



How did COVID-19 Influence Anatomy Education Around the World?

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ABSTRACT

The Coronavirus Infectious Disease 2019 (COVID-19) disrupted the higher education sector worldwide in several disciplines, especially those in healthcare as well as science, technology, engineering, and mathematics (STEM) that require active, experiential learning via practical application of concepts centering around Anatomy. Dynamic instructional and technological interventions took place rapidly in an effort to minimize the adverse repercussions of moving away from traditional means of education in these critical scientific fields. COVID-19 necessitated administrators, faculty, students, and interns at colleges, universities, medical/healthcare science programs and residencies to pursue teaching, learning, and assessment of Anatomy courses/curricula through innovative strategies without compromising the quality or rigor of education. Adaptation and integration of remote/hybrid learning and teaching methodologies were essential, along with governmental as well as organizational interventions. Alternative synchronous and asynchronous approaches of e-pedagogy were implemented through simulation labs, virtual cadaver dissections and histological examinations, recorded video-lectures, online meeting platforms, and cutting-edge technological software and tools to maintain the quality of education while prioritizing everyone's health and safety. Based on varying economic stability, different countries and regions dealt with the ramifications of COVID-19 on Anatomy and Physiology education differently. This systematic review encapsulates, for the first time, original reports published around the globe from the past three years on such key implications of COVID-19 in Anatomy higher studies, combined with relevant recommendations. This comprehensive analysis would help improve the content, delivery, and efficacy of education in these clinically important subjects to facilitate better preparation for future pandemics.

Keywords: COVID-19, Anatomy education, Global influences

1 Introduction

The COVID-19 pandemic presents a significant challenge for countries worldwide, requiring concerted efforts to mitigate its transmission. Among the major impacts of the pandemic is its disruption of anatomy education, which creates obstacles for students to meet educational requirements for their future careers. To navigate this challenge, educators, governments, agencies,

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and students globally must come together and innovate to effectively manage COVID-19. In particular, advances in technologies such as artificial intelligence, online software, live streaming with high-definition cameras, and three-dimensional images or models have all contributed to the development of innovative approaches to anatomy education. The present study aims to investigate the impact of the COVID-19 pandemic on anatomy education worldwide, exploring the various strategies employed to ensure the delivery of quality education despite the disruptions caused by the pandemic.

2 Research Methodology

The research methodology for this study involved a comprehensive review of peer-reviewed articles published over the last 2 years on the topic of how COVID-19 has influenced anatomy education. The literature search was conducted using electronic databases such as PubMed and Google Scholar using a combination of keywords related to COVID-19 and anatomy education. Inclusion criteria for the articles were that they had to be peer-reviewed and published between January 2020 and April 2023. Exclusion criteria were articles that did not pertain to the topic of COVID-19 and anatomy education. A total of 31 articles were identified and analyzed. Data was extracted from the articles and studied thematically to identify common themes and patterns related to the impact of COVID-19 on anatomy education. This research methodology allowed for a systematic and comprehensive analysis of the existing literature on the topic, providing valuable insights into the effects of the pandemic on the teaching and learning of anatomy.

3 How COVID-19 affected Anatomy Education in the Broader View

Since the inception of the pandemic, universities and institutions across the globe have been forced to rapidly close all non-essential facilities, including anatomy education. All labs and classrooms were shuttered, and students were temporarily denied access to any form of education. The closure of these facilities was a necessary measure taken to reduce the transmission of the virus and protect the health and safety of students and faculty [23-24]. COVID-19 and social distancing requirements forced many educators to consider alternative pedagogical methods [1]. Despite these challenges, anatomy faculty have led the transition toward a virtual teaching and learning environment [1]. These alternatives were a challenge to employ such as pre-COVID-19 content, delivery, pre-existing electronic materials, and the laboratory technique previously used [1]. As a result, soon after classes and labs were shut down a transition from in-person classes to remote learning was underway [2]. From this transition, the use of technology in the learning process of students from different disciplines became essential and became the only way to teach, communicate, and collaborate for months [3].

4 Impacts of COVID-19 on Technology and Resources used in Anatomy Education

Institutions and faculty globally have made significant strides in adapting their classrooms to adequately meet the needs of students during the COVID-19 pandemic. Some of the most common changes included the incorporation of virtual reality such as Holo-Lens or 3D anatomy software (23%) and a decrease in cadaver dissections (13%) [4]. Views of the anatomic structures were

achieved via 3D programs, virtual labs, and pictures of cadaveric material [5, 23]. Another method to view the anatomic structure included live sessions of synthetic models such as the SynDaver Anatomy model. Despite these changes, anatomy education continues to face challenges. Course directors reported that COVID-19 had a negative impact on the quality of learning due to decreased interactive or in-person (62%) learning and lack of dissection (44%) [4]. These percentages were derived from a survey comprising 117-course directors. In addition to these novel methods of teaching anatomy in the context of COVID-19, more traditional methods were used in other parts of the world, such as providing paper-based learning materials or posting videos and lectures online for the class to view as other forms of delivery for 3D materials (Figure 1) [28-29]. To facilitate collaboration in a socially distanced context, some faculty incorporated discussions on Zoom and Microsoft Teams within the class to encourage social interaction among peers [17]. Anatomy education is still evolving as new technologies become available. Overall, all methods adopted promoted social distancing and reduced the risk of infection for students and faculty alike.

Platforms for 3D Learning

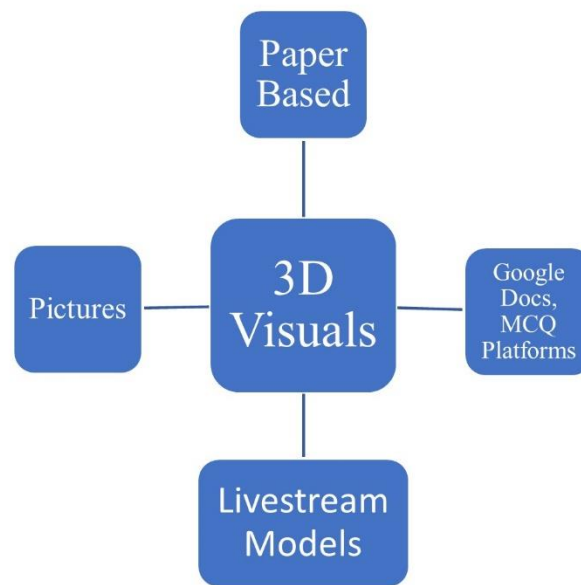


Figure 1. Various modalities used for 3D learning.

5 Impacts of COVID-19 on Anatomy Education and Factors to Consider

The COVID-19 pandemic has affected populations worldwide, with different regions experiencing various hardships in adapting to the pandemic. Socio-economic status is a factor that is often overlooked when considering who is affected by the pandemic and who is deprived of education the most. Studies have shown that underprivileged communities are among the hardest hit when it comes to adapting to COVID-19 education [20-22]. The availability of resources and access to technology can also be a challenge for some populations. Governments' aid and policies play a significant role in determining the level of assistance that communities and countries receive,

affecting how they adapt to the pandemic. These variables create disparities in the way different regions cope with the pandemic.

6 Impacts of COVID-19 on Anatomy Education in North America

Developed regions such as North America face different repercussions than other regions of the world. The advancements made and available are not available around the world in regard to technology to combat COVID-19 social distancing. At the University of Minnesota, anatomical labs are replaced with simulation education which provides a means for students to engage in clinical practices and bridge the gap between clinical exposure and virtual learning in a meaningful way [7]. Given the visuospatial nature of anatomy, the transition from hands-on lab to virtual learning has been understandably more difficult. Attenuation of content learning that would normally be facilitated in-lab small group discussions, combined with a lack of interaction with the cadaveric specimen, at-home distractions, and poor audio-video quality resulted in a sub-optimal learning experience [16]. The adaptations made such as remote learning, video conferences through Zoom and Microsoft Teams, lab kits delivered to the student, and portals such as Canvas and Blackboard the students' ability to continue anatomy education continued in this developed and resourceful region of the world.

7 Impacts of COVID-19 on Anatomy Education in Europe

COVID-19 has changed many aspects of the European region of the world. Social distancing takes place at extreme levels during the height of the pandemic. The region has multiple countries with different ecosystems of education because of the different governing bodies at hand. In Spain, the COVID-19 pandemic stopped all educational and most university research activities [9]. Social distancing, which is one of the most abundant and important methods of protection from infection, has halted face-to-face education in many countries and education has continued remotely [10]. Distance education for anatomy has revealed many problems that have not been recognized in the past. Students are deprived of accessing the benefits of all learning styles such as touching, 3D perception, association, and discussion in small groups [10]. At the German university Universität Hamburg, the loss of peer-to-peer interaction was seen as a major cause of concern for students as seen in (Figure 2) [11]. Methods to counteract these problems include Zoom to connect with peers, 3D virtual software to visualize the anatomical models, and Canvas or Blackboard to post pictures or class material for all the class to view. Virtual reality technology has made it possible for participants from around the world to feel like they are together in the same classroom [10]. Synthetic models such as the SynDaver model have also been in use specifically at the Kharkiv National Medical University in Ukraine [5]. All these innovations are taking place within the European region of the world and institutions are continually adapting to the hardships of COVID-19. These developments reveal in the near future, that systems joining with technology will have a strong and resilient place in anatomy education [10].

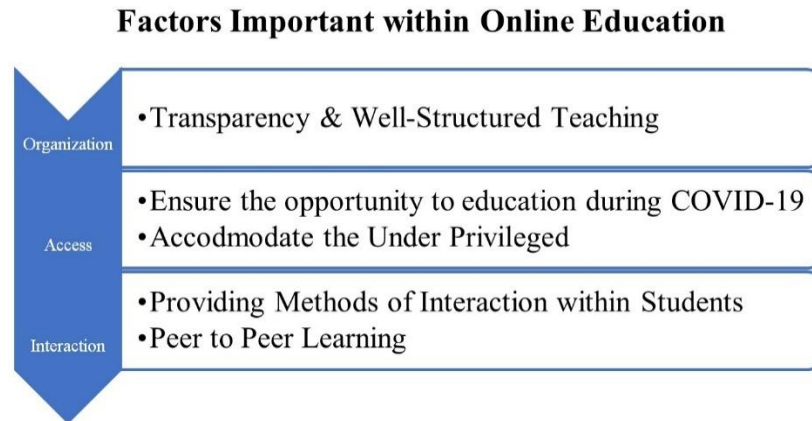


Figure 2. A hierarchy of factors when learning online with organization being first, then access, and interaction as the last part of the puzzle to ensure students have what they need for effective education online.

8 Impacts of COVID-19 on Anatomy Education in Africa

Universities within Africa had multiple factors to consider when COVID-19 interfered with their education. Students suffered from little to no internet access, limited technology, and poverty. In South Africa, the president ordered all universities to shut down and find alternative ways to deliver lectures online [5]. Due to the lockdown, all students were forced to be quarantined in their homes [5]. These instant measures interrupted the academic year and all activities had to be moved online with no campus access for university members. The university adopted emergency remote teaching (ERT) [5]. Incorporated into the ERT program were resources to support students that did not have reliable internet access, technology, or the money to acquire resources. The University of Cape Town supplied students with laptops, internet bundles, and structures for students in need [5]. In addition, students with less internet connectivity in their area were provided with physical paper-based materials [5]. Zoom was once again used as a majority of the peer-to-peer discussions in conjunction with Microsoft Teams. The prohibition of cadavers due to the pandemic resulted in the use of Anatomedia and Primal Pictures to demonstrate dissections and show anatomical structures with different body systems [5]. The endeavors taken by Africa's institutions prove to be useful; with students continuing their education and the governmental bodies cooperating with universities to supply students with materials and logistics even with factors such as poverty and little to no technological access.

9 Impacts of COVID-19 on Anatomy Education in Asia

Asia has been devastated by COVID-19 and anatomy education has morphed to adapt. From East to West Asia many educational institutions faced the repercussions of COVID-19. Various countries within Asia utilized technology as their driver in the continuation of education and transforming pandemic adaptations through e-learning to reduce the risk of COVID-19 spreading [12, 27]. Within countries such as Iraq, videotelephony has been used largely, and software such as Zoom, Google Classroom, and Telegram were adapted [12]. Pakistan used new modalities such as virtual reality case-based simulated learning to teach medical sciences, with less emphasis on

classroom teaching [13]. For instance, students are shown how to dissect human bodies layer by layer using an anatomy dissection table. This innovative method allows several students to observe and learn simultaneously in small groups, utilizing smart boards [13]. This approach ensures that students can still gain practical experience in anatomy without compromising their safety, promoting social distancing during COVID-19 [18]. Another approach observed in Asia, specifically in Japan, involves the utilization of cross-body communication between the administrative body and the student body. The deans and faculty members, in collaboration with medical students, set up a working group to solicit the opinion of medical students on educational policies [25]; the group would provide feedback and form an information loop with the admins to keep them informed and adapt if necessary (figure 3). They aimed to prevent students from exclusion with this cooperative approach [14]. This way students' issues and problems were taken into consideration rather than just the upper echelon of individuals making the final decision. Japan has also utilized 3D interactive models to improve their student's understanding and retention of anatomic knowledge as many other countries have [26]. In South Korea, medical universities possessed greater resources compared to the average medical school, enabling them to provide extensive support tools to assist students in maintaining social distancing measures [19]. SNUCM (The Seoul National University College of Medicine) provided e-Anatomy (Panmun Education, Seoul, Korea) videos, which provide an overall dissection of human anatomy, and complete anatomy (Elsevier, Amsterdam, Netherlands), an educational 3D anatomy platform [15]. Nevertheless, the university has demonstrated a dynamic and adaptable response to the COVID-19 pandemic as well, incorporating schedule changes and rapid transitions from face-to-face to online instruction during times of decreased virus transmission (Figure 4) [15]. This strategic approach aims to optimize students' laboratory hands-on time while prioritizing their safety in accordance with evolving public health circumstances. China has also dedicated efforts to students grasping the lab segment of anatomy education. Just as most countries and institutions, they adopted and used online teaching platforms and courses for their students. However, (CSB) case-based learning was emphasized heavily and conducted virtually by surgeons [8, 30]. The laboratory sessions were taught on the online learning platform that included (2D) images, pre-recorded videos of human specimen dissection demonstrations, and carefully annotated texts [8]. Asian countries were found to be initiative and resourceful regarding education and fulfilling the students' needs throughout the COVID-19 Pandemic [31].

Cross-Communication Among Administrations and Student Bodies

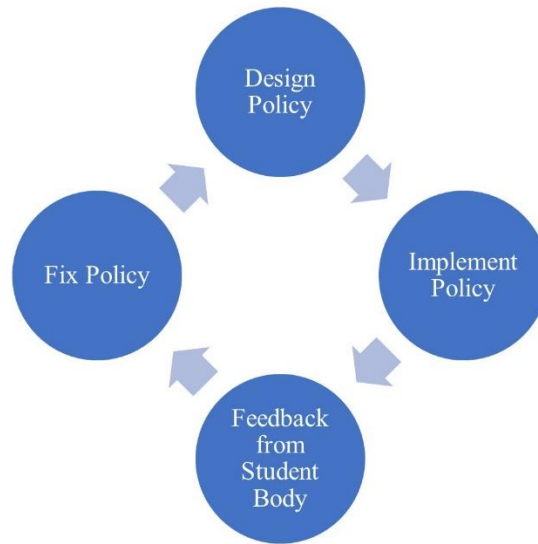


Figure 3. Information loop with admins and students to provide feedback on policies and adapt if needed.

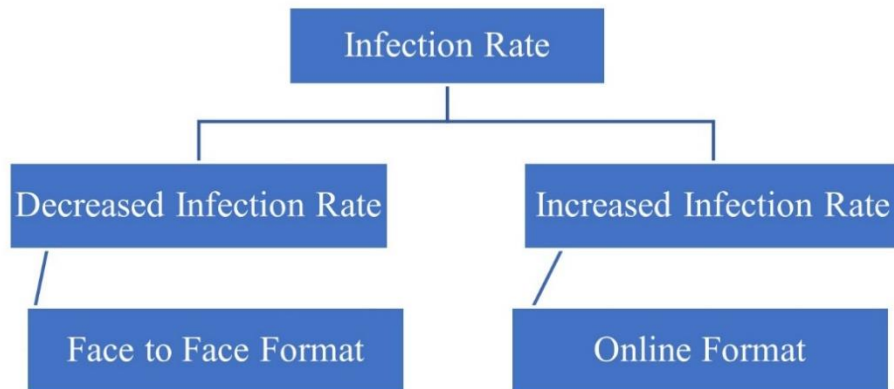


Figure 4. Dynamic adaptable response to infection rate of COVID-19 in South Korea.

10 Discussion

The COVID-19 pandemic has disrupted traditional education, including anatomy education, as in-person classes and laboratory sessions have been canceled. As a result, anatomy educators have turned to digital technologies to provide remote learning experiences. This shift has been particularly challenging for anatomy education, which has traditionally relied on cadaver dissection and hands-on learning experiences in the laboratory. Nevertheless, digital tools such as 3D models, virtual reality, and augmented reality have provided a means for students to explore anatomical structures in a simulated environment, enabling continuity in anatomy education during the pandemic worldwide. The adoption of digital technologies in anatomy education has underscored the importance of innovation and adaptability in education. Digital technologies have provided an opportunity for educators to experiment with alternative teaching methods, which can lead to improvements in teaching practices and student learning outcomes. Moreover, digital technologies have expanded access to educational resources and opportunities to a wider audience, providing a platform for greater inclusivity and diversity in education. In addition, the integration of digital technologies in anatomy education has facilitated international cooperation and scholarly exchange among educators and learners. The ability to share pedagogical resources and engage in virtual collaboration has enabled educators and students from diverse geographic locations to work together and promote the development of innovative approaches to anatomy education.

11 Conclusion

The COVID-19 pandemic has brought about a rapid shift towards online and virtual learning, forcing countries and educational institutions worldwide to adapt their traditional teaching methods. This work will form a foundation as the first paper for future research on a global scale to better understand and prepare for future pandemics. The study provides a comprehensive review of the literature on the different modalities used for anatomy education during this unprecedented time. It highlights the challenges faced by educators and students and examines the modes of virtual and online teaching methods. The insights provided by this paper will be valuable to policymakers, educators, and students alike, as they navigate the new normal of virtual and online learning in a post-pandemic world.

12 Declarations

12.1 Study Limitations and Future Recommendations

This study offers a comprehensive review of the worldwide impact of the COVID-19 pandemic on anatomy education, based primarily on peer-reviewed publications. It is important to note that this review has limitations as it excluded significant factors from unpublished papers. Moreover, since the pandemic has evolved into an endemic, new developments and reports may have emerged since the completion of this review. Therefore, future studies are recommended to investigate the influence of COVID-19 on enrolment rates in anatomy education and students' perspectives on changes in anatomy education worldwide.

12.2 Conflicts of Interest

The authors declare no conflicts of interest.

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