LETTERS TO THE EDITOR

Considerations for the value of extended reality versus ex cathedra format for neuroanatomy education

TO THE EDITOR: It was our pleasure to read the very interesting paper by Sandralegar et al., who implemented mixed reality (MxR) for neuroanatomy teaching and found that this technology led to greater participants’ knowledge in comparison with traditional ex cathedra teaching (Sandralegar A, Bernard F, Khatchatourou S, et al. Mixed reality compared to the traditional ex cathedra format for neuroanatomy learning: the value of a three-dimensional virtual environment to better understand the real world. Neurosurg Focus. 2024;56(1):E14). We agree that MxR has the potential to become a powerful neuroanatomy education tool, given that it can offer 3D visualization of the nervous system. We would like to comment on the aforementioned finding of this interesting study and on the interpretation that was provided.

After teaching with 3D MxR visualization versus the traditional ex cathedra format, the authors attributed the greater knowledge gain, especially about the anterior circulation arteries, to greater complexity compared to white matter fiber tracts. It was also stated that the use of augmented reality (AR) is favorable for complex 3D anatomy teaching and that some studies that assessed the value of AR and virtual reality (VR) also used vascular models.2,3

We would like to point out that, in the two cited studies that used vascular models,2,3 the use of 3D visualization did not lead to significantly superior neuroanatomical knowledge gain compared to the use of 2D methods. In other words, cerebrovascular anatomy, despite its complexity, was not more effectively taught via 3D visualization compared to 2D visualization. Especially, in the paper by Greuter et al.2 the use of 3D VR did not lead to significantly better understanding of cerebrovascular anatomy in comparison with the use of 2D images. Also, in the study by Stepan et al.,3 the use of 3D VR for the study of complex neuroanatomical structures, including the ventricular system and cerebral vasculature, was not accompanied by significantly greater knowledge gain compared to the use of 2D methods. To the best of our knowledge, there is a lack of evidence that the effectiveness of VR, AR, and MxR in neuroanatomy education increases in proportion with the complexity of structures.

Regarding AR, the study by Henssen et al.,4 which was also cited, showed that this technology was not favorable for neuroanatomy education. More specifically, AR was a significantly less effective neuroanatomy teaching method than the use of cross-sections. In this study, this significant difference was especially noted in the cross-sectional neuroanatomy questions. Thus, cross-sectional neuroanatomy knowledge was found to be more effectively conveyed with ex cathedra methods.

We certainly agree with Sandralegar et al.3 that the 3D visualization provided by VR, AR, and MxR is an important advantage of those technologies. However, at present, there are aspects of neuroanatomical knowledge that seem to be better, or at least equally effectively, delivered with specific methods that belong to ex cathedra teaching.

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Response
We would first like to express our gratitude to Salmas et al. for their interest and for having carefully reviewed our article. Their letter provided a thoughtful critique of our study, particularly regarding previously published results in neuroanatomy education using 3D.

While we appreciate the studies Salmas et al. referenced, including those by Greuter et al., Stepan et al., and Henssen et al., we respectfully disagree with the interpretation of their findings in relation to our research. Our study specifically focused on the utilization of MxR technology, which encompasses a broader range of immersive experiences beyond AR alone. We found that MxR, with its ability to provide 3D visualization of neuroanatomical structures, significantly enhanced participants’ understanding and retention of complex anatomical details, particularly regarding the anterior circulation arteries.

Concerning the study by Henssen et al., which compared a traditional neuroanatomy learning method based on cross-sections (control group) to a method using AR as a tool, it is crucial to consider the impact of the cross-sectional questions in the comparison methodology as the results favor the control group. However, once these questions are excluded, the authors found that the results either favor the AR group or show that AR is equally efficient as the cross-section method. This nuanced perspective underscores the importance of carefully evaluating the methodologies and outcomes of studies in the field of neuroanatomy education.

Regarding the study by Stepan et al., which compared learning neuroanatomy using textbooks to using AR, we would like to clarify that we did not claim that AR achieves better results than traditional teaching methods. Rather, we emphasized its value in the context of teaching cerebral vascular anatomy regarding engagement. The authors concluded that using AR is as effective as using textbooks. This distinction is important to note, as it highlights the possible applications of AR within neuroanatomy education.

Greuter et al. assessed the speed at which neurosurgery residents and medical students detected an aneurysm using either a 2D model or VR with a 3D model. We must refute the assertion that their findings do not demonstrate a benefit for AR. On the contrary, Greuter et al. highlighted that medical students, particularly those with limited anatomical and clinical experience, derived significant advantages from using 3D VR. The notably shorter time to detect an aneurysm in the 3D VR group emphasizes the efficacy of AR models in improving students’ performance and spatial visualization abilities.

Of course, the discrepancy between our findings and those of previous studies may be attributed to several factors, including the specific methodologies employed, the nature of the neuroanatomical content studied, and the major technological advancements in MxR during the last couple of years (such as the goggles used for the purpose of the study).

In conclusion, while we appreciate the insights provided in the letter to the editor, we firmly stand by the conclusions drawn from our research. MxR holds considerable promise as a powerful tool for neuroanatomy education, offering new opportunities for enhanced visualization, engagement, and learning outcomes.

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