactions and learning will increasingly occur in XR spaces. Three-dimensional holographic avatars and interacting and manipulating objects in XR spaces will become easier. Most medical education can occur in these spaces. Universities will invest substantially in these spaces. The safety of the physical world, the cost and usability will determine the extent of use of these learning spaces.

Keywords: *Education, Extended reality, Health sciences, Learning spaces*

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INTRODUCTION

COVID-19 continues to ravage the world. On 8th November 2020, there were 48.5 million confirmed cases and 1.2 million deaths attributed to the pandemic (1). The pandemic has severely impacted education. The deleterious effects on different aspects of health professions education range from suspension of classes, practical, small group sessions and stoppage of clinical postings (2, 3). Education and assessment have mostly shifted online, and this has been extensively described in the literature. Major challenges remain especially about teaching-learning and assessment of clinical skills. Online learning has played a vital role in sustaining student learning during the pandemic preventing a total collapse of education.

LEARNING ONLINE

However, concerns remain that online learning and interactions may not capture

the nuances of non-verbal communication and in-person interactions (4). One of the major challenges is that the computer screen provides only an image of the person's face and upper body. We are relying exclusively on voice, facial and upper body gestures in understanding the other person. Regarding the student-teacher interaction, this raises several problems. As teachers, we may have felt weird speaking to a microphone in front of a webcam either during a live teaching session or while recording a session for later student viewing. We are used to an audience and during an online session, we cannot always see the audience.

The principle of focused interaction concentrates on each person noticing how s/he is being experienced by other people. We use what we see to make decisions on how to react and about the future course of action when we are meeting in person. Another challenge with online interactions is peripheral participation which plays an important role in educating health professionals. Newcomers often start at the periphery and slowly develop "who knows what" knowledge directories and move slowly towards the centre of the profession. In-person informal interactions play an important role in developing the knowledge directory and in increasing participation.

DRAMATIC ADVANCES IN COMPUTERS AND THE INTERNET

Computers have been in use since the 1960s and Moore's law which states that the processing power of computers will double every two years has mostly held true (5). There has been a trillion-fold increase in the processing power of computers from 1956 to 2015 (6). The Apollo Guidance Computer that got man to the moon had less processing power than today's smartphones. So, with the steady increase in processing power computer-created worlds will become richer and more detailed. The physical world can be created down to the minute detail in these virtual worlds and the

real world can even be modified. Accessing these worlds, manipulating and "living" in them will require increasing internet speeds and bandwidth. Internet speed has steadily increased from about 50 kilobytes per second in 1980 to around 500 megabytes per second or 1 gigabyte per second today (7). Network 2030 envisages a massive increase in our capabilities with the internet of things, holographic avatars, and a massive increase in speed and bandwidth (8).

EXTENDED REALITY

Extended reality (XR) refers to all real- and virtual-combined environments and human-computer interactions generated by computers and wearables (9). XR is an umbrella term for all immersive technologies including augmented reality (AR), virtual reality (VR), mixed reality (MR) and others that have yet to be developed. Virtual information and objects are overlaid on the real world in AR. In VR, users are fully immersed in a simulated virtual environment, while in MR real-world and virtual objects can co-exist and interact with each other. We will use the term XR space to refer to a computer-generated space combining real-world and virtual objects, keeping in consideration that in the next two decades newer methods of creating these spaces may be developed.

THE FUTURE PHYSICAL WORLD

The future world is likely to have several challenges. The COVID-19 pandemic continues and there are predictions of more frequent pandemics with rising global temperatures. Increasing population density and destruction of animal habitats make the transmission of diseases between animals and humans and between humans easier. Climate change might make a large part of the world difficult to live in. Storms, wildfires, droughts and floods will become more frequent (10). In the future with increasing internet bandwidth and the

decreasing cost of computing power, many human interactions will likely take place in computer-generated spaces. The current methods of producing XR are cumbersome though displays are getting lighter. In the future, creating an XR space may be easier and we can more easily flip between the real and the XR space. We could create them on a smaller scale to save space and cost.

AVATARS

Currently, we depend on "avatars" to represent us in virtual worlds, and though steadily improving, these are still clunky and difficult to manipulate. Holographic avatars, a three-dimensional representation of one's body placed in virtual space will offer a much better representation. Holographic telepresence projects full-motion, realistic, three-dimensional images in real-time (11). People can interact, learn and work in the virtual world just like they do in the physical one.

XR SPACES

How common XR becomes and the extent of their use in work, education and recreation may depend on the state of the physical world and on improvements in the technology to create and interact with XR. If the current COVID-19 pandemic becomes endemic and other frequent pandemics happen, then there will be a big push towards XR spaces. I believe a proportion of our teaching and learning will happen in XR spaces and we will continue to interact in the real world when required. We face challenges in manipulating objects in the virtual world and obtaining the sensation of touch which plays an important role in constructing reality. Researchers are working on several ways to deliver the sensation of touch. Electronic skin with artificial sensors can enable us to manipulate real and even virtual objects (12). An article (12) mentions the creation of highly compliant magnetosensitive skins that were used by wearers to manipulate virtual knobs and virtual dialling pads.

Over millions of years, we have interacted with people face-to-face in the real world and not as flat two-dimensional images on computer screens and other devices. The cost will be an important factor in determining how many spaces we can create and support. With steady advances in computer technology, we believe soon it may become cheaper in many situations to create an XR space rather than a detailed real one.

XR IN MEDICAL EDUCATION

In medical education online classes, small group sessions, virtual labs and problem-based learning can take place online in XR spaces. It is highly likely that a new set of interactive learning tasks will be created. Examples may range from constructing an artificial joint to creating a mitochondrion. As technology advances, these tasks can become richer and more complex. With more ability to receive tactile and visuospatial sensations, and manipulate objects in virtual spaces simulation can shift online and students can learn to start an intravenous line and insert an airway in an XR space. A simulated patient can be examined and feedback will be provided.

XR spaces can overcome many of the challenges in present-day online interactions. Medical schools and other institutions may have to decide on how much of their learning and interactions should happen in the real world and how much in XR ones. Most institutions will continue to have physical spaces where faculty, students and other staff can meet and interact face-to-face. The nature of these XR spaces and how they will be regulated are important issues to work out. We are likely to interact with computers using voice and touch rather than through a keyboard as we do now.

Three-dimensional multi-user virtual worlds can connect multidisciplinary learning communities in which users (students and instructors) can learn together more easily (13). We always believed our physical environments will become better, richer and safer with the passage of time and the development of technology and resources. The COVID-19 pandemic may lead us to question this belief and make resources available towards learning and working in XR spaces. Economics, physical safety and the advance in technology will have an important role in determining the extent of XR spaces use. Careful thought and consideration should be given to this future development in education, living and working.

CONCLUSION

XR learning spaces will play an increasingly important role in health professions education. Rapid increases in computing power, internet bandwidth and speed, holographic telepresence, the ability to deliver the sensation of touch and to manipulate objects in XR spaces will make the experience more realistic and common. Regulation of these spaces will be an important issue. Economics, physical safety, and the advance in technology will have an important role in determining the extent of their use.

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