Re-Designing a 2-Semester Anatomy and Physiology Lab Course for the Online Environment

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Abstract
In March 2020, in-person, on-campus courses were temporarily suspended due to the Covid-19 pandemic. For summer and fall semesters of 2020, we have conducted Anatomy and Physiology courses in the online environment, which required re-design of the lab component of the course. Objectives for our re-design included maintaining key curricular components; replicating a hands-on lab experience for students, maintaining engagement with students, and employing our existing pool of teaching assistants. In the new online lab course, students complete at-home hands-on lab activities, guided by teaching assistants during a weekly one-hour video conferencing session. Lab assessments are shorter, weekly assessments outside of lab time. With this new format, we have continuity of content coverage along with the ability to serve students and maintain support of teaching assistants. https://doi.org/10.21692/haps.2020.024

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Introduction and Context
In March 2020, Georgia State University, like many academic institutions in the United States and around the world, responded to the public health crisis of the Covid-19 pandemic by pivoting instruction to online. After a two-week extended spring break, we did not come back to campus and finished the spring semester completely virtually. In moving instruction to online, we attempted to recreate our spring courses in the virtual environment by replicating the in-person experience, using video conferencing platforms. As we looked forward to summer and fall semesters, it became clear that we would continue to have public health concerns about meeting in-person. Surveys of our available classroom space for lecture and lab made it clear that for large-format lecture and smaller in-person labs, meeting on campus while maintaining public health guidelines and serving the same number of students would not be feasible. For example, for a lab space designed for 24 students, public health guidelines requiring six feet between each person would limit the attendance to only seven students. With limited lab space, the same teaching staff (instructors and teaching assistants (TAs)) and continued enrollment, designing a fully online course for the summer and fall was the only viable option.

Planning for Summer 2020, our immediate goal was to build an online lab course that would support the fundamental learning goals for Anatomy and Physiology students aspiring to careers in health care, but also engage with students as much as possible. Although there had been discussion previously about developing online courses, we had only two faculty members in the entire Biology department at Georgia State University with experience teaching online prior to March 2020. As we considered how to create an online course for Anatomy and Physiology, we were starting from the beginning in terms of learning about online education pedagogy, the different formats for online courses, the technology required for various formats, and the implications for students, TAs, coordinators, and faculty. Many other instructors were in a similar situation, and we participated in a flurry of conversation about online course design, both within our own department and also within the larger community of Anatomy and Physiology instructors. Historically, many online lab courses have operated asynchronously, with students ordering lab kits and performing hands-on labs independently at home. We wanted to replicate the hands-on lab experience even though students would be learning from home, but we did not want to discontinue having synchronous virtual sessions.

The Anatomy and Physiology lab is an essential component of the Anatomy and Physiology course, supplementing student learning in lecture and providing a hands-on experience as students learn about the human body through exploration (Knowles and Associates 1984; Pratt 1993). We were, however, nervous about expecting students to complete lab activities on their own. In-person Anatomy and Physiology often has a high percentage of students who end these courses with a grade of D or F, or who withdraw (Hull et al. 2016), and we were concerned about the potential for a low completion rates in our online courses. In person, an important aspect of the lab experience is to build relationships between students and their TA, to help motivate students and hold students accountable for regular work (Hopp et al. 2019). We were also concerned with the need to continue training TAs. At some point, we expect to be holding labs on-campus again,

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and we will need to have a pool of TAs available to staff these labs. Thus, continuity in our training and development of TAs is essential to the long-term health of our Anatomy and Physiology program.

In summary, our goal as we moved toward Summer 2020 was to create an Anatomy and Physiology lab course with the following components:

1. The lab course would not be on-campus; it would be completely remote.
2. The remote lab would retain the same curricular components as the in-person lab.
3. The remote lab would replicate the hands-on lab experience.
4. The remote lab would engage students in their learning throughout the semester.
5. The remote lab would be staffed by TAs, to continue our TA training program.

Structure of Previous In-Person Lab

Prior to the changes set forth in this article, the in-person lab ran the length of the 14-week semester, with one week off for the Labor Day or Martin Luther King Day holiday. (Notably, before Covid-19, we had made the decision to shift our Monday labs to another weekday allowing us to extend the lab semester to 14 weeks; the first semester for this scheduling change was previously set to Summer 2020.) Labs were scheduled for 150 minutes, once a week. There were three unit lab exams scheduled for Anatomy and Physiology I and two unit lab exams scheduled for Anatomy and Physiology II. Thus, approximately 11 sessions were dedicated to hands-on lab activities, excluding the time taken for these summative assessments. The lab exams were slightly shorter In Anatomy and Physiology I, and students returned to lab for the second half of the testing period to begin the next lab activity.

Each lab section was capped at 24 students with one TA. TAs are typically Master's students enrolled in the biology, medical science, occupational therapy, physical therapy, or health policy programs. TAs complete an apprenticeship for one semester which involves shadowing a TA, demonstrating competency with the material, and practicing leading the lab.

A typical in-person lab session run by a TA would include taking attendance, conducting a review of the Prelab homework, and giving a mini-lecture over key concepts. The TA would spend the majority of the lab time working with individuals or small groups of students explaining models or specimens. TAs circulated to answer questions and quiz students. Some weeks, there is also a Lab Quiz, which replicated the format of the Lab Exam and encouraged students to study each week.

Students pay a $50 lab fee which is applied toward the procurement of specimens and models for the lab. Students must also purchase a custom lab manual which is printed by a third-party publisher and supplied by the university bookstore; this 2-semester lab manual costs approximately $40. The lab manual contains a small amount of background material, along with learning outcomes, the "tag list" of structures for each module, and workbook pages for the students to complete as Prelab homework. The lab manual supplements the textbook used in lecture. For the textbook, students are encouraged to purchase the eText as the most cost-effective option. The publisher's online homework platform is used to assign "review" homework assignments for each unit.

Lab exams and lab quizzes consist of 80% identification questions and 20% short answer questions. For the identification portion of each exam or quiz, the TA will project a PowerPoint presentation with slides showing pictures. Along with a photograph or illustration, each slide will have four question stems (the question stem is often "Identify X."). Students face the screen, pen or pencil in hand, with their answer sheet on a clipboard covered by a cover sheet. The questions are timed; the first round, each slide is projected for 90 seconds. After finishing round one, the TA returns to the first slide and gives a short review of each slide for 30 seconds. In this manner, each slide is projected for two minutes total, which equals 30 seconds per question.

Once the two rounds are complete, students turn in their answer sheets and continue to the short answer portion of the exam. A lab quiz will have one short answer question worth four points; a lab exam will have one page of short answer questions, typically one per topic, similar in scope to the short answer questions on the quizzes. All lab sections take the lab quiz or lab exam in the same week. To prevent question sharing between sections, there are multiple versions of each lab quiz or lab exam, assigned randomly. TAs are responsible for grading lab quizzes and lab exams, using a standard key, which is reviewed during the weekly TA meeting. Students may review their exams during the following week's Lab session, although exam papers are archived by the program. The topics covered on each Lab Exam for Anatomy and Physiology I and Anatomy and Physiology II are shown in Table 1.

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Course	Unit	Topics Covered
BIOL 2110K (Anatomy and Physiology1)	1	Terms, Cells, Tissues, Integumentary System
	2	Skeletal and Muscular Systems
	3	Nervous System
BIOL 2120K (Anatomy and Physiology2)	1	Endocrine, Cardiovascular, and Lymphatic/Immune Systems
	2	Respiratory, Digestive, Urinary, and Reproductive Systems

Table 1: *Unit coverage for in-person lab exams in on-campus Anatomy and Physiology1 and Anatomy and Physiology II labs.*

The Lab functions as a one-credit component of the four-credit Human Anatomy and Physiology course (either semester one or two). Students are concurrently enrolled in the lecture component of the course as well. The lab grade constitutes 30% of the total course grade, of which 15% is for lab exams, 5% for lab quizzes, 5% for online unit review assignments, and 5% for lab attendance (on time, with completed Prelab Homework). At the end of the semester, the single lowest lab attendance score is dropped for each student, as well as the lowest lab quiz grade.

Design Decisions for The Remote "Pandemic Edition" Lab

New Assessment Strategy

Our first decision was to move the assessments outside of "lab" time. Instead of lab quizzes and lab exams, we switched to a lower-stakes, more frequent assessment schedule, using our Learning Management System (LMS) to administer the assessments.

Lab assessments occur weekly, and are open for a specified window, from 6:00am Friday to 11:59pm Sunday. Students are allowed two attempts to answer questions randomly selected from a question pool that was generated within the LMS. Each attempt is timed, with time limited to 30 seconds per question, plus a two-minute grace period. Lab assessments typically contain either 32 or 40 questions. Students then receive 16 or 20 minutes to complete the lab assessment. Students can move freely within the assessment. Students are required to utilize the browser lockdown and video recording software that is housed with our LMS. Questions on lab assessments mirror the identification portion of the previous Lab Exams and Lab Quizzes, and are formatted as four related questions on a "slide" with one image.

For "Identify X" types of questions, students must type their answers in the appropriate text box, with correct spelling. We eliminated the short answer questions previously employed in person. Some of these concepts are now assessed using multiple-choice or multiple true/false questions embedded within the standard format of four "write-in" questions next to picture, figure, or illustration.

Lab assessments are autograded by the LMS. Student grades are immediately released once a student has submitted an attempt. Assessment questions highlight the most current content but may also review previous lab material. Guidance as to that week's assessment is posted a few days before the assessment is set to begin. Although students can immediately see their scores, they can view neither the questions nor their responses. To review their lab assessments, students make an appointment with the lab coordinator for a 15-minute virtual meeting.

New Semester Schedule

Since assessments are now conducted outside of lab time, we were able to re-distribute the semester's content over the entire 14 weeks. Our new schedule can be seen in Table 2.

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Week #	Fall 2019	Fall 2020
1	Intro to Anatomy & Physiology	Intro to Anatomy & Physiology
2	No Lab – Labor Day Holiday	The Cell
3	The Cell	Tissues
4	Tissues	Tissues + Skin
5	Skin	Bones
6	Lab Exam 1 / Bones	Bony Landmarks
7	Bony Landmarks + Joints	Joints
8	Muscles	Muscles
9	Muscles	Muscles
10	Lab Exam 2 / Brain	Brain
11	Spinal Cord	Spinal Cord
12	ANS	ANS
13	Special Senses	Special Senses
14	Lab Exam 3	Review / Semester Wrap-Up

Table 2a. *Comparison of BIOL 2110K (Anatomy and Physiology I) Schedule, Fall 2019 versus Fall 2020.*

Week #	Fall 2019	Fall 2020
1	Endocrine System	Endocrine System
2	No Lab – Labor Day Holiday	Heart Anatomy
3	Heart	Heart Physiology
4	Blood Vessels	Blood Vessels
5	Blood	Blood
6	Lymphatic / Immune System	Lymphatic / Immune System
7	Lab Exam 1	Respiratory System Anatomy
8	Respiratory System	Respiratory System Physiology
9	Digestive System	Digestive System Anatomy
10	Urinary System	Digestive System Physiology
11	Reproductive System	Urinary System Anatomy
12	Fetal Pig Dissection: all systems	Urinary System Physiology
13	Case Study Session	Reproductive System
14	Lab Exam 2	Review / Semester Wrap-Up

Table 2b. *Comparison of BIOL 2120K (Anatomy and Physiology II) Schedule, Fall 2019 versus Fall 2020.*

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New Virtual Lab Session

In the spring of 2020, when we pivoted to online instruction, TAs led lab sessions that attempted to comprehensively replicate our in-person labs, over video conferencing. These replacement sessions were 150 minutes. Although this served the purpose of finishing the semester, most lab activities cannot be completed in a hands-on manner over video link.

In our new course design, we wanted to maintain the opportunity for students to connect with their TAs in a set, scheduled format. Video conferencing for lab sessions can allow for question and answer time, as well as personal announcements and encouragement. We redefined our expectations for TA-led lab sessions, and changed the time frame to 60 minutes. In preparation for each week's session, TAs are provided with a PowerPoint presentation; these PowerPoint presentations are prepared by the Lead TA and reviewed at the weekly TA training meeting.

The first 30 minutes of each lab session is devoted to reviewing commonly missed questions, drilling on important terms, or discussing what was learned in the previous lab activity. Then the second half moves to the topic for the current week's lab activity. One of our key goals is to lay the foundation for students to subsequently complete lab activities on their own. Within this "preview" portion of the lab session, TAs do spend some time presenting mini-lectures over the new material, often following key concepts with an overview of the instructions for that week's lab activities. Several TAs have also chosen to ask students to download the lab activity instructions during their session, so that students can read over the instructions and ask any questions they might have at that moment. After leaving the lab video conference, students complete that week's lab activities on their own and submit their work for grading.

New Lab Activities and Lab Supply Kit

Students completing lab activities at home do not have access to the anatomical models and specimens housed in the campus lab spaces. In order to provide students with as many hands-on lab experiences as possible, we partnered with a lab supply company to create a student lab supply kit that students purchase to complete lab activities at home. Ideally, these supplies would allow students to complete the lab activities described in the custom lab manual. Unfortunately, due to various supply chain issues, we were not able to include all of the lab supplies that we would have ideally chosen.

For Anatomy and Physiology I, the lab kit contained activities for the third unit, the nervous system. For Anatomy and Physiology II, the lab kit included supplies for the cardiovascular system and the urinary system. Students are not paying the university lab fee of $50 per semester. For comparison, the cost of the kit was either $104.45 or $110.45 (Anatomy and Physiology I versus Anatomy and Physiology II).

In addition to asking students to purchase lab supply kits for at-home labs, we also utilized lab resources provided by our textbook publisher. These include an online anatomy and histology atlas and virtual physiology lab simulations. An additional resource that we provided to student was a subscription to a 3D anatomy atlas app that they could download onto a laptop, tablet, or phone through our institutional subscription.

All of these lab resources were utilized during the new lab activities to substitute for lab activities based on in-lab models, specimens, and TA-led group work. We did require that students purchase both the lab manual and the textbook, as previously assigned for the course. We have also recorded and posted videos which explain the content necessary for each lab.

New Grading Scheme

The Lab grade still counts for 30% of the student's grade for the entire course. The scoring breakdown for that 30% is as follows: 15% for lab assessments; 10% for lab activities; 2.5% for Prelab homework (and lab attendance); and 2.5% for practice homework assignments (see Table 3). We are still dropping one lab attendance grade. Previously, we dropped one lab quiz grade; now we are dropping the lowest lab assessment score at the end of the semester.

Fall 2019		Fall 2020	
Lab Exams	15%	Lab Assessments	15%
Lab Quizzes	5%	Lab Activities	10%
Lab Attendance + PreLab Homework	5%	PreLab Homework + Lab Attendance	2.5%
Lab Assignments	5%	Lab Practice Assignments	2.5%
TOTAL	30%	TOTAL	30%

Table 3. *Grading Scheme for Anatomy and Physiology Labs, Fall 2019 versus Fall 2020*

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Summary of Changes

We now have an online Anatomy and Physiology lab with a small synchronous virtual component and a majority of student work completed independently. We have been able to continue to teach students about all of the major topic areas previously covered in the two-semester Anatomy and Physiology lab sequence, with many hands-on lab experiences. We have maintained TA involvement with students, although contact hours are 40% of what we would have on campus. Now students submit their Prelab homework and their Lab Activities to the LMS for grading by their TA. Consequently, a large part of the TA commitment to the course is now for grading. By grading both the Prelab homework and the Lab Activities, TAs can see where students have questions, and students receive feedback on their work.

In addition to time spent grading, this new structure has required a significant time commitment for communicating with students. Prior to the start of the semester, specific details of the course structure and expectations of students were published on the LMS and also emailed to students. In spite of this, at the beginning of the semester, many students had questions about how to access course materials and how the various components of the course would be graded. TAs were able to answer some of these questions during lab, but many of these questions came to TAs and lab administrators in the form of individual email communications. As the semester has progressed, the overall amount of time spent answering student emails has decreased. Although it is hard to compare with an in-person semester, it seems that email communication is more time-consuming when teaching in the online environment.

One change to the grading format that generated questions from students was a change to the way that lab attendance points are earned. We received many comments from students who were surprised that their Prelab homework is now graded for correctness, not just completeness. In-person, Prelab Homework is checked for completeness, not accuracy. Some students now taking Anatomy and Physiology I had previously taken the course and are now re-taking in hopes of achieving a higher grade. Also, many students in Anatomy and Physiology II have taken our Anatomy and Physiology I course, and expect to follow the same format.

Also, we now have a disconnect between lab attendance and the grading of Prelab homework. Our in-person grading scheme required students to come on time to lab with their completed PreLab Homework to earn lab attendance points. In the online environment, we continue to require students to submit Prelab homework on time and come to lab on time. However, students must all turn in their Prelab Homework by 11:59pm on Sunday night, in advance of labs that meet Tuesday, Wednesday, and Thursday. The separation of these two events (submitting Prelab homework and arriving at lab on time) has increased the expectation that the two events be graded separately, or that partial credit should be granted for submitting Prelab homework on time, even if students are absent from lab.

Implementing online assessments with video recording generates hundreds of hours of footage of students taking assessments. In an effort to curb cheating during assessments, we have mandated specific procedures for generating an environment scan. Students who do not submit an acceptable environment scan (one that clearly shows the surface of the desk or work area where the student is completing the assessment, along with a 360-degree tour of the room) receive a 15% deduction on their lab assessment score. For this reason, review of assessment video recording, and environment scans, has become another role of the TA in the administration of this online lab. Documenting the 15% point deductions, as well as communicating with students about their videos and their deductions, has become another part of administering the Anatomy and Physiology lab online.

Initial Impressions of The New Course Structure

It has been satisfying to be able to deliver an Anatomy and Physiology lab with a hands-on lab component, even when we are in the midst of this pandemic, facing public health limitations on gathering on campus in groups. We have created a new structure in which students have interactions with TAs, and they receive frequent feedback on their work. Within virtual lab session meetings, TAs do get some contact hours with students, allowing TAs to witness some of those "aha" moments which especially energize teaching. Otherwise, the TA experience would be limited to grading and responding to student emails.

With the extension of lab content to 14 weeks, students actually get more time to study key areas. In Anatomy and Physiology I, we now have five weeks devoted to the skeletal and muscular systems, where previously we had only four weeks. In Anatomy and Physiology II, we now have separate sessions for anatomy versus physiology of the heart, the respiratory, digestive, and urinary systems.

Weekly lab assessments encourage regular studying (similar to the function of in-person lab quizzes) and review. Lab assessments vary in length from week to week. A typical lab assessment for Anatomy and Physiology I is 40 questions (ten slides). In Anatomy and Physiology II, lab assessments are typically 32 questions (eight slides). With this system, a student who takes each lab assessment only once will answer 400-500 questions.

In the in-person lab system, an Anatomy and Physiology I student who takes five quizzes (80 questions) and three unit exams (240 questions) will answer 320 identification questions over the course of the semester. For Anatomy and Physiology

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II, students who take seven quizzes (112 questions) and two unit exams (200) questions will answer a similar number of 312 identification questions. Thus, in the online environment, we are asking students to answer a larger number of questions, in smaller pools, over the course of the semester. Students who complete additional attempts will see an even greater number of questions in total.

Because of the larger number of questions that students answer, with multiple attempts possible, and questions pulled from random question pools, a significant amount of time has been invested in generating questions within the LMS. We are finding that through this process, we are asking a broader range of questions, compared to the questions for lab exams and lab quizzes in person. Because there are more questions, more structures are represented. For example, through the LMS, a student might randomly draw one of the questions showing carpal bones; rather than always asking the same one or two carpal bones, now there are four versions of this question, and more of the carpal bones are represented.

Previously, we encouraged TAs to minimize time "lecturing" to students, and to incorporate as many active learning, hands-on activities as possible within the 150-minute time period. Now that we are limited to 60 minutes, methodical planning of how to use those minutes has become crucially important. Since the shorter time frame has made it impossible to "cover" all of the material for lab, there is an increased importance in planning ahead of time what to discuss and what to omit.

With the virtual meeting set-up, certain ways to engage with students have become difficult. Making eye contact, scanning the room, and circulating while students work are less effective in the virtual environment. We are continuing to stress the importance of student engagement and active learning, however, and we are working on expanding our toolbox of active learning techniques that work well virtually. We do routinely implement Kahoot! games (www.kahoot.com) for review. Some lab sections enjoy doing Kahoot! every week, but others need a break from time to time.

It has been gratifying to see students using the lab resources like the anatomy atlas, and the various publisher-provided study tools, to a greater extent. These lab resources were available to students when we were on campus, but many students did not take advantage of them. Now that we are not in the lab with hands-on models and specimens, students and staff alike are being driven to make use of these resources that have always been available.

One side effect of more students spending time with study tools is that students are noticing more alternate nomenclature or spelling variations compared to the textbook. This is fantastic in terms of students gaining more knowledge and building their skills, although it can be confusing, and it does add an additional layer of complexity in terms of coding the LMS-based answer keys for lab assessments. Designing lab activities and the answer keys for those activities has necessitated more time in our textbook and more time reading about potential alternate correct answers. Even though we continually encourage students to use their textbook as a resource, many students are relying on Google to be their reference, which can generate interesting alternate answers.

At some point in the near future, it will be interesting to look back over the past couple of years to compare student success and student performance semester-by-semester as we have implemented such a variety of courses in different environments: completely in-person; emergently virtual; online only. Some reports suggest that modality of instruction (in-person versus online) is not the biggest factor in determining student performance (Attardi et al. 2018; Biel and Brame 2016) but that online platforms can lead to specific learning gains (Kuyatt and Baker 2014).

For now, the general feeling is that both instructors and students are doing their best to keep learning within the current pandemic constraints. Our impression is that many students are finding that it is difficult to learn Anatomy and Physiology independently, individually, at home. We all want to be back on campus, and back in the lab, but safely, without health risks.

Summer 2020 was essentially an accelerated course design process for our online Anatomy and Physiology labs. We had discussed the structure of these labs prior to the first week of the summer semester but then worked continuously throughout the summer to format the Prelab homework assignment instructions, the lab activity instructions, the practice homework assignments, and the lab assessment questions and answer keys.

As we moved from summer into fall, we had the opportunity to re-design specific lab activities or Prelab homework assignments that were perceived as ineffective in the summer. We have also continued to build our library of lab assessment questions, as there are 14 weekly lab assessments in Fall 2020 compared to only seven in Summer 2020. In the summer, the shortened semester compresses the time between a particular lab and the correlated assessment. We may refine the assessment schedule for future full-length semesters to connect the lab content with the lab assessments in a timelier manner.

The most striking lesson learned from our experience implementing online labs in Summer 2020 was the importance of onboarding students to the online experience, whether that be through a syllabus quiz, a technology set-up mock quiz, or continued technology training for both students and TAs throughout the first weeks of the semester.

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The biggest positive from a course design perspective is that the work of designing replacement lab activities has prompted deep thinking about how students learn this material and what students need to do to learn the structures and functions that are fundamental to a strong foundation in Anatomy and Physiology. We have designed this sequence of learning activities, assignments, and assessments in the hopes that by working through the activities, doing the practice homework online, and studying for the assessments, students will build the Anatomy and Physiology content knowledge that they need to be successful not only in this course and subsequent courses, but in their future health care careers. Hopefully, by doing guided self-study, students will also become better students.

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Literature Cited

Attardi SM, Barbeau ML, Rogers KA. 2018. Improving online interactions: Lessons from an online anatomy course with a laboratory for undergraduate students. Anat Sci Educ 11(6):592-604. https://doi.org/10.1002/ase.1776

Biel R, Brame CJ. 2016. Traditional versus online biology courses: Connecting course design and student learning in an online setting. J Microbiol Biol Educ 2016 17(3):417-422. https://doi.org/10.1128/jmbe.v17i3.1157

Hopp R, Britson C, Mukhopadhyay S, Goldina A, Chapman M, Nielsen M. 2019. Teaching assistants in human Anatomy and Physiology: their prevalence, recruitment strategies, funding, retention, and training. HAPS Educ 23(2):367-380. https://doi.org/10.21692/haps.2019.015

Hull K, Wilson S, Hopp R, Schaefer A, Jackson J. 2016. Determinants of student success in Anatomy and Physiology: do prerequisite courses matter? A task force review 2016. HAPS Educ 20(2):38-45. https://doi.org/10.21692/haps.2016.005 Knowles MS & Associates.1984. Andragogy in Action, Applying Modern Principles of Adult Education. San Francisco (CA): Jossey Bass.

Kuyatt BL, Baker JD. 2014. Two-year community: Human anatomy software use in traditional and online anatomy laboratory classes: student-perceived learning benefits. J Coll Sci Teach 43(5):14-19.

Pratt DD.1993. Andragogy after 25 years. In: Merriam S, editor, Adult Learning Theory: An Update. San Francisco (CA): Jossey Bass, pp. 15-25.

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