Transition to Effective Online Anatomical Sciences Teaching and Assessments in the Pandemic Era of COVID-19 Should be Evidence-Based

Priti L. Mishall^{1,2} · Eiman M. Abdel Meguid³ · Mohammed K. Khalil⁴ · Lisa M. J. Lee⁵

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Abstract

The world has changed rapidly since the emergence of the COVID-19 pandemic, and the education community has not been immune to these changes. With abrupt school closings and a rapid transition to online teaching and learning, the educational technologies have been stretched to their limits and pedagogic approaches blossomed. As the world strives to reestablish normalcy, it will be under the influence of the long-lasting impact of the pandemic. This manuscript provides recommendations for the online conversion of anatomical sciences curricula in health sciences programs. Strategic guidelines are emerging for building on these changes to enhance teaching and learning in the current pandemic era.

Keywords COVID-19 teaching · Anatomy education · Synchronous/asynchronous learning · Online assessment

Introduction

The COVID-19 pandemic has transformed societies across the globe in a short time frame, restricting mobility by government-imposed lockdowns. Almost all educational institutions have been affected by this, including universities and professional health sciences programs, which closed their campuses and rapidly converted to online delivery of education and assessments. While such rapid conversion has challenged educators, students, and their families, it also has revealed several strengths, weaknesses, opportunities,

and threats to our current educational programs [1]. Among the strengths, current technologies can support large-scale online education and assessments, and most educators and students are adaptable and resilient in their pursuit of teaching and learning [1].

However, with the likelihood that campus closures will extend for the remainder of 2021 and beyond, it is imperative to re-evaluate curriculum design and leverage evidence-based pedagogical strategies in digital education. The aftermath of the COVID-19 pandemic is likely to have a lasting impact on the educational system, well beyond the heroic short-term responses implemented in the past several months, and calls for a global-scale collaboration of educators to share knowledge and influence policies to ensure that digital educational models are pedagogically sound. Beyond ensuring competency in knowledge domains, the digital curriculum must also promote online learning communities utilizing social media [2].

For anatomical sciences, the lab component is traditionally hands-on using embalmed cadavers. The hands-on experience with cadavers is either whole-body dissection or faculty-guided demonstrations on prosected cadavers. Both rely heavily on in-person interactions. Moreover, during the last couple of decades, many schools partially or completely replaced the cadaver dissection to digitized experience [3]. During COVID-19, the need for digital course conversion added an extra challenge due to the hands-on nature of the

✉ Priti L. Mishall
priti.mishall@einsteinmed.edu

¹ Department of Anatomy and Structural Biology, Albert Einstein College of Medicine, 1300 Morris Park Ave, Bronx, NY F620SA10461, USA

² Department of Ophthalmology and Visual Sciences, Albert Einstein College of Medicine, Bronx, NY 10461, USA

³ Centre for Biomedical Sciences Education, School of Medicine, Queen's University Belfast, Dentistry & Biomedical Sciences, Belfast, UK

⁴ Department of Biomedical Sciences, University of South Carolina School of Medicine Greenville, Greenville, SC 29605, USA

⁵ Department of Cell and Developmental Biology, University of Colorado School of Medicine, Aurora, CO 80045, USA

subject and the significant reliance on laboratory activities. Little is published on pedagogical and assessment methods to teach anatomy during the pandemic era. The purpose of this essay is to provide guidelines for evidence-based pedagogical strategies in designing effective and engaging online anatomical sciences curricula and outline assessment strategies ensuring that students attain competency.

Selection of Effective Online Instructional Strategies

The first step in designing an effective online curriculum is to re-evaluate the alignment of learning objectives with online pedagogies. For this, assessment plans need to guide curriculum mapping, which identifies instructional content, teaching methods, and curriculum sequence to demonstrate links between elements of the curriculum [4]. The selection of effective instructional strategies for online learning should be guided by learning theories and the science of instruction [5]. Re-evaluation of pedagogical and assessment strategies is necessary for effective online learning.

The goal of online learning is to use media and digital technology to deliver content and establish consistent communication between learners and teachers [6]. There are three methods to deliver the content: asynchronous, synchronous, and hybrid. Based on the intended learning outcomes and type of teaching activities (large group and small groups), anatomy instructors should select the appropriate content and determine the online delivery method, which can include videos, chat forums, discussion boards, and learning communities. Furthermore, a robust learning management system (LMS) helps to store and make the online content accessible to students.

Asynchronous Online Learning

In an asynchronous online curriculum, the transmission and receipt of information do not occur simultaneously [7]. This has been described in the context of distance learning as “archived” [8, 9].

During COVID-19, a survey ($n = 67$) was distributed globally to gross anatomy educators through professional associations and listservs. One component of survey gauged the status of lecture delivery that is in-person vs prerecorded. The survey responses found that the in-person lecture time was decreased during COVID-19 (before: 76%; during: 8%; $P < 0.001$) [10]. These survey results clearly emphasize the importance of crafting a successful pre-recorded lecture for asynchronous content delivery. Lecture pre-recording is possible by using applications like Camtasia, MediaSite, and ScreenCast-O-Matic and requires appropriate organization of the content and preparation of the script for repeated use

[11, 12]. Each pre-recorded video lecture should state clearly the learning objectives to set up learner expectations.

The lecture content should use effective visuals and images and pace the graphic and narration appropriately. Anatomical images usually have an excessive number of labels, e.g., an image of the pterygopalatine ganglion and its connections. In this scenario, the instructor should focus on the key message that the image informs. The best way to highlight the key message is to use an unlabeled image (copyright publisher), type the labels, and apply simple animation using Microsoft PowerPoint. The labels pop-up only during content narration. This step minimizes learner distraction due to irrelevant labels on the image [13]. The pre-recorded video should include quizzes to help students assess the understanding of the content [11]. For example, embed quizzes in the video asking learners to pause the video and submit an answer, or build in a quiz at the end of the video.

The script and narration of the video should be brief, clear, and concise. It is a good idea to limit lectures to between 6 and 12 min [14]. Shorter videos generate smaller file size, which improves video downloads to facilitate viewing on mobile devices. Also, shorter videos are more likely to be watched in their entirety [15]. For most anatomists, the concept of creating a lecture of less than 12 min is incomprehensible. However, video lectures provide a different experience to the learners than in-person lectures. In a video lecture, the learner can rewind to hear the lecture again for clarity, which is not possible during an in-person lecture where the learner temporarily loses attention [15]. In addition, complicated materials like development of head and neck may require students to watch video lectures in a specified sequence to make connections and understand context of where content fits into a larger blueprint. For example, students might need to first watch development of neural crest cells, then migration of neural crest cells in the head region, and then transformation of neural crest cells to form the cartilage, muscles, and nerves in each pharyngeal arch. Appropriate labels to these video lectures and instructions on the sequence of viewing the videos let students know that the video lectures build upon each other [11]. Asynchronous content delivery requires faculty to actively monitor student learning and progress by tracking click rates and/or website metadata for use of videos and completion rates of quizzes.

Anatomy labs have a unique setting. Anatomy labs are usually cadaver dissection-based, hands-on in nature and almost exclusively in-person. During COVID-19, the biggest challenges at institutions with no in-person teaching were to deliver anatomy lab content asynchronously. Another component of the survey distributed globally to gross anatomy educators through professional associations and listservs to assess the use of cadaveric material during COVID-19 found that the use of cadaveric

teaching declined significantly during COVID-19 (before: $76 \pm 33\%$, during: $34 \pm 43\%$, $P < 0.001$) [10]. A number of alternate methods replaced the in-person cadaver experience. Such as pre-recorded dissection videos (in-house/commercial) or virtual and augmented reality and/or 3D printing. Literature review revealed that studies in support of virtual dissection that incorporate 3D anatomical structures can complement traditional dissections and help in improving enthusiasm for learning anatomy [16, 17]. Literature reports that online dissection videos had a positive correlation with feeling better prepared for dissection [18, 19]. Unfortunately, during COVID-19, in some institutions, not having proximate follow-up dissection activity left a bigger gap in the anatomy experience of learning and assessments. Some schools addressed these gaps by planning to provide students dissection opportunities in later years of the medical school curriculum in the guise of electives.

Another way to supplement cadaver experience is to create cadaver image-based lab modules with associated quizzes. The lab modules can use in-house cadaver dissection images with animated labels. These self-directed lab modules will help students develop the skills to identify the anatomical structures and self-assess their learning by completing an associated image-based quiz. The use of commercially available image-based quizzing platforms (H5p.com, Quizlets, Anki) allows learners to self-assess and test retrieval of information. Faculty motivation and time to develop these cadaver image-based labs should be considered and may require the support of teaching assistants.

In summary, asynchronous content allows learners to pace their learning, providing students with several benefits. Students learn and make contributions at a time that suits them rather than in a fixed time frame. Students have time for reflection and research prior to composing an answer and are able to contribute equally to the class activities [20, 21]. There are, however, some disadvantages with asynchronous online videos. Research shows that some of the primary barriers to developing pre-recorded videos are constraints on faculty time and limits to technical knowledge [22]. A potential disadvantage of an asynchronous course might be that students lose motivation, resulting in failure to meet intermittent course milestones or even non-completion of course requirements. Several methods could be employed to ensure student accountability for learning content and monitor progress of their expected knowledge level. For example, early warning learning management system (LMS) tools can send auto notification emails to alert students about their logging status and access to certain objects within a set period. A similar email alert to the instructors can trigger a follow-up with students to encourage them to re-engage with the course material. Additional LMS features set minimum course completion requirements within each module, which

ensures that students achieve foundational competency prior to gaining access to the next module of the course.

Synchronous Online Learning

Synchronous delivery refers to real-time, “live”, instructor-led e-learning, where all learners receive information simultaneously and communicate directly with other learners [7–9]. Examples include teleconferencing (audio, video, or both), instant messaging, and Internet chat forums [7].

Anatomy lectures can be delivered “live” and in real time by using teleconferencing tools such as Zoom, Microsoft Teams, and WebEx. During COVID-19, in response to rapid school closures, synchronous online curricula emerged as the most common form of course conversion [10]. In this format, the overall curricular elements changed little, and instructors used video conferencing tools to deliver didactic lectures in the same or similar way they would in-class, at regularly scheduled class times. Although the online “live” sessions mimic in-person lecture delivery, faculty need to adapt to the new online/onscreen teaching environment.

Student interaction that happens organically in a lecture hall is now replaced by tiles of student images on the screen. At the beginning of each session, faculty should remind students of the expectations regarding classroom engagement and pause to ask if students have any questions. For example, during the live lecture session lecturer can ask guiding questions to check student learning. This activity requires the lecturer to do some prior preparations. The lecturer needs to intersperse few questions within the lecture slide deck. These questions should be displayed in the natural sequence of the lecture presentation. After the question gets displayed give students a few minutes to respond “live” in the chat. Then the lecturer immediately provides feedback on correct and incorrect responses. It is important to thoughtfully design these questions. These questions should be based on the content that was just presented live to the learners. The goal of this exercise is to progressively engage learners with the content and give learners an opportunity to track and reinforce their learning. Additionally, the lecturer should encourage students to keep their webcams on to promote a sense of presence and community of learning. Some students may feel uncomfortable to share their environment on live webcam. These students can be reminded to use virtual backgrounds to reduce visual distractions and improve equity [23].

It is a good practice to connect previous class discussions to current discussions to demonstrate how ideas are connected and to bridge any gaps in understanding [24]. For example, at the beginning of lecture, display an unlabeled image from a previous lecture, example the base of skull. Then, ask students to use the annotate tool on zoom to label the foramen spinosum. Afterward, ask the class what structures pass through the foramen spinosum? And what is the likely location of a hematoma when the artery passing through the foramen spinosum is injured?

Consider using the breakout room functionality for discussions or video-enabled group work if you want students to participate in smaller groups. You can further complement the group work via collaborative tools like Google Docs, Slides, or Sheets. Use collaborative problem-solving and active learning method by asking students to digitally annotate on virtual whiteboards. Always summarize critical takeaway points at the end of the lecture.

Synchronous delivery of anatomy lab content was a major challenge during COVID-19. Schools with limited access to digital technologies reconfigured the structure of the anatomy laboratory teaching sessions, which continued to be in-person by reducing the number of students in the lab, following the social distancing guidelines, and using personal protective equipment. Dividing the class into two groups with subgroups, carefully scheduling one subgroup at a time to attend the dissection labs, and having the other non-attending subgroups engage in asynchronous learning activities are ways to achieve this. The subgroups then alternate and switch the next learning activities. This modified arrangement for dissection provides hands-on experience to students using cadavers. Prerecorded dissection videos can be used to supplement student learning. In-person teaching puts an additional onus on faculty and students to ensure that there is no unnecessary closeness while demonstrating the dissected structures. In instances where someone tests positive, both faculty and students need to voluntarily inform their group and institutional environment health and safety office, and follow the CDC protocol of self-isolation/quarantine.

In summary, live synchronous instruction, using conferencing tools, replaced in-person lecture providing a robust platform to educate learners during COVID-19. However, synchronous learning requires facilitators to be mindful of challenges that students face when joining a real-time event including access to strong Internet and time zone differences. Facilitators should consider making synchronous sessions optional, recording the session, and posting the recorded session on the LMS for later viewing. Therefore, the online curriculum inevitably blends into using asynchronous elements, i.e., recorded lectures and live sessions, which technically makes the curriculum a “hybrid curriculum”.

Hybrid Online Learning

This method consists of a mix of asynchronous and synchronous learning. An online hybrid curriculum can offer an engaging and rich learning experience to students by incorporating the best features of both learning modalities [25]. The asynchronous component provides the benefits of increased convenience and flexibility, with greater reach to students in multiple locations [26, 27]. The synchronous component provides quality of interaction with peers and instructors, which can further support competency development [25, 28].

An example of this method is designing flipped classroom sessions that incorporate asynchronous learning via pre-recorded videos, reading, and self-assessment exercises with synchronous components that provide discussion of practical applications of learned concepts can support experiential and meaningful learning experiences for students [29]. During COVID-19, the asynchronous out-class activities allowed learners to use resources in the form of reading material, videos, narrated PowerPoints, lecture captures, and animations [30] while the live synchronous session incorporated active learning methods of case-based learning, problem-based learning, and team-based learning. In a case-based learning session, for instance, faculty asked higher order case-based clinical questions using Poll Everywhere, an audience response application. Students responded remotely to the questions by using the Poll Everywhere app on their mobile phones. Faculty used screenshare to show the distribution of responses and discuss correct and incorrect answers. When used well, this can be a powerful complement to promote student engagement and critical thinking skills. However, given the curricular, technological, pedagogical, administrative, and social aspects of online hybrid curricula, it is no surprise that developing a well thought-out, evidence-based online hybrid course demands dedicated time and can quickly add to the workload of faculty and staff [25, 31].

Furthermore, a successful learning environment requires an open two-way communication between the faculty and students. To achieve the goal of communication and learning support, faculty should consider use of discussion boards/forums to address content-related student questions. Previous studies reported that discussion forums improved student learning outcomes [9, 32] and promoted strong social interactions among students to foster a sense of community through learning [33]. An alternate way to communicate with students is via class emails and LMS announcements. Class emails can be used to post answers and to chat questions that did not get addressed due to time constraints during the live session.

Create Learning Communities Using Social Media

Social media consists of a variety of web-based tools including networking platforms such as Facebook, YouTube, Twitter, blogs, and wikis that are designed to engage students through knowledge sharing, interactions, and collaborations [2, 34]. Multiple studies have indicated that using social media as an educational tool can increase student engagement [34–38]. There is no doubt that social media played an integral role in how students learned during COVID-19. Participation in social media in this period created a more collaborative and communicative learning environment for students by providing opportunities for interactions and discussions with their teachers and peers. By encouraging engagement with social media, students can establish

a virtual community of learners with peers that will lead to better content-learning. Evidence strongly indicates that incorporating Twitter into anatomical sciences education during the COVID-19 period created a supportive network for students and positively affected their learning experience and morale [2]. Furthermore, it broke down barriers with the teaching staff. There are some negative impacts of social media usage, however, as it can distract students from completing their coursework [39]. Students who spend excessive time on social media may have difficulty balancing their online activities with their academic preparation. It is therefore vital for students to allocate their time wisely to fully benefit from social media.

Strategies for Online Assessments

The assessment of learning is crucial to ensuring competency in medical education. Knowledge of anatomical sciences is usually assessed in 2 components: theory and practical. The theory component consists of online case-based multiple-choice questions, essay questions, or short answers. The practical component typically involves a diverse number of assessment methods to gauge a student's ability to identify structures on cadavers. A few ways to conduct practical exams on cadavers are traditional staple chase method (spot-ter or bell ringers) [40, 41], oral examinations for small class size [42], dissection evaluations [43], and objective structured practical exams [44]. The conversion of traditional staple chase to “online” staple chase using quiz facility in WebCT™ and Moodle™ was described by Inuwa et al. [40]. Other studies found that student performance on practical gross anatomy examination is not affected by assessment modality [45–47].

There are two types of assessments: formative and summative, and each is utilized in different ways. One of the most challenging aspects of assessing students' learning is how to administer and proctor online assessments. Many institutions were already conducting in-person online assessments by using test administration applications, e.g., Examsoft and assessment tools embedded in LMS such as Canvas and Blackboard. During the rapid curricular transition in response to the COVID-19 pandemic, most institutions used the same software programs to administer tests remotely. A significant decrease in in-person lab assessments was found during COVID-19. The in-person lab assessments during COVID-19 were only 20% compared to 80% during pre-COVID-19 [10]. On the other hand, computer-based practical exams increased exponentially during COVID-19. Usage of computer-based practical exams during COVID-19 increased to 61% compared to 9% pre-COVID-19 [10].

To ensure effective proctoring and avoid cheating on exams, some institutions used remote proctoring tools that

allow continuous audio and video monitoring of exam takers. Other institutions proctored remotely by asking students to connect via a video-conferencing tool and keep their cameras on so that faculty and staff can observe them during test taking. Many others decided not to proctor at all, instead relying on students' professionalism.

In response to different online testing strategies, a diverse number of grading policies were used. Some instructors addressed the challenge of cheating during the tests by changing the grading policies from traditional letter grades to pass/fail [48]. From the medical education perspective, it should be noted that the USMLE Step 1 exam has changed its policy to reporting scores as pass/fail [49], effective January 22, 2020. Likewise, many medical schools in North America have changed the grading policy to pass/fail for most basic sciences curricula [48, 50]. Although the advantages and disadvantages of such policy changes continue to be debated, it appears that the pass/fail policy has had no adverse effect on academic performance [50] and is here to stay for the foreseeable future. It therefore warrants consideration in online assessments. Additionally, some instructors pivoted and made assessments open-book and relied on the honor code.

While many of these measures are implemented with students' best interests in mind, the ongoing challenges from the evolving COVID-19 spread will likely affect online teaching. It is imperative, therefore, to re-evaluate assessment strategies in the digital era to ensure sustainability, integrity, and purpose. The re-evaluation of assessment should start with a critical review of aligning learning objectives, educational strategies, and digital learning platforms. In a well-aligned digital curriculum, there should be no surprises for students during assessments. To ensure appropriate assessments of competencies outlined in course goals and learning objectives, educators may have to decide whether a mere “copy and paste” of in-class assessments to an online format is sufficient. Due to the limited in-person interactions in an online course, it may become necessary to spell out professional competencies that students must acquire from the course and then strategically employ specific assessment plans to assess such non-traditional skills as self-directed learning, professionalism, communication, and teamwork. Assessing these “hidden curriculum” skill sets is more difficult in an online course than in a physical class. There are methods to assess these skill sets and they come in the form of message boards participation, reflective writing assignments, and monitoring small group breakout sessions [51].

In the absence of face-to-face interactions and limited feedback, assessments become the critical – and possibly the only – opportunity for students to receive feedback. Therefore, more frequent formative assessments are warranted in a digital curriculum. The formative assessments should provide instant feedback on performance outcomes

and accompanying learning objects to ensure that inaccurate understanding is immediately corrected [52]. Evidence suggests that the more frequent the opportunity for feedback, the better the engagement and learning adjustments [53].

As with all pedagogical modalities, understanding the needs of the learners must be considered in online courses. One way of reaching out to learners is through anonymous surveys that gauge students' concerns, and by communicating that survey outcomes will guide or influence the method of course instruction. Such surveys should include items to assess learners' access to appropriate digital devices, Internet connectivity, and required online content. It may also be important to inquire about any personal circumstances and environmental factors that influence learner engagement. Personal circumstances may range from illnesses, living conditions, family dynamics, time zone differences, and other socio-economic factors. Other survey items could address the level of experience students have with various digital and conferencing tools such as the LMS, WebEx, Zoom, and Microsoft Team; how facile students are with social media engagement; and the students' comfort level with the assessment tools. More specific to the anatomical sciences curricula, it is imperative to know whether any learners are color blind. Color blindness has been correlated with performance in the anatomical sciences, and taking steps to ensure clear transmission of visual information in an online course is vital to establishing an equitable learning environment (equitable LE) [54].

By taking the unique circumstances of students into consideration during course design and implementation, the instructors demonstrate their interest in and commitment to the students. This, in turn, can motivate students to engage more vigorously with the course and the instructors.

Conclusion

The emergence of COVID-19 pandemic has affected our daily lives as well as formal education at all levels, leading to a rapid transition to online teaching and learning. The teaching and learning of anatomical sciences are not immune to these changes, and many schools have tried adapting to the new reality. However, we recommend that the design and implementation of online anatomical sciences curricula due to COVID-19 start with the selection of an effective curriculum design model and be guided by learning theories, the science of instruction, and successful past experiences in digital anatomy curricula.

Although faculty could decide whether the online experience should be asynchronous, synchronous, or hybrid, an online hybrid anatomy curriculum was viewed as the most effective method because it incorporates the best features of synchronous and asynchronous components of the

course. Faculty need to consider learners as equal partners of learning and construct a continuous feedback loop by creating an online learning environment of inclusivity and equity.

For anatomical sciences, a complete digital conversion poses an added challenge due to the visual nature of the subject and a significant reliance on hands-on laboratory activities that ensure complete visuospatial understanding of the body.

Advances in technology have made it easy to transition to online assessments. It will be interesting to follow up in the future to find out if the online conversion of anatomy practical assessments was only a temporary phase during COVID-19 or if the change persists in the post-COVID era.

This guideline provides evidence-based pedagogical strategies for designing online anatomical sciences curricula for maximum engagement as well as for planning learning, and assessment strategies to ensure competency achievement for our students.

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Declarations

Conflict of Interest/Competing Interests The authors declare no competing interests.

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