COMMENTARY

Augmented & Virtual Reality via High Mounted Display: Commentary to Cybersickness Questionnaires

Nur Izah Ab Razak[1,2], Razif Abas[3,4], Rahmita Wirza O.K. Rahmat[5]

[1] Physiology Unit, Department of Human Anatomy, Faculty of Medicine & Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
[2] Family Medicine Clinic, Hospital Pengajar Universiti Putra Malaysia, Persiaran Mardi-UPM, 43400 Serdang, Selangor, Malaysia.
[3] Anatomy Unit, Department of Human Anatomy, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
[4] Department of Anatomy and Embryology, Faculty of Medicine, Leiden University Medical Centre, 2300 RC, Leiden, The Netherlands.
[5] Department of Multimedia, Faculty of Computer Science and Information Technology, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.

Corresponding author's email: nurizah@upm.edu.my
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INTRODUCTION

During the COVID-19 pandemic, educators and learners (E&L) are not permitted to enter university areas such as the faculty, anatomy museum, and clinical skill lab for anatomy and physiology teaching and learning (T&L) sessions. The pandemic prevents the conventional small-group teaching utilising cadaveric dissection or 3D human organ objects at an anatomy museum or other specialised learning environment. Students' access to cadavers, high-quality learning modalities, normal and pathological specimens, musculoskeletal models, and other resources is impacted by the loss of direct access to this facility. However, despite the difficulties of forecasting future COVID-19 trends, educators may be encouraged to develop alternative teaching techniques through new application inventions, in this case, through immersive online learning via augmented reality (AR) and virtual reality (VR). The T&L of pre-clinical subjects has a significant influence during COVID-19 (1), and online immersive learning have been reported to increase students' enthusiasm and interest in the subjects learning during COVID-19 (2, 3).

The dynamic processes of anatomy and physiology subjects require clear and exact depiction to impart this detailed information to medical students successfully. Many medical lecturers adapt the two-dimensional (2D) platform through lecture slides, whiteboard, medical book references and other traditional ways. While cadavers and mannequins can provide three-dimensional (3D) images, their availability and sustainability are quite challenging despite being regarded as the gold standard in pre-clinical teaching (4). An alternative method is necessary to supplement and assist the current T&L process. One of the emerging techniques in immersive learning through augmented reality (AR) and virtual reality (VR) (5-7).

AR is a combination of real and virtual images in a real-time and real environment, and both images are aligned with each other (8, 9). AR aims to overlay computer-generated visuals onto real-world photos rather than creating a completely artificial virtual environment in VR. AR allows the real-world surroundings to be visible while also enhancing them with virtual 3D visuals. The AR images can be experienced via computer hardware, tablets, smartphones, AR glasses, and other optimised devices.

On the other hand, VR is utilised to immerse the senses with stimuli generated to create the illusion of presence in a simulated or virtual environment (10). It is a real simulated world translated into stimuli that interact via a head-mounted device (HMD). The initial research on HMD for VR was started in 1968 by Sutherland's group (11). The major stimulus delivery mechanism in the current VR-MHD system could deliver sound, vibrotactile feedback, and in some advanced technology, HMD could deliver cool or warm air sensation and different olfactory experiences to VR users (12).

Recently, many AR applications utilised the HMD technology as well. The HMD hardware limitations could induce cybersickness due to the field of view, display resolution, refresh rate, flicker, temporal delays, and input-output latency. Therefore, some developers attempted to improve hardware features like binocular displays, interpupillary distance, and position tracking sensors (13). However, the cybersickness persists despite many technical improvements using current-generation HMDs, and many users reported experiencing undesirable, unpleasant side effects (14).

Contribution of AR and VR to Teaching & Learning
There are many contributions of AR or VR usage in teaching and learning especially in medical and health sciences discipline. Moro et.al reported that both AR and VR are valuable for anatomy teaching and stimulate intrinsic benefits to the end user by increasing the engagement and promote immersive learning (7). Both VR and AR are as valuable for teaching anatomy as tablet devices, but also promote intrinsic benefits such as increased learner immersion and engagement. In one experiment, Cak Mak et.al reported that human muscular arm avatar (HMAA) through AR/ VR platform significantly useful and effectively increase the engagement among users and peers (15). Bork et. al was comparing the AR Magic Mirror system, a 3D AR system that enable users to learn anatomical structure in conjunction to medical image, to traditional radiological atlas. He found that the academic achievement through pre and post-test were significantly improved for the Magic Mirror system (16). Similar academic finding was noted among dentistry students, they were found to have better final exam and overall grade for dental anatomy course when they utilise the AR virtual teeth identification (17). In another study, it is reported that AR emphasised the system's potential to serve as an additive learning resource for anatomical education through active learning by increasing the understanding of the 3D structure through AR (18).

Cybersickness
The term "cybersickness" refers to a cluster of temporary symptoms that a user may experience while or after being exposed to an immersive environment (19). It is not a disease but a natural physiological response to uncommon stimuli. Cybersickness, also known as visually induced motion sickness, continues to be a negative consequence that impairs the user experience of VEs (virtual environments) designed for AR, VR, or other immersive learning platform. Nausea, dizziness, headache, eyestrains, blurred vision, vertigo, difficulty retaining balance, perspiration, and physical discomfort are among the most common cybersickness (20). Moro et. al reported that among the VR users, they are more likely to develop adverse reaction such as headaches, dizziness or blurring of vision as compared to AR and tablet-based application (7). More than 2 decades ago, it was reported that female are more susceptible to cybersickness than males (21). Disproportionate interpupillary distance (IPD) to the VR set was found to be the primary reason of gender cybersickness-related. Female participants with unsuitable IPD to the VR set was significantly found to suffer from cybersickness, however when this condition is adjusted, there was no difference of cybersickness with the male counterpart (22). However, other aforementioned finding disregard the gender susceptibility towards this side effect, but more focus on the visuo-spatial abilities among participants (23).

The frequency and severity of reported cybersickness vary depending on the duration of exposure and the nature of virtual material and display technology. The tendency of having cybersickness is multifactorial, including the type of profession (military or public). Military personnel is less likely to experience unpleasant side effects because they are involved in demanding automobile motions, have a better physical form, or stay immersed in VR longer despite experiencing unwanted symptoms (24).

QUESTIONNAIRES TO SCREEN ADVERSE EFFECTS OF AR & AR

MSQ
Motion Sickness Questionnaire (MSQ) was first developed by comparing the labyrinthine defective (LD) and normal participants, the motion sickness was observed after all participants were flown in zero-gravity manoeuvres. In the zero-gravity manoeuvres concept, the flight reproduces gravity-free condition or microgravity environment for research purpose, without going to the space. The LD groups showed an absence of motion sickness, while 65% of normal exhibited related symptoms (25). The later version was improvised to develop a scale under less extreme stimulation settings (26). The labyrinthine defective (LD) is the group of participants lacking vestibulo-ocular reflex (VOR), where this reflex is required to stabilize gaze during head movement via activation of vestibular system by eye movement. The labyrinth is an inner ear chamber that houses vestibular (balance) and auditory (hearing) organs. Loss of labyrinthine function bilaterally could cause oscillopsia (illusory movement in static environment) and chronic imbalance. LD among students could impair their ability to read and learn via traditional methods, therefore by using VR or AR might help to improve their learning skill as they have lower motion sickness symptoms.

SSQ
The SSQ (Simulation Sickness Questionnaire) was derived from the MSQ (27). This simulator study involved military, aviation, and marine personnel and comprised 16 symptoms corresponding to three types of simulator sickness: nausea (N), oculomotor (O) and disorientation (D) effects. It is a tool for assessing the severity of users' sickness symptoms and is widely used in AR and VR. However, some argued that the SSQ's design was flawed since it was built using data gathered from a select group of highly trained and qualified individuals (13). Furthermore, it has been questioned for its psychometric properties and application in virtual reality to measure cybersickness (13). Nausea (burping, nausea, salivation, stomach awareness) ratings are related to gastrointestinal distress. The oculomotor (blurred vision, difficulty focusing, eyestrain) scores are correlated to visual

distress. Upon testing a group of participants while playing several VR games, the incidence of headache, nausea, perspiration, exhaustion, general discomfort, "fullness of head," and eyestrain are at the top of the VR sickness list (28). The scores of disorientations (dizziness with eyes open/ closed and vertigo) are associated with vestibular distress (13, 27).

Nausea and oculomotor components are VR immersions' most common side effects (14). The findings corroborate the high correlation between SSQ (Simulation Sickness Questionnaire) scores and anxiety, but they also reveal a significant link between anxiety and several SSQ symptoms, even though symptoms were not generated by VR immersion (14). Due to the overlapping of anxiety and cybersickness symptoms, it is suggested that SSQ be reviewed for future research (14). This study recruited general population that suffers from anxiety disorder and healthy controls from several resources including participant from universities. They were given the SSQ before and immediately after VR immersion.

CSQ

Cybersickness Questionnaire (CSQ) is one of the SSQ variants. When compared to the SSQ and F-SSQ (French translation of SSQ), which were meant to evaluate simulator sickness, CSQ and Virtual Reality Sickness Questionnaire (VRSQ) was created to measure cybersickness, which had higher psychometric properties (13).

VRSQ

Virtual Reality Symptom Questionnaire (VRSQ) is another variant of SSQ. The VRSQ was created primarily to assess cybersickness focus mainly on ocular symptoms (29). The questionnaire contains eight non-ocular symptoms and five ocular symptoms, with a scale of 0 (none) to severe (6) (29). However, another different version of VRSQ design focuses on possible human factors that could contribute to simulator sickness, including the calibration of the system, headgear discomfort, image lag and blurriness, auditory glitch, and movement control awareness of body location and other factors (28).

The Recommendation and Opportunities

There are multiple questionnaires to assess the cybersickness in immersive learning. SSQ assesses the N, O and D properties. In comparison, the CSQ offers extra miles of assessment for psychometric elements. The VRSQ is intended to aid game development by reducing virtual reality sickness in particular ocular symptoms. In the future, many opportunities could be done to revisit these questionnaires to integrate other relevant factors contributing to cybersickness, including anxiety and related psychological rudiments, changes in the physiology of cardiopulmonary and neurovascular functions. These could contribute to the optimisation of the AR and VR experience in immersive learning, especially through the Covid-19 pandemic era.

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