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VIEWPOINT

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A review of anatomy education during and after the COVID-19 pandemic: Revisiting traditional and modern methods to achieve future innovation

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Abstract

The coronavirus disease 2019 (COVID-19) pandemic has had enormous effects on anatomy education. During the pandemic, students have had no access to cadavers, which has been the principal way to learn anatomy since the 17th century. As it is difficult to predict future access to cadavers for students or in-person classes, anatomy educators are encouraged to revisit all possible teaching methods in order to develop innovations. Here, we review anatomy education methods to apply to current and future education.

KEYWORDS

anatomy education, teaching, cadaver, COVID-19, dissection, medical education, novel coronavirus, SARS-CoV-2, technology, virtual

1 | INTRODUCTION

Anatomy is considered the "basis of the medical sciences", through the study of which healthcare providers acquire basic knowledge to build a solid background (Saverino, 2020). The coronavirus disease 2019 (COVID-19) pandemic has had enormous effects on anatomy education (Franchi, 2020). It was believed that students' experience of dissection had decreased before the pandemic, although cadaveric dissection is invaluable for developing skills (Drake, McBride, & Pawlina, 2014; Krähenbühl et al., 2017). Saverino (2020) indicated that anatomy education with cadaveric dissection has decreased in many medical schools because the number of donated bodies has been far outstripped by the growing number of students, particularly during the pandemic, although the situation could differ among areas and countries. It is understandable that both the quality and amount of education that students can receive from schools is now lower than before the pandemic (Franchi, 2020). According to the Centers for Disease Control and Prevention (CDC), the COVID-19 outbreak could be of a long duration (CDC, 2020), which no one can yet estimate.

The use of technology in anatomy classes has increasingly become popular, as it can allow students to learn more interactively. Further, many studies have concluded that students are motivated and interested in using such technologies as augmented reality (AR) and virtual reality (VR) (Saverino, 2020; Triepels et al., 2020). These technologies can enable students to understand anatomical structures three-dimensionally, as they can observe them from many different viewpoints. Thus, such technologies could significantly contribute to learning anatomy during the pandemic. Technologies could also provide an alternative teaching method to cadaveric dissection if social distancing is required for a protracted period or schools do not allow students to dissect cadaveric specimens (Longhurst et al., 2020). Surprisingly, Brenner, Maurer, Moriggl, and Pomaroli (2003) proposed using six techniques for anatomy education as early as 2003: in-person lectures, cadaveric dissection, inspection of prosected specimens, models, living and radiological anatomy teaching, and computer-based learning, including VR, AR, and 3D.

Active learning methods such as flipped classrooms, problem-based, team-based, and case-based learning, and audience response systems, are learner-centered methods developed for use beyond traditional large group lectures (Bell et al., 2019; Gleason et al., 2011; Tsang & Harris, 2016). However, some believe that no other type of learning can replace human cadaveric dissection.

Cadaveric dissection has been the "gold standard" for anatomy teaching in the medical curriculum since the 17th century (Hidebrandt, 2010). It is widely accepted that the human cadaveric dissection process helps students understand the 3D relationships among anatomical structures and reinforces the contents of textbooks and lectures (Aziz et al., 2002; Ghosh, 2016; McLachlan, Bligh, Bradley, & Searle, 2004; Moore, 1998). However, it is becoming ever more difficult to hold cadaveric dissection laboratories because of COVID-19, as it is nearly impossible for students to engage in social distancing in that context. Accordingly, anatomy educators require alternative teaching methods. Most studies have compared one or two newly-developed methods to traditional teaching, revealing their advantages/disadvantages. The number of students and educators, the number of available specimens, the modalities, spaces, and classrooms, and even access to the internet, vary among schools. Therefore, educators should be prepared to use all innovative methods in any situation. The goal of this paper is to review the different learning methods reported, from traditional to innovative, to discuss the future of anatomy education.

2 | DISSECTION

It has been considered that cadaveric dissection is useful not only for learning anatomy but also in the interests of ethics and humanity (Souza, Kotian, Pandey, Rao, & Kalthur, 2020). As the expansion of "medical education" has limited the time and lab space available for "anatomy education", the quality of anatomy teaching could be seriously impaired (Zhang et al., 2019). At the end of the debate following a symposium entitled, "Do we really need cadavers any more to learn anatomy in undergraduate medicine?" (McMenamin et al., 2018), the audience was evenly split on the need to use cadavers to teach anatomy to medical undergraduates; and of course, this subject is controversial (Dharmasaroja, 2019). Stephens, Rees, and Lazarus (2019) conducted a cross-sectional and longitudinal qualitative study to analyze the contribution of cadaveric dissection to modern anatomy pedagogy. Their study revealed a rich synergy between students' anatomical education and their ethical perceptions and highlighted the potential for integrating anatomy with ethics education. Participants in this study perceived five major themes related to the cadaveric dissection of donated bodies and medical ethics, that is, dignity, beneficence, consent, and justification versus the necessity of dissection, and the dichotomy between objectification and personification.

3 | PROSECTION

Lackey-Cornelison, Bauler, and Smith (2020) compared the effectiveness of learning via dissection or prosection and found no difference. However, different studies have given varied results (Cuddy, Swanson, Drake, & Pawlina, 2013; Whelan, Leddy, & Ramnanan, 2018; Winkelmann, 2007). Interestingly, even today's students recognize the benefits of dissection and indicate a strong preference for having the choice to participate in cadaveric dissection during their anatomy education (Whelan et al., 2018). In addition, anatomical knowledge prior to prosection or dissection influenced the short-term retention of knowledge more than the learning modality did (Lackey-Cornelison, Bauler, & Smith, 2020).

4 | PLASTINATION

Outcomes of studies on the use of plastination in anatomy education are limited and are based mostly on students' reactions and perceptions (Chytas et al., 2019). The value of using plastinated rather than fresh-frozen cadavers in teaching is unclear, although one study found that plastination was more acceptable to second-year than first-year medical students (Baker, Slott, Terracio, & Cunningham, 2013; Haque et al., 2017). According to Azu, Peter, Etuknwa, and Ekandem (2012), 33.3% of the participants believed that cadavers could not be replaced with plastination, and Bhandari, Acharya, Srivastava, Kumari, and Nimmagada (2016) reported that approximately two-thirds of their respondents wanted to have the additional experience of cadaveric dissection.

5 | VIDEO

Several studies of dissection videos have shown that anatomy exam scores are generally no better than historical controls (Granger & Calleson, 2007; Mahmud, Hyder, Butt, & Aftab, 2011; Saxena, Natarajan, O'Sullivan, & Jain, 2008). According to Topping (2014), dissection videos are useful for bridging the gap created by an 11% curriculum reduction. Another study showed that students in osteology scored higher marks with the traditional method than the visually-aided method (Viswasom & Jobby, 2017). In general, students tend to like video learning and report that it enhances their learning satisfaction (Alameddine, Englesbe, & Waits, 2018; Autry et al., 2013; Chen & Wu, 2015).

However, Langfield, Colthorpe, and Ainscough (2018) indicated that anatomy videos alone do not improve students' learning outcomes because they constitute passive learning. They suggested that videos should be used as active learning tools. Grosser, Bientzle, Shiozawa, Hirt, and Kimmerle (2019) emphasized that the key to successful education using videos was to strengthen the link between clinical and anatomical knowledge.

6 | ONLINE RESOURCES

In 2012, the first traditional face-to-face systemic human anatomy course with a prosection laboratory using Blackboard Collaborate (BBC) 12 video conferencing software (Blackboard Inc., Washington, DC) and the Netter 3D Anatomy computer model (Netter, 2014) was conducted fully online. This allowed teachers and students to interact live online while using 3D models (Attardi, Choi, Barnett, & Rogers, 2016; Attardi & Rogers, 2015). However, the students' performance was consistent with that in the previous year and was predicted by prior academic achievement, not the course format (Attardi, Barbeau, & Rogers, 2018). Other authors have developed audio-visual dissection resources to help students prepare for a dissection course, revise after it, and prepare for their examination, although many students still prefer traditional learning (Choi-Lundberg et al., 2016).

7 | SOCIAL MEDIA (FACEBOOK, TWITTER, YOUTUBE)

Social media have gained popularity in anatomy education (Pollock & Rea, 2019), and anatomists have developed Facebook pages to help students learn (Jaffar, 2012, 2014; Pickering & Bickerdike, 2017). Interestingly, the Jaffar and Eladl (2016) study of Facebook showed that students who performed well on the pages engaged more deeply in discussions than did lower-performing students who contributed with a single "like" or comment. The authors concluded that the deeper engagement of those who performed well proved that Facebook could be a suitable platform for engaging students in an educational context rather than a distractor. Another Facebook survey showed that most respondents did not consider the cadaveric video excessively graphic (Rai et al., 2019). A Twitter hashtag set up by Hennessy et al. (2016) also helped students to learn, and those who used Twitter valued the way it facilitated simple and quick communication between students and educators. Students are also familiar with YouTube videos for learning anatomy (Mustafa, Taha, Alshboul, Alsalem, & Malki, 2020), and their effectiveness has also been studied (Barry et al., 2016). However, educators need to ensure that photos and videos of cadavers or cadaveric materials are handled sensitively (Hennessy et al., 2020; Miller & Lewis, 2016). Nevertheless, many people maintain that the best way to learn and teach anatomy is through cadaveric dissection; but laypersons who want to learn anatomy have limited access to such facilities, so social media could fill this gap (Rai et al., 2019).

8 | 3D PRINTING

Three-dimensional printing (3DP) digital models can be made of various materials, for example, nylon, polyvinyl alcohol, polyacetic acid, acrylonitrile butadiene styrene, wood, metal, and carbon fiber filaments (Baguley, 2017). Fasel et al. (2016) suggested that 3DP specimens have a very good quantitative and excellent qualitative correlation with anatomical reality, so 3DP could be incorporated into an undergraduate anatomy curriculum. Many authors have compared the test scores after learning using 3DP group with other tools (e.g., text, atlas, 2D images, dried specimens, and disarticulated skulls), and most of them have concluded that the 3DP group is more likely to gain higher scores (Backhouse, Taylor, & Armitage, 2019; Chen et al., 2017; Garas, Vaccarezza, Newland, McVay-Doornbusch, & Hasani, 2018; Kong et al., 2016a, 2016b; Lim, Loo, Goldie, Adams, & McMenamin, 2016; Mogali et al., 2018; Smith, Tollemache, Covill, & Johnston, 2018). Chytas et al. (2020) concluded that learning through 3DP is generally perceived to be enjoyable and effective; however, there is limited evidence of its educational effectiveness compared to cadaveric dissection, so further study is required.

9 | AUGMENTED REALITY (AR)

AR is a new generation of 3D-visualized technology, defined as "…the concept of digitally superimposing virtual objects onto physical objects in real space so the individual can interact with both at the same time" (Azuma, 1997). It has been explored recently in anatomy education and research (Kuehn, 2018; Moro, Štromberga, Raikos, & Stirling, 2017). The most distinctive feature of AR is its ability to represent an anatomical model in three dimensions without losing the sense of the user's own environment (Bogomolova et al., 2019). An example of the implementation of AR in anatomy education is its application in a mobile display device, the camera in which it scans images of books (Küçük, Kapakin, & Goktas, 2016). One study showed that AR resulted in better test scores than traditional lectures and dissection, although students preferred the traditional methods (Peterson & Mlynarczyk, 2016). Another study showed that students who used mobile AR had significantly higher test scores than those who used two-dimensional pictures, graphs, and text ($p < 0.05$) (Küçük et al., 2016). Chytas et al. (2020) also encouraged the use of AR, although available research outcomes on AR in anatomy education are relatively limited.

10 | VIRTUAL REALITY (VR)

One of the most interesting aspects of VR is that users can interact with the virtually generated environment (Izard, Juanes Méndez, & Palomera, 2017; Kilteni, Normand, Sanchez-Vives, & Slater, 2012). VR has been used and its effectiveness in learning evaluated (Codd and Choudhury, 2011; Khot, Quinlan, Norman, & Wainman, 2013; Kockro

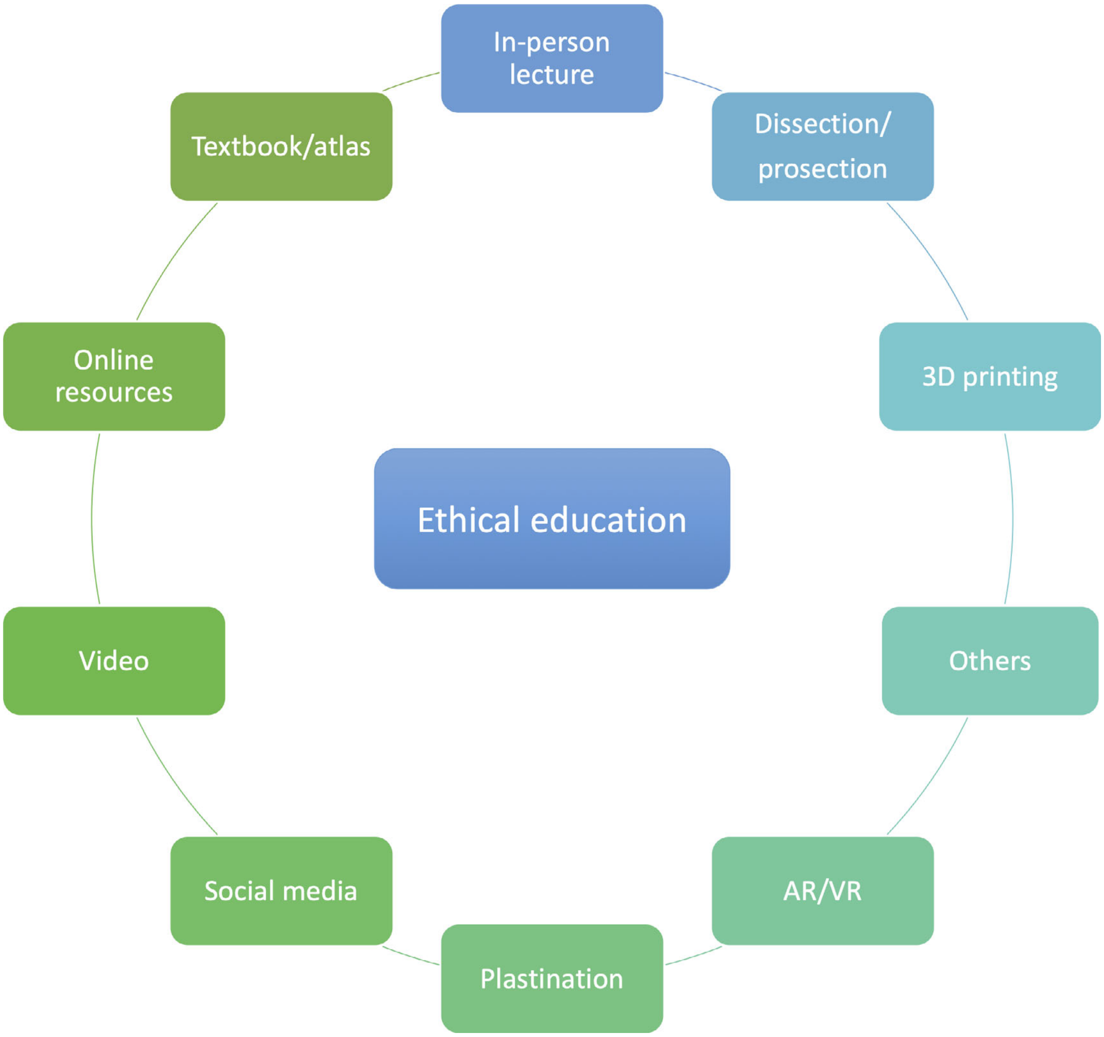

FIGURE 1 A multidisciplinary approach to anatomy education [Color figure can be viewed at wileyonlinelibrary.com]

et al., 2015; Solyar, Cuellar, Sadoughi, Olson, & Fried, 2008; Uruthiralingam & Rea, 2020; Zhao, Xu, Jiang, & Ding, 2020). Although some studies have promoted the use of VR (Kockro et al., 2015; Solyar et al., 2008; Zhao et al., 2020), the structures on which the VR focuses could affect the results. Birbara, Sammut, and Pather (2019) compared the perceptions of anatomy using 3D skull models and suggested that a desktop could be appropriate for delivering VR resources. Interestingly, the authors emphasized that the more important factor was prior knowledge.

11 | CONCLUSIONS

Many studies evaluating the effectiveness of these education methods/modalities have been relatively subjective, as it is difficult to compare them with traditional methods under equal and unbiased conditions. The meta-analysis by Wilson et al. (2018) showed that when traditional dissection was compared to other laboratory approaches, that is, 3D models, prosection, digital media, and hybrid approaches, the students' scores were statistically equivalent. The authors encouraged educators to select the educational method on the basis of its purpose, not the inherent attributes of the method itself. As Lackey-Cornelison, Bauler, and Smith (2020) indicated, prior anatomical knowledge has a greater influence on the short-term retention of knowledge than the learning modality does. Not only does cadaveric dissection help medical students to learn human structure and function, but the dissection experience can also promote the development of teamwork, self-reflection, interprofessional and communication skills, and ethical qualities (Ghosh, 2016; Moore, 1998). Lastly, rather than arguing whether human cadavers should or should not be used for anatomy education, we should argue for using them as one of many parallel approaches (McMenamin et al., 2018) (Figure 1).

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