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Letters to the Editor | Medical Education

Visualization in Anatomical Sciences for Effective Teaching and Learning

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Abstract
Anatomy is one of the basic subjects of medical science. Medical students gain detailed knowledge of human body by dissecting cadavers. Hence, cadaveric dissection has become an essential tool in teaching and learning anatomy. In anatomy, visualization plays an important role in understanding the spatial orientation of structures. Due to technological advancement and a shortage of cadavers, there is a need to look for various complementary tools which can provide an adequate visualization of bodily structures. This issue was very well understood and reflected during the recent pandemic when cadaveric dissection was substituted by experimenting with various teaching tools. In this paper, we have tried to briefly describe the various options that can complement/supplement dissection and assist in self-directed learning.

Keywords
Visualization; Anatomy; Medical Education; Teaching Tools; Technological Advancement

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Background

Dear Editor-in-Chief of the Galician Medical Journal,

Recently, we have come across an interesting article discussing the importance of visualisation and integration of new technologies in teaching anatomy to medical students [1]. Studying anatomy includes the study of tissues and organ systems and their three-dimensional (3D) orientation [2]. Sound knowledge of anatomy is essential for understanding disease process, future clinical practice, as well as for acquiring surgical skills and interpreting radiological images [3]. Therefore, it becomes mandatory for a medical undergraduate to have an optimal understanding of the key concepts, spatial orientation of tissues and their relationships. Anatomy is often taught with the aid of textbooks and didactic lectures involving 2D images [4]. Without well-dissected specimens or cadavers, the knowledge of anatomy gained through the atlas/textbook illustrations is limited and it causes a significant cognitive load on a student when they try to convert 2D perception to 3D knowledge [5]. Learning anatomy includes two vital components - visualisation and observation [6]. The ongoing pandemic with infrequent lockdowns has seriously necessitated exploring the available resources or modalities, including self-directed learning (SDL), for effective teaching dynamic 3D anatomy in virtual scenarios as well [7, 8]. Moreover, a medical teacher has faced a significant challenge to convey the complex dynamics of anatomy by simply using handmade models, leaving the imagination to students [9, 10]. This letter to editor addresses the vital role of visualisation techniques in teaching and learning anatomy in the current digital era.

Concept of Visualisation in Anatomy

While delivering learning content, it is essential for an instructor to be aware of the preferred learning modality and background knowledge of students [11]. Although students are usually categorised into different groups based on their learning preferences using the VARK model (visual, auditory, reading/writing, and kinaesthetic modalities) the concept of modality appropriateness advocates that the steps used to deliver learning content are directly related to the disciplines being studied. Such modalities do not depend on or are no superior to learning preferences of a student [12]. Hence, the implementation of learning styles should not be restricted to students' preferences; they should rather be used appropriately depending on how effectively the modality can help in effective understanding the subject. Learning anatomy is not limited to assessing the structures in the cadaver/specimen, it requires understanding the microanatomy of structures, their relative size and orientation and identifying those structures on radiological images [1]. For this purpose, in addition to cadaveric dissection, anatomy is taught and presented to students visually, using microscope and clinical images. Therefore,

the implementation of visual methods in learning anatomy might be more relevant, with respect to the modality appropriateness model [13]. Furthermore, the recognition of 3D concepts is known to be one of the vital areas a medical student should be aware of when learning anatomy, especially when understanding the dynamics of embryology and 2D cross-sectional images [14, 15].

Cadavers are known to be the best teachers in revealing the intricate anatomy of the human body. There is no doubt that ongoing pandemic has caused a significant decrease in the availability of cadavers for anatomy learning [16]. Apart from that staggering body donation program and the cost of running dissection labs, ethical issues have caused hindrance in universal adoption of wet lab teaching to medical students [2]. Despite having a good collection of specimens and various teaching modalities, students reported insufficient knowledge of anatomy, especially 3D orientation [17]. Studies have concluded that students prefer using 3D models over 2D images to better understand the concepts [5]. There is an ongoing debate about the advantages and disadvantages of using Technology Enhanced Learning (TEL) rather than cadaveric dissection. TEL approaches are often practised to improve the study of clinical anatomy.

Recent Technologies Related to Visualisation

There is a positive correlation between spatial ability and anatomy learnt as the skills that make up spatial ability are vital and widely applied when students integrate new technologies such as Anatomage and Sectra 3D printed anatomical models, decomposable X3D models, volumetric anatomical data visualisation, and digital autostereoscopic 3D visualisation technology in learning anatomy [18]. In addition, 3D printing of DICOM images can produce better models in certain challenging areas where the resources are scarce. Stereoscopic 3D visualisation is much more evolved technology which provides an intuitive and alluring spatial orientation of different organs and organ systems. Most of the 3D anatomy resources are displayed on a computer screen (2D) which reduces the three-dimensional perception a student is supposed to have. Stereoscopic visualisation overcomes this limitation by providing textbook-level stratified view of the human body with 3D glasses [19, 20]. A few technologies are presented below:

Augmented reality (AR)

This technology provides users with an experience of real-world environment with computer-generated perceptual information. It is mainly used to provide enhanced visual perception of the environment. The primary advantage of AR is that it manages to blend digital and 3-dimensional components. The user will perceive the environment with added information or masking the part of the environment using glasses/smartphones [21]. This technology can help students understand 3D orientation of organs and organ systems in case there is a shortage of cadavers available for dissection.

Virtual reality (VR)

This technology enables users to construct virtual 3D model of any structure/region that will be imported to the VR platform using appropriate software. Such models can be visualised, rotated, and scaled by the user with VR controllers [22].

3D Web- and PC-Based Software

This technology helps incorporate 3D human models to a learning management system (LMS). Interactive visualisation can be created based on user's need. Such software is used in virtual dissection tables which visualize the structures in virtual cadavers [23, 24].

The identification of anatomical structures in clinical practice is a professional requirement. Using visualisation techniques in anatomy should not be limited to simply demonstrating and interpreting radiological images; it should rather be aimed at preparing medical students for effective using such techniques in their future practice [25]. In this regard, teaching radiology through technology-assisted visualisation should be effectively integrated in anatomy learning [26].

Conclusions

With the wide implementation of interactive online tutorials, it is important that this learning technologies to be checked for their practical implementation beyond the face-to-face learning environment in order to support modern approaches such as SDL. As the latest technologies can provide 3D visualisation of the human body, they can reduce the cognitive load of students to some extent. They play a significant role when there is a shortage of cadavers and inevitable need for SDL. Hence, increasing the resources and options available for SDL can greatly help medical students. In addition, learning visual anatomy can be effectively catered to students via e-learning sources.

Ethical Statement & Informed Consent

Not applicable.

Data Availability

There were no new data generated, data sharing is not applicable.

Conflict of Interest

The authors declare that no conflicts exist.

Financial Disclosure

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