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Editorial: Redefining the pedagogy in virtual and augmented reality in medical science education

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Editorial on the Research Topic
Redefining the pedagogy in virtual and augmented reality in medical science education

The modern advancement and interdisciplinary use of virtual reality (VR) and augmented reality (AR) immersive technologies has rapidly evolved and in parallel has also advanced the way medical education is being taught in the 21st century. However, the development of careful, evidence-based reports evaluating which VR and AR technologies, pedagogical methods, and instructional designs are most effective has not kept pace with the rapid increase in reports on educational use of immersive technologies. As a result, there are currently several gaps within the field regarding which immersive technologies and teaching methods have been proven to be effective for instructional learning. The questions that arise from these gaps in the literature seek to address the following: what are the best contexts for integrating immersive technologies into the pedagogical curriculum; what instructional designs work best and why; and how does such VR and AR pedagogy influence the learner's cognitive load when compared to the traditional lecture. These questions are important for the field to address as it moves forward, in order to provide evidence-based teaching and research. Such corroborating evidence will guide the future development of immersive technology pedagogy in medical science education.

As technology and the curriculum for medical science education continues to evolve, it is important to continue to gather papers that serve to *"Redefine The Pedagogy in Virtual And Augmented Reality in Medical Science Education"* to track both the history, the advancements, and to evaluate what has been deemed both effective and ineffective pedagogical developments. These VR and AR advancements have been increasingly sought after since the coronavirus-19 (COVID-19) as a means to keep learning immersive, relevant, and timely. Additionally, the need to create such immersive learning with first-person point-of-view (FP-POV) technology has become increasingly sought after. The first two papers in this Research Topic highlight some of these advancements. A thorough evaluation comparing VR platforms to enhance medical education for teaching procedures to oncology residents was conducted by Shah et al. The pressures brought on by the COVID-19 motivated VR content creators to develop a wide-range of VR educational tools that could improve students' confidence and proficiencies despite the challenges of the pandemic. This pilot study evaluated the cost effectiveness of a low-cost Cardboard viewer VR (CVVR) and commercially available integrated headset VR (IHVR) using a 2D, 360-degree VR video of an intracavitary brachytherapy. The findings indicated that both VR technologies improved self-perceived overall confidence in the procedures with similar results in implant time and objective proficiencies of implant quality. Since CVVR-based programs from the assessment yielded similar results, being ×33 less expensive than IVR, CVVR was recommended for further exploration as a cost-effective alternative to IHVR as a virtual video-based education tool with much promise. Additionally, Neuwirth et al. conducted a pilot study with fourth-year medical students to compare learning outcomes between third-person point-of-view (TP-POV) and FP-POV immersive VR in surgically implanting a subdermal drain on cadavers. The results showed pedagogical learning differences on a single procedural skill motor assessment whereby the FP-POV improved the cleanliness and accuracy of the surgical dissection movement and drain placement with 100% proficiency. There were also significant improvements in the dissection movement and the tension test in the FP-POV group when compared to the TP-POV group. The findings from this study suggest that future VR curriculum could benefit from repeated-measures designs on the surgical procedural motor skills to assess learning curves as more sensitive measures of VR impacts on students' acquired skillsets.

In contrast, to the aforementioned applied medical training using VR, there were a few creative uses of immersive pedagogy assessing education of brain networks, using AR for time-based visual cue displays, and VR for temporal bone dissections. Hellum et al. attempted to overcome the limitations of existing software solutions lacking pedagogically relevant approaches to permit both education and exploration of the complex neural networks of the brain. To address this problem, they designed the immerSive custOmizable Neuro learnIng plAtform (SONIA), a novel, user-friendly VR software system with a multi-scale interaction paradigm permitting a wide-range of flexibility and customizable learning content. Using a combination of quantitative and qualitative assessments, SONIA was found to have high usability, offering attractive visual content with good educational value to its learners. Specifically, college/university-age students with familiarity of neuroanatomy were educated on the brain sub-systems, being able to explore neuroanatomy and its connectivity. Considering these findings in VR advancements, an equal evaluation of AR advancements is necessary to compare pedagogy in medical education.

As such, through AR filters, Stuart et al. developed a pedagogical approach using time-based visual cues in the healthcare system (e.g., moulage to represent symptoms) but found that the current practices are limited in representing how visual symptoms evolve over time. Their work addressed this challenge by developing AR filters to enable real-time interactive visualization of symptom development and how the impact of the object and filter fidelity influenced the second-year nursing students' perceptions. They found that users experienced symptom realism and severity with the AR and perceived the experience to be more realistic when it was overlaid on a real person. They reported earlier identification of symptoms when overlaid on the mannequin, and these symptoms were rated more severely when observed on a real person. Their work opens new directions for using time-based AR display of visual cue filters in early symptom identification, detection, and treatment to reduce worsening of symptoms on case-by-case basis for nurses.

Lastly, Timonen et al. evaluated the feasibility of VR to train otorhinolaryngology residents on temporal bone dissection. They used VR software to design preoperative planning to create 3D models of the imaged temporal bones for dissection training and compared this group with a group that just received dissection training. The groups switched as a counterbalance design and the assessments showed a decreased surgical time for the VR trained group and more efficient ability to identify the anatomical landmarks. This VR training suggested that implementing preoperative VR training could have a positive effect on reducing surgical time, increasing accuracy of the procedure, and offering the same surgical benefits as dissection alone.

In summary, this Research Topic gathers recent empirical results on VR and AR pedagogy to guide advancements in medical science education. As the field of VR and AR have swiftly developed and evolved, the pace of evidence-based pedagogy, assessment, and standardization for developing medical training through immersive technologies has not advanced at the same rapid pace. Thus, more work in the next decade will be required to advance the field through additional, more intentional efforts in redefining the best pedagogical practices for student learners at the medical and graduate professional training levels, which have the highest potential for applied translations and generalization. By standardizing these pedagogical efforts, we can learn how to tailor the pedagogy for student learners at the undergraduate, high school, and K-12 levels to be more able to utilize AR and VR for future careers in the medical fields. This approach will not only introduce VR and AR earlier in the curriculum but also scaffold their procedural learning skill sets throughout their educational years. This will help students at all learning levels to integrate these procedural skill sets in accordance with Bloom's taxonomy of learning (i.e., remembering, understanding, applying, analyzing, evaluating, and creating content). What can be foreseen is an emergent immersive curriculum that can produce richer applied learning experiences with more memorable content through procedural skill sets that enhance and supplement the students' content knowledge; all of which serves to educate students by increasing their competencies and proficiencies, and reducing errors when working in a wide range of medical sciences.

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