The Viability of Mixed Reality as a Medical Tool

An STS Research Paper
presented to the faculty of the
School of Engineering and Applied Science
University of Virginia

by

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March 27, 2020

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Virtual Reality (VR) is a computer-generated simulation where users can interact with the environment in seemingly real and physical way. Augmented Reality (AR) superimposes a computer-generated simulation on one's current, physical environment. Robert Mann (1965) proposed the first use of VR in medicine, outlining a new training environment for orthopedics. In the 1990s, hands-on training procedures were introduced (Brooks, 1988). Recently, medical schools have begun to use VR in their curriculum. Doctors, patients, education systems, and corporations compete to shape the role of VR in medicine.

According to Wu et al. (2019), while AR promotes engagement, contextualization, and authenticity in education, users can incur cognitive overload from complex tasks. Some MDs, such as Verghese (2011), fear that VR and other high-tech medical training is displacing other important techniques, such as shadowing and other direct experiences with real patients. However, because AR can elicit real emotion, such as fear or sense of threat, it can be useful in research and clinical applications (Chessa et al. 2019). There are two opposing perspectives towards this problem: high-tech medical training can simulate experiences that would otherwise be difficult to obtain or repeat, but reliance on these techniques can be overwhelming and divert students from real human interaction. How are advocates and critics of high-tech medical education techniques competing to shape their place in medicine? Medical professionals tend to question high-tech medical treatment, concerning the extent VR/AR will go. They fear its detriment to the quality of a patient visit. Some patients tend to be optimistic about VR, and some share the same fears as medical professionals. Education systems and VR corporations tend

to favor it. They value its quantitative benefits to a patient, such as surgery success rates and costs per patient. The doctor and the patient value the social implications, while education systems and VR developers value the technical implications.

Review of Research

On the technical aspects of VR in medicine, Wu et al. (2019) found that AR promotes engagement, contextualization, and authenticity in education, however users can incur cognitive overload from complex tasks. Chessa et al. (2019) found that AR can elicit real emotion, such as fear or sense of threat, which can be useful in research and clinical applications. Dyer et al. (2018) found that VR can enhance a student's understanding of age-related health problems and develop empathy for adults with certain health conditions. Krishnan et al. (2017) found that the pros of simulated medicine include immersive and experimental learning, better understanding of abstract concepts, skill acquisition, and patient safety among others. The cons include incomplete mimicking of human systems, defective learning, attitude of learners, cost, time, and technical/programming difficulties among others. Even though VR education can be realistic, users approach simulations different to real life. Such research has substantiated the basis that VR/AR could be a powerful tool in medical education if designed carefully.

On the social aspects of VR in medicine, Sauerland et al. (1999) found that critics of evidence-based medicine tend to claim it's a dangerous tool because they fear it will be used against themselves. Pensieri et al. (2014) found that there is no clear consensus on the topic "VR in Medicine." They found that for physicians and surgeons, the "goal of VR is the presentation of virtual objects to all the human senses in a way identical to their natural counterpart." For clinical psychologists and rehabilitation specialists the goal is to "provide a new human-

computer interaction paradigm in which users are no longer simply external observers of images on a computer screen but active participants within a computer-generated 3D virtual world." They also found that some patients and clinicians believe VR raises safety and ethical issues from its common side effects. This plays a key role in understanding why doctors are divided in how they question high-tech medicine. Ventola (2019) found that it's unclear whether or not patients will be accepting of VR in pharmaceutical applications. While most patients would opt to be treated with VR again, some found the equipment confusing, uncomfortable, or difficult to use. He also found that students and teachers may prefer a traditional instructional approach, and that the overhead of designing lessons in VR may be too much of a burden on teachers. He suggests that external support would be required for VR to be used in education. Janisse (2000) outlines the idea of belief-based medicine, which strongly appeals to low-tech medicine advocates. He found that patients and physicians tend to act on their beliefs, which may be rooted in ancient wisdom or science. Physicians may disregard the personal or cultural beliefs of patients as they aren't scientifically backed or because a physician may not want to leave the safety of their training experience.

The Patient-Facing Perspective

Medical professionals who directly interact with patients tend to question high-tech medical treatment. The American Hospital Association values cost-effective healthcare. It argues that "low-tech solutions can be as straightforward as building time into patient visits… 80 percent of diagnoses can be made just based on the patient story alone" (Bathija, 2019). The Society for Science Based Medicine values the integrity of medical products and treatments. It contends that "as a profession we struggle to integrate the human warm-and-fuzzy aspects of

medicine with the advantages that modern technology bring" (Novella, 2018). GiHealth values patients' control over their health. It contends "there is tremendous hope and hype around VR, but VR cannot cure cancer and should be recognized for what it is – a single tool that, in some people, can help relieve distress in concert with a panoply of other treatments. I have sometimes heard that VR is "transforming" healthcare. I think that is an overstatement and we should be careful to recognize its limitations while also acknowledging its benefits" (Spiegel, 2016). Those who hold such views argue that VR's place in medicine should be carefully considered.

MDs present a variety of reasons high-tech medicine can be a setback. Verghese (2011) suggests that high-tech medicine marginalizes real patients. Milani (Hansen, 2017) argues that "technology is an enabler towards a better patient experience and better patient engagement… we've got to make it easier for the caregivers to give care and not give them one more step to do." Janisse (2000) fears that high-tech medicine will supplant procedures physicians perform now, the abundance of patient information will make it harder for a physician to provide a diagnosis without external confirmation, and that physicians will forget that listening carefully, attentively, and empathetically to a patient is a key role of their profession. Snyderman (2019) contends that "technology must be continually advanced to improve care, but should never eliminate the compassionate bond between patients and their physician. Technologies that replace human interactions must be carefully judged against the need for, and value of, compassion, which provides not only deep benefit to both the patient and physician but is more cost-effective in many situations." Pearl (2014) sums up these perspectives by claiming new technologies don't address the real problems, no one wants to pay for new technologies, physicians are reluctant to show patients their medical information, technology slows down many physicians, and many physicians see technology as impersonal. Those who hold such

views suggest VR should be kept away from patients, that medical visits should prioritize the doctor-patient relationship, and that technology should be considered more carefully from the role of the doctor.

The Patient Perspective

Patients tend to be split about the use of VR in medical treatment. Veeravagu (Erickson, 2017) claims that patients have chosen Stanford over other nearby hospitals solely because of their VR technology. He contends that it helps the patient better understand the procedure they will undergo and puts their minds at ease. Patient Sandi Rodoni (Erickson, 2017) used VR to review her procedure, and she states that "[she] knew that Dr. Steinberg would be able to see the same thing [she] saw, and he wasn't going to run into any surprises." Guillen et al. (2018) conducted a survey on patients' attitudes towards VR as a treatment for stress-related disorders. She found that they had high opinions before treatment and even higher after. Some patients reported that they "found it easier to express emotions" or that it was a "very useful treatment" for them. Boeldt et al. (2015) conducted a more general survey on patients' attitude towards high tech medicine, and found that patients are generally supportive and tend to have greater enthusiasm compared to health care providers. Patients believed that having more access to health care resources gave them better management over their health, in contrast to health care providers who believed that it would lead to anxiety. Cognitant values patient education through 3D experiences. They contend that "patients tend to feel overwhelmed because there's so much conflicting, concerning information online … it's important to move away from print and to move to online, and to use visual tactics like VR and immersive content in 2D to empower people with any educational background to understand their health" (Kent 2019). Those who

hold such views suggest VR will put the patient at ease and give them more control over their health.

On the contrary, there are those who find high-tech medicine as a detriment. Ernest Quintana was a patient who found out he would soon pass away through a video stream at the hospital. His daughter contends "it should have been human; it should have been a doctor that came up to his bed side … I just don't think critically ill patients should see a screen, it should be more human with compassion" (Jacobs, 2019). GiHealth values patients' control over their health. It claims that "patients still do not want to use VR in the hospital … We approached [a patient] with a set of goggles, explained how the VR technology might help with pain management, and described how the experience might offer a temporary "escape" from the hospital. She looked at us, silently and unblinkingly, as if we were dropped into her room from another planet. She politely turned down the VR, but I could see in her eyes that our request was simply out of place" (Spiegel, 2016). Those who hold such views suggest VR is a detriment to the doctor-patient relationship. They also suggest that VR may be misunderstood by or be too overwhelming for the patient.

The Educational Perspective

Medical professionals who educate aspiring doctors tend to favor high-tech methods. Advocates of experiential learning argue VR can "guide students on a path from novice to expert, a path that is difficult to traverse until they are faced with real-life experiences" (Drescher et al., 2018). The Association of American Medical Colleges values health equity through improving medical education, medical research, and patient care. It contends that if one can "rehearse the surgery ahead of time [in VR], when [they] get there it's not a surprise. It's as if

[they] have been there before" (Breining, 2018). Educause values information technology in higher education. It argues that "VR, AR and Mixed Reality are leading to innovations in the learning environment, providing new opportunities to learn-by-doing for increased retention and proficiency, share valuable resources globally, and offering savings in the high cost of training and time" (Craig, 2017). To its advocates VR is the next innovation for medical training. It gives students repeatable experiences that would otherwise be unattainable.

Some institutions, such as the University of Virginia, have already began implementing such techniques. Dr. Ziv Haskal (Barney, Haksal 2019) argues "watching a 2-D animation, listening to a lecture, or watching a physician on video simply fails to convey the subtleties of the procedure … With this approach (VR), doctors are simply going to be able to do things better." University of California San Francisco has taken a similar approach by offering a pilot course in its anatomy curriculum. They contend that "virtual reality is exciting… because it is going to help enhance the students' understanding of the arrangement of the body. Because the better they know the body, the better physicians they will end up being for the rest of their careers" (Baker, Harmon, 2017). Stanford recently opened up Neurological Simulation Lab, which allows doctors to practice upcoming surgeries. They contend "the VR system is helping train residents, assist surgeons in planning upcoming operations and educate patients. It also helps surgeons in the operating room, guiding them in a three-dimensional space" (Erickson, 2017). Northwestern takes a more conservative approach. They argue that "we need to better understand the impact of [VR]. We need to engage in more scholarly activity before deploying this just for the sake of deploying it, but we've got to start somewhere — it's clearly the wave of education in the future" (Williams, Garcia, 2018). These institutions believe that doctors will be

more capable having been trained with VR, and have began to incorporate VR in their curriculum to reflect that.

The Corporate Perspective

Trade associations representing VR developers view it as a benefit to medicine. The VR/AR association works closely with companies to promote medical VR for training, rehab, and patient education. It believes VR is "helping in training, providing services, and of course, education" (Kolo, 2018). Visualise values creating new immersive content. It contends "VR will be used more and more to improve the accuracy and effectiveness of current [medical] procedures, and enhance the capabilities of the human being, both as the care-giver and the patient. Quite simply, the potential for VR in the healthcare sector is huge, limited only by the creativity & ingenuity of those creating and applying the technology" (Engels, 2017). These groups acknowledge the benefits of VR and seek its continued development in the medical field.

Some companies have already formed around VR medicine. Osso VR values patient outcomes from surgeries. It claims that VR "gives users the opportunity to preview the procedure they will be performing, without the risk of operating on an actual human patient or on a complicated rig that requires setup and takedown just to use" (Onkka, 2018). XRHealth values engaging methods for physical therapy. It claims that "the gamification element that VR can add to physical therapy is a crucial feature to improve patients' engagement and overall progress… A strong immersive experience can stimulate the patient and accomplish the same objective as conventional therapy, but with a simpler approach" (XRHealth 2019). These views suggest that VR can be a profitable model in medicine. According to Delshad et al. (2018), hospitals can use VR to cut costs, on average $5.39 per patient.

Data-driven VR developers believe VR will benefit a patient's health. MD Connect values data-driven healthcare services. It contends that VR can build a better doctor-patient relationship; "many doctors try to encourage their high-functioning patients by downplaying the severity of their symptoms compared to other cases… how would doctors know? They've likely never experienced their patients' pain themselves" (Cartley, 2017). It suggests VR will allow doctors to better empathize with their patients' symptoms and provide better treatment and patient satisfaction. The International Data Corporation values engaging technology buyers with data. It contends that "the industry and, more importantly, patients have suffered under inconvenient access to healthcare; digital patient engagement is poised to change that by providing healthcare consumers access to both administrative and clinical support conveniently in a personalized and interactive dialogue when needed. IDC believes this will improve not only the patient experience but improve patient compliance to health improvement strategies and result in better health" (Burghard, 2018). These companies emphasize an improved patient experience with VR, but they are truly interested in its quantitative results; patients will continue to use their products.

Insurance corporations take a supportive stance. Aetna values affordable and accessible health care. It argues that "the ability to access high quality health services via technology such as VR offers a lifeline to employees in the field" (Aetna, 2018). Blue Cross Blue Shield is a health insurance provider. It contends "virtual Care has the ability to reach so many people who may otherwise not be able to visit a physician or counselor" (Page, 2018). The American Telemedicine Association values accessibility and availability of healthcare. It contends that VR and other high-tech medicine is transforming the way healthcare is delivered, with an emphasis on accessibility, cost efficiency, quality, and consumer demand (Telehealth, 2019). These

corporations believe VR is a benefit to medicine as it makes healthcare more accessible. Consistent with other VR developers, their interests are in the numbers; how many more people can be treated by VR healthcare.

Conclusion

Many doctors who interact with patients fear that VR in medicine may impair the doctor-patient relationship they value, make it more complicated to provide a diagnosis, or replace responsibilities of the doctor. They contend that VR substitutes artificial interactions for the doctor-patient relationship. Patients tend to be optimistic that VR can give them more control over their health and reduce anxiety from uncertainties in procedures they might undergo. However, some dread the lack of empathy it may create and some find the technology confusing or misunderstand its purpose. The doctor and the patient prioritize social implications that VR has in medicine.

On the contrary, many medical schools and VR corporations advocate VR as an effective method of teaching and treating a patient. Their interests are in the numbers; higher surgery success rates, rehab effectiveness, savings per patient, and patient satisfaction among others. Some VR corporations contend that it will actually improve the doctor-patient relationship by teaching doctors to better empathize with their patients, or that patients will receive better care when provided more access to their digital record. Although these contentions appeal to the social side, the latent function is to improve the experience of the patient, which is where hospitals and those specific corporations make their money. Medical schools and VR corporations prioritize the technical implications that VR has in medicine.

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