How 3D Printing Software Enhances and Rewards Student Learning of Brain Anatomy

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EDITOR NOTE

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ABSTRACT

Dear Editor,

I am a medical imaging student at Curtin University who is exploring the use of three-dimensional (3D) printed models of human anatomy as an educational tool for health professionals, students, and patients. Volumetric medical imaging datasets, typically Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) images can be post-processed and segmented to produce 3D virtual anatomical models which may then be 3D printed. The resulting physical anatomical models support kinaesthetic learning by providing a tangible and spatial representation of complex anatomy. Access to 3D printing as an educational tool is currently limited by the high cost of commercial software, hardware and 3D printing facilities, and a lack of defined protocols and techniques to achieve accurate and time-efficient segmentation.

Image segmentation involves using manual, semi-automatic, and fully automatic processes to mark/select the voxels within a volumetric dataset which correspond to the anatomical structure chosen to be reconstructed as a 3D virtual model. Learning how to segment volumetric imaging data has significantly improved my knowledge and

understanding of anatomy. It has increased my understanding of medical imaging informatics, particularly the relationship between original DICOM (Digital Imaging and Communications in Medicine) and alternative image formats, and has built my appreciation of how CT and MRI protocols impact image reconstruction. The learning process has been highly engaging and genuinely enjoyable. This letter aims to share my experience and demonstrate how creating segmentations with 3D imaging software can enhance student learning of brain anatomy.

I used open-source software tools 3D Slicer (Brigham and Women's Hospital, Boston, Mass) and volBrain (Valencia Polytechnic University, Valencia, Spain and University of Bordeaux, Bordeaux, France) to produce segmentations suitable for 3D printing of cranial structures, including the frontal, temporal, parietal, occipital, insular and limbic lobes; four main cerebral ventricles; brain stem; and cerebellum. The literature supports the use of 3D Slicer and volBrain to calculate cranial volumes and produce 3D visualisations for research, and for clinical applications where regulations allow[1]. 3D-Slicer is increasingly used in image post-processing and segmentation and has been shown to achieve the same goal as commercial software tools for 3D printing purposes.

3D Slicer is a free, open-source software designed to process, visualise, and analyse 3D MI data. Extensions are available which massively increase the capabilities of the software beyond basic segmentation and there is a large online community for support[2,3]. VolBrain is a free, online platform which uses T1-weighted MRI data to produce detailed segmentations of the brain which measure total brain volume and intercranial volume. The process is fully automated and only requires the user to perform a file conversion from DICOM to NIFTI (Neuroimaging Informatics Technology Initiative) format[4].

I learned to operate 3D Slicer via online tutorials provided on their website and several invaluable face-to-face tutorials with more experienced users at Curtin University. I