



## Review Article

# Different approaches for teaching and learning anatomy and future directions

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### ABSTRACT

Anatomy has been educated using different methods including didactic lectures, practical sessions based on models, cadaveric dissection, and computer-based learning. Covid-19 pandemic crisis led to an immediate alteration to distance learning by most of higher education institutions. The aim of this paper is to review the different traditional and recent anatomy educational approaches to know the appropriate approaches to use with Covid-19 pandemic and to plan for future education.

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## 1. Introduction

Human Anatomy is one of the most important basic medical sciences and has a crucial aspect of medical education that is relevant to all health care specialties (Zilverschoon et al.,<sup>1</sup> 2017). Therefore, medical students need to gain the essential anatomical knowledge to build a strong basis for future clinical and qualified practice. Anatomy teaching is undertaken several changes with the adoption of modern effective teaching and learning approaches. Several studies described the benefits of multimodal teaching by integrating, dissection, modernized digital technology, and problem-based learning (Vertemati et al.,<sup>2</sup> 2018). Recently, Anatomists face the pressures of the changing modes of medical education and assessment, with few teaching contact hours, and limited resources to teach an enormously diverse group of students (Singh et al.,<sup>3</sup> 2019). Furthermore, Covid-19 pandemic with the widespread application of self-isolation guidelines and social distancing. It is not clearly reasonable for teachers and students to attend lessons or assessments and an urgent need for many

institutions to quickly implement an alternative educational and assessment methods (Longhurst et al.,<sup>4</sup> 2020). The aim of this paper is to review the various traditional and recent anatomy educational methods and the influence of Covid-19 pandemic on the present and the future of the anatomy education.

As early as 2003, some methods for anatomy education were reported (Brenner et al.,<sup>5</sup> 2003). These education methods are in person- lectures, cadaver dissection, prosected specimens, models, radiological- living anatomy teaching and computer-based learning, for example, AR, VR, and 3D (Iwanaga et al.,<sup>6</sup> 2021).

## 2. Lectures

Anatomy lectures follows the learning objectives in which a lecturer presenting academic contents to a group of students. The traditional teaching lectures method requires the presence of the students in a specific location like lecture hall or classroom on precise time (Chang et al.,<sup>7</sup> 2019). Recently, student-centered policies such as flipped classroom, team-based learning and case based learning have shown to improve student collaboration, commitment

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and shift the focus of teaching from knowledge transmission to knowledge construction by the students (Bell et al.,<sup>8</sup> 2019). Engaging recent and alternate approaches in medical education has become crucial element today. Some anatomy classrooms use a wide range of technology in the form of e-textbooks, 3 D atlas, CD-ROMs, models and simulations(Singh et al.,<sup>3</sup> 2019).

### 3. 3D atlas

3D atlas applications are designed as new learning materials in which applications are tablet-based software that permits students to touch and rotate the virtual bodies and recognize the spatial relationships. 3D atlas is not very helpful in memorizing the location of anatomical structures or gaining deep anatomical knowledge but it can simply help in the quick identification of the anatomical structures. The 3D atlas will show good link with 2D atlas if used properly in the gross anatomy (Park et al.,<sup>9</sup> 2019).

### 4. Plastic Models

Plastic models have been used to avoid problems associated with cadaveric dissection (McLachlan,<sup>10</sup> 2004). The plastic models are in common use in high schools and medical schools, but anatomical specimens are often lack essential specific details. Plastic models are suitable for some basic simple teaching purposes but not ideal for teaching detailed anatomy required in most of anatomy medical courses (McMenamin et al.,<sup>11</sup> 2014).

### 5. Simulation

Simulation is one of the educational methods implementing in the basic course of the anatomy (Torres et al.,<sup>12</sup> 2014). It is a technique, which substitutes or strengthens doctor and patient experiences in controlled settings and therefore evokes or repeats considerable aspects of the real world in a fully collaborative manner. Through simulated patients and peer examination, anatomy can be studied in the living body and this technique is very useful in studying bones, joints, muscles, peripheral nervous system and abdominal organs (Chang et al.,<sup>7</sup> 2019; McLachlan,<sup>10</sup> 2004).

### 6. Dissection

Cadavers have been always used in teaching anatomy and it is the gold standard simulator for the living anatomy (Darras et al.,<sup>13</sup> 2018). Cadaver dissection is the traditional method of teaching anatomy after theoretical classes and discussions on the atlas pictures. Some of the distinctive aspects of cadaveric dissection include the realistic environment of this teaching method that allows students to have and know clearly the organization of human body and experience the texture of the human tissues (Dissabandara et al.,<sup>14</sup> 2015). Cadaver

dissection supports medical students in understanding the relationship of different anatomical structures, appreciating the anatomical variations and contributes significantly to a future professional work (Ghazanfar et al.,<sup>15</sup> 2018). Most students showed preference for having the choice to join dissection during their anatomy education (Whelan et al.,<sup>16</sup> 2018). In addition, surgical practices based on adequate anatomical knowledge of human anatomy which can be learned from cadaver dissection training contribute to an increase in surgical efficacy and self-confidence (Lim et al.,<sup>17</sup> 2018). Disappointingly, cadaver dissection is redundant from the anatomy curriculum in some medical schools due to shortage of cadavers, insufficiency of anatomists and short courses (Samarakoon et al.,<sup>18</sup> 2016). Dissection can necessitate recurrent access to dissecting rooms and laboratories by students which can be challenging to achieve mainly in institutions with limited resources. Furthermore, in some countries, dissection is prohibited due to religious (McMenamin et al.,<sup>11</sup> 2014). A review published of anatomical dissection as a teaching method in medical schools have been shown that a number of studies suggested dissection as a superior method of learning in comparable to non-dissection methods while some studies were of a conflicting opinion (Winkelmann,<sup>19</sup> 2007). Contradictory opinion from some students about cadaver dissection can be improved by preparing students effectively before the dissection sittings by using other methods of learning such as introductory lectures, prosection and model-based meetings prior to the dissection activities and by providing suitable guidance during the dissection sessions (Dissabandara et al.,<sup>14</sup> 2015).

### 7. Prosection

In the absence of cadaver dissection, prosected specimens (the use of pre-dissected cadaver specimens) have been widely used in the teaching anatomy to medical undergraduate students (Collins,<sup>20</sup> 2008). Interestingly, anatomical knowledge proceeding to prosection influenced the short term retention of the knowledge (Lackey-Cornelison et al.,<sup>21</sup> 2020).

### 8. Plastination

Plastination technique has been developed and is one of the best methods for preservation of organic tissue. It is widely used in anatomy to develop robust anatomical specimens of the whole body or body parts. In 1977, Dr. von Hagens in the Department of Anatomy at the University of Heidelberg planned plastination method for conserving anatomical specimens with reactive polymers (von Hagens,<sup>22</sup> 1979). In plastination technique, water and lipids in the biological tissues are replaced by polymers such as silicone, epoxy and polyester. After the hardening of these materials, odourless, dry, long-lasting and easily transported specimens were

obtained (Sora et al.,<sup>23</sup> 2019). In sheet plastination, semi-transparent slices of tissue are obtained and students become easy to study the structural and topographical anatomy in detail (Sora et al.,<sup>24</sup> 2012). Plastination procedure offers fully preserved specimen without any foul smell or toxic fumes (Hayat et al.,<sup>25</sup> 2018). Specimens can be preserved and storage easily for longer times more than that of conventional method (Haque,<sup>26</sup> 2017). Plastination is not a replacement for traditional guided cadaveric dissection, but it does offer an additional learning implement to know and understand complex human anatomy (Riederer et al.,<sup>27</sup> 2014). Importantly, some students from recent studies have proved that the use of plastinated specimens is useful when learning anatomy (Latorre et al.,<sup>28</sup> 2016). Learning anatomy only in plastinated specimens is a compromise because of its restrictions in terms of tactile and emotional experience and skills that is delivered by wet cadavers (Fruhstorfer et al.,<sup>29</sup> 2011).

### 9. Body Painting

Body painting is used to assist the living anatomy, clinical skills classes and traditional anatomy courses. Several structures such as bones, muscles, vessels, nerves, and internal organs are painted on real living body and allowing for easy examination and palpation (Jariyapong et al.,<sup>30</sup> 2016). The costs are cheap and the entertaining activity can be concomitantly achieved with large classroom size. Using body painting exercise is helpful to promote active learning and increased knowledge retention whereby student's pursuit for tools to accomplish understanding of the subject instead of just repeating what they have learned in the anatomy classes (Jariyapong et al.,<sup>30</sup> 2016; Finn,<sup>31</sup> 2018). The colourful visual images of different structures were achieved after painting exercise, increased their memory and fun while learning (Nanjundaiah, Chowdapurkar,<sup>32</sup> 2012). In this technique, students are changed their position from being a listener to being a teacher. Importantly, body painting is also useful to understand the surface anatomy and its relation with underlying structures (Philip et al.,<sup>33</sup> 2008). Surface anatomy is a way of bringing the cadaveric anatomy to the life and body painting aids to reach that goal (Finn,<sup>34</sup> 2015). Furthermore, this process of painting and examining acts as being beneficial for future clinical practice (Cookson et al.<sup>35</sup> 2018 and Jack et al.<sup>36</sup> 2012).

### 10. Radiology

Diagnostic images and the understanding of these images require a solid thoughtful of anatomy and its normal variants. These images has been aided in narrowing the gap between the basic anatomy and the clinically applicable anatomy which many believe has been deficient (Jack et al.,<sup>36</sup> 2012). Radiology teaching such as ultrasonography, computed tomography (CT), magnetic resonance imaging

(MRI) and x-ray offers in vivo visualization of the anatomy, as an addition to traditional ways and gaining approval to further strengthen the learning of anatomy in the practical situation (Chaudhury et al.,<sup>37</sup> 2019).

### 11. 3D Printing

The three-dimensional (3D) printing is a modern enjoyable, effective method in which a 3D computer model is converted into a physical object (Silver,<sup>38</sup> 2019; Garas, et al.,<sup>39</sup> 2018). 3DP digital models can be made of several materials such as nylon, polyvinyl alcohol, polyacetic acid, acrylonitrile butadiene styrene, wood, metal, and carbon fiber filaments (Iwanaga et al.,<sup>6</sup> 2021).

Some of students found 3D printed models are more flexible and durable in comparable to conventional plastic models (Mogali et al.,<sup>40</sup> 2018). But, if students only have access to 3 D printed models, it could lead to a deficiency of understanding the real size and the relation to other anatomical components (Huang et al.,<sup>41</sup> 2018). Furthermore, the research on 3D printing of the foregut, archived fetal materials and organs, using a donated body or 3D files on the internet, are of ethical implication (DG,<sup>42</sup> 2019).

### 12. Virtual reality/Augmented reality

In virtual reality (VR), the user is fully immersed and feels present in a virtual setting. In augmented reality (AR), virtual objects such as anatomical models are superimposed into the user view of the real world. Models can be exhibited on an individual basis through devices including desktops, mobiles, head mounted devices and to broader audiences with stereoscopic projectors and screen-based AR systems. Students who used mobile AR had significantly higher test scores than those used text, two-dimensional pictures and graphs, are reported (Küçük et al.,<sup>43</sup> 2016). These technologies are still innovative and research on the usefulness is rare (Heather et al.,<sup>44</sup> 2019).

### 13. Virtual Dissection

Virtual dissection or digital dissection provides students with the innovative learning opportunities in anatomy. Now, virtual dissection is achieved on anatomy visualization table. Patient CT scans are loaded on a near life-size computer screen and through the powerful software interactions, students can operate the data to accomplish their dissection. Importantly, virtually dissection of the CT scans, through touchscreen, students can work in groups to understand the complex anatomic relationships and one of the best techniques to prepare medical students for clinical practice (Darras et al.,<sup>13</sup> 2018; Darras et al.,<sup>45</sup> 2019). Unfortunately, students interacting with only touchscreen, they are not able to appreciate the way bone, tendons, muscle feel and loss of haptic feedback accompanies

cadaveric dissection (Darras et al.,<sup>13</sup> 2018).

#### 14. Social Media

Social media gained popularity in the anatomy field and becoming increasingly recognized as educational help to the anatomy educators (Pollock, Rea,<sup>46</sup> 2019). Facebook pages created by anatomists and most of the student users observing that interacting with the anatomy education pages helped their learning (Pickering, Bickerdike,<sup>47</sup> 2017). The best way to teach and learn anatomy is through cadaveric dissection, but because the limited resources and access to such facilities so the social media could fill the gap (Iwanaga et al.,<sup>6</sup> 2020; Rai et al.,<sup>48</sup> 2019). Human cadavers or cadaveric material images or videos are being shared on public and this has a major ethical implication since there is no clarification of cadaveric source or consent received from the donors to share (Hennessy et al.,<sup>49</sup> 2020).

#### 15. Influence of Covid-19 Pandemic on Anatomy Education

Coronavirus disease 2019, Covid-19, pandemic has been driven the fastest alterations to higher education across the world, required by social distancing measures avoiding face-to-face teaching. This has led to an almost direct switch to distance learning by most of the higher education organisations (Longhurst et al.,<sup>4</sup> 2020). A number of universities including the medical schools through the world passed from these Covid-19 pandemic experiences and had to familiarize to a new distant environment in order to remain providing the medical education to their students (Longhurst et al.,<sup>4</sup> 2020 ; Pather et al.,<sup>50</sup> 2020).

Dr Saverino suggested that the study of anatomy with cadaver dissection has become almost non-existent in most of the medical schools due to the deficiency of the number of corpses as compared with the increasing number of students. Furthermore, this dissecting cadaver practice would be impossible in this pandemic time due to COVID-19 (Saverino,<sup>51</sup> 2020). Other authors proposed that teaching anatomy with dissection in the time of COVID-19 pandemic is important and possible. Three main things are mandatory for this to occur safely such as non-infectious cadavers, mechanisms to meet the demands of social distance, and the institutional commitment to remain training physicians using the best possible approaches (Ross et al.,<sup>52</sup> 2020).

In India, some authors present some of their experiences on pandemic time teaching due to COVID-19. Initially, few faculties started with sending power points and YouTube links to students to make successful process, but some of students have been a lot of confusion regarding the new teaching technique. Few institutions started with online teaching using platforms such as Zoom, Google Meet and Webex. Authors continue experience in their institution (All India Institute of Medical Sciences, Bathinda) by taking students' opinion regarding online teaching method. They

found some of students from either rural or suburban areas facing network issues and were not in favour of online platforms. The anatomy department started used video lectures with recorded narration and students found this useful. By time, most of students found agreement with online discussions using Google classroom, followed by an online assessment such as quiz competition (Patra et al.,<sup>53</sup> 2020).

#### 16. Conclusion

Students must receive an appropriate and adequate training in the anatomy education. A shift to virtual anatomy education is significant to support the learning of students in COVID-19 crisis (Singal et al.,<sup>54</sup> 2020). The anatomists are encouraged to explore and revisit all possible teaching approaches to improve and develop renovations in the anatomy education. Recognizing difficulties facing teachers and students in COVID-19 pandemic to develop new strategies to help them is an essential. Further studies should be recommended from different medical schools all over the world to collect and analyse the feedback of students and teachers which will be helpful for an appropriate and timely adjustments in the online anatomy education and assessments.

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#### 18. Conflict of Interest

None.

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