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Developing an Online Learning Environment for Community College Students Enrolled in Human Anatomy & Physiology and Microbiology Courses Amid the COVID-19 Pandemic

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ABSTRACT

This paper details methods that were adopted during the transition to an online learning environment for students enrolled in Human Anatomy & Physiology and Microbiology courses at a community college designated as a Minority Serving Institution (MSI) in light of shelter-in-place orders established to mitigate the spread of COVID-19. Traditionally carried out in a physical setting, strategies for teaching inquiry-based activities using virtual software will be described. The use of home laboratory science kits for the purposes of engaging students, aligning with Texas Higher Education Coordinating Board (THECB), and maintaining a hands-on approach will also be described. Challenges of transitioning to online instruction and how they were addressed will be further discussed.

Introduction

From the sudden transition to online instruction to potential decreases in future student enrollment, institutions of higher education have been presented with striking challenges resulting from the COVID-19 pandemic (Crawford et al., 2020; Jaschik, 2020). With such heavy emphasis placed on inquiry and experimentation, science instructors are uniquely tasked with ensuring students continue receiving enriched educational experiences in the absence of a physical laboratory setting. This paper details methods that were adopted during the transition to an online learning environment for students enrolled in Human Anatomy & Physiology and Microbiology courses at a community college designated as a Minority Serving Institution (MSI) in light of shelter-in-place orders established to mitigate the spread of COVID-19.

Pre-COVID-19 Context

Students were enrolled in an Anatomy and Physiology I & II lecture and laboratory course and a Microbiology lecture and laboratory course at a MSI community college in north Texas. Prior to the implementation of mandated closures of institutions of higher education, students were able to attend in-person lectures followed by laboratory instruction. Between lecture and laboratory sessions, the instructor was able to have conversations with students in the hallway or office. Once students entered the laboratory setting, the instructor was able to provide them with instructions and later walk around the classroom to ensure they were engaging with the content and to further probe their thinking. The laboratory setting was equipped with safety gear (e.g., aprons, goggles) and laboratory equipment. With the exception of gloves, students were not required to purchase any additional laboratory materials. The instructor was able to easily communicate instructions and to monitor students when they were working with laboratory equipment. If necessary, the instructor provided corrective feedback to students improperly using laboratory equipment. Students could also indicate

to the instructor if they were having difficulty operating microscopes or if they were unsure of where to make an incision on a specimen.

For Anatomy and Physiology, the laboratory consisted of students interacting with physical models, conducting inquiry-based activities, viewing histology slides, and dissections. To complete these activities, the laboratory equipment included anatomy models, high quality microscopes, dissection materials (scalpels, probes, scissors, pins, trays), specimens (e.g., sheep hearts, cow eyes, sheep kidneys), and proper safety disposal units (e.g., biohazard bins, broken glassware containers). Students were able to use these materials to facilitate their conceptual understanding of structure, function, and connections between body systems. Outside of laboratory instruction, students could check out anatomy models, although this option was very limited given the small number of models and multiple sections that required them for instruction. To address this inequity, students were encouraged to use Visible Body Courseware® (described further in a subsequent section).

For Microbiology, the laboratory consisted of techniques unique to the discipline, and students conducted a number of inquiry-based experiments. The laboratory setting contained instructional materials that were absolutely vital for instruction and learning. Students had access to bacterial stocks, a variety of growth media, tools required to aseptically transfer bacterial stocks to sterile media, Bunsen burners to sterilize tools, and incubators needed for bacterial growth. The laboratory preparation area was also equipped with an autoclave to prepare sterile media and to dispose of used media. Students were able to practice isolation and staining techniques.

Once nationwide shelter-in-place orders went into effect for the purposes of mitigating the spread of COVID-19, the instructor was faced with many challenges. One major challenge of transitioning to online instruction was that many students no longer had the ability to access and interact with their peers and instructor in a physical space. Students were also unable to manipulate physical models/apparatuses. To overcome this challenge, Visible Body Courseware® was officially integrated more comprehensively in the Anatomy and Physiology I and II courses to ensure that students could still learn the content in an interactive manner. In addition, the use of at home science kits was adopted for both Anatomy & Physiology and Microbiology.

Post-COVID-19 Strategies for Online Instruction

Learning Management Systems (LMS)

Certain features within learning management systems (LMS) allowed the instructor to engage with his students in the absence of a physical classroom and laboratory setting for both Anatomy and Physiology I & II and Microbiology. The instructor's institution relies on Blackboard Collaborate Ultra, which provides a live learning platform where students can listen to lectures, view demonstrations, get clarification on objectives, and re-watch sessions after they have ended. The instructor used the screen sharing capabilities of the software to share power points, navigate Visible Body Courseware®, navigate the textbook, and answer questions. The instructor could also show videos and mute the audio to add more detailed narrations pertaining to the learning objectives. To engage students in scientific discourse, the instructor encouraged them to utilize the chat board, audio, and video features (Epp et al., 2010). Students were able to pose their own questions regarding a particular topic, which often led to an expansion of the conversation. For example, a student asked why fish scales were used in treating burns when discussing varying degrees of burns, which then led the instructor to show videos and peer-reviewed articles related to the use of fish scales in treating burns. The instructor also created a discussion board with an open thread, so students could share study strategies with one another and further engage in discourse outside of lectures and virtual laboratory sessions.

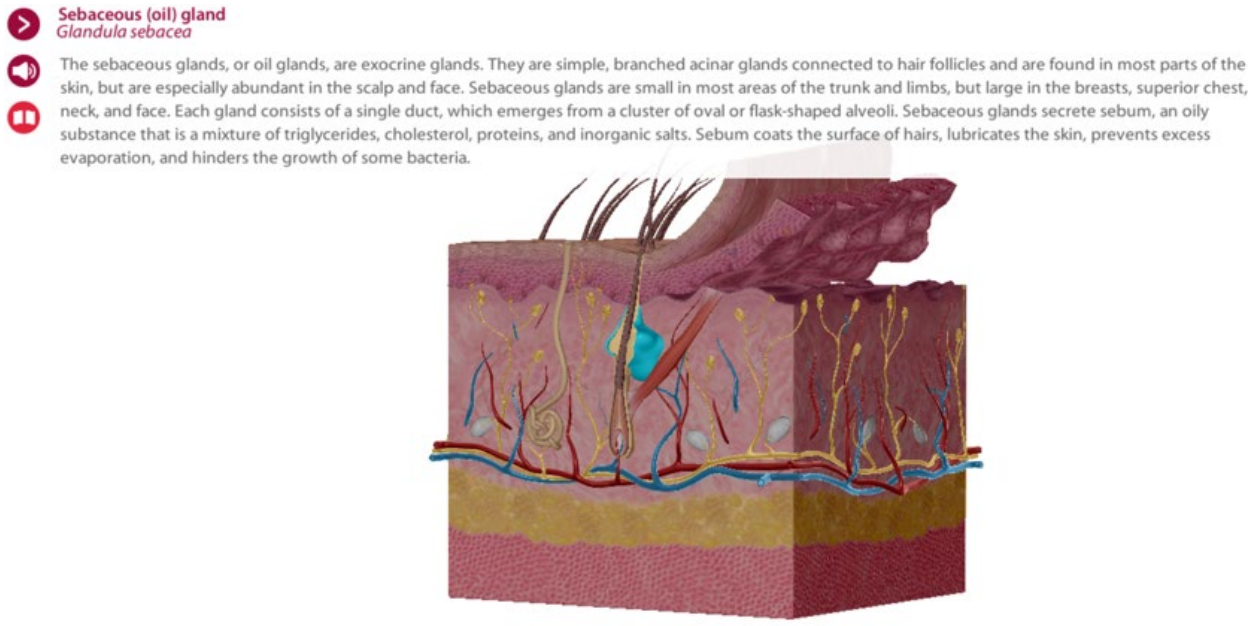
Human Anatomy & Physiology

Virtual simulations of gross anatomical structures have been shown to be an effective tool in supplementing the teaching of theoretical and experimental gross anatomy to increase learner immersion and engagement (Deng et al., 2018; Moro et al., 2017). Visible Body Courseware® is an affordable, interactive software that contains 3-D anatomy models, physiology animations, histology, and pathologies that helped to address course objectives and enrich student learning experiences. This software was chosen for the Human Anatomy & Physiology course because of its inclusion of all body systems from Gross Anatomy to Microanatomy and high quality 3D visualizations and animations for students to virtually interact with outside of a laboratory setting. The software is also accessible on a variety of devices including cell phones, tablets, laptops, and desktops.

The interactive models on Visible Body Courseware® were used to help build students' conceptual understanding of body systems. For example, when students were learning about the integumentary system, the 3D model of the skin layers had several features to help students learn the anatomy. Students were able to click on specific components associated with the skin layers such as the sebaceous gland to hear how the structure is pronounced and learn about its structure and function (Figure 1).

Figure 1

Interactive Models in Visible Body Courseware® to Learn Structure and Function (Image courtesy of Visible Body)



Another benefit of using Visible Body was that students were able to see muscles in action. When the physical models in the classroom were used, students were only able to remove muscles from the model and place them back in their appropriate place. Some of the models were not able to have muscles removed, nor were students able to generate motion. Visible Body Courseware® allowed students to visualize the different types of movements at synovial joints and the muscles involved in specific movements. For example, students were able to observe what muscles were involved in elbow flexion and elbow extension (Figure 2). If a particular muscle or bone were selected, the software would also indicate its name, origin, and insertion.

Figure 2

Interactive Models in Visible Body Courseware® to Learn Body Movements and Associated Muscles, Bones, and Joints (Image courtesy of Visible Body)

Considering many universities may not accept credit transfers from 100% online science courses, the biology department agreed that all future courses taught in an online environment would adopt the use of home science laboratory kits. Though these home laboratory kits alone may be insufficient for a student to fully understand concepts, they can be effective if combined with online guidance from a professor (Orozco, 2017). In addition to increasing the chances of credit transfer, the department also chose to adopt home laboratory kits to align with the standards set forth by the Texas Higher Education Coordinating Board (THECB). According to the Epstein and Perez (2018), students should be able to achieve the following learning outcome upon successful completion of Human Anatomy & Physiology: Appropriately utilize laboratory equipment, such as microscopes, dissection tools, general laboratory ware, physiology data acquisition systems, and virtual simulations. While many of the learning objectives listed by the THECB can be accomplished in a 100% online learning environment, this particular learning outcome is difficult to accomplish, as it requires manipulation of physical laboratory materials. Therefore, use of home science kits is necessary to achieve this learning outcome. Aside from credit transfers and alignment with THECB learning outcomes, a hands-on approach to science learning has also been shown to increase student performance and participation (Ekwueme et al., 2015).

Microbiology

Prior to carrying out certain laboratory techniques, students were required to complete online virtual laboratory exercises to gain a better understanding of techniques they would physically perform after being provided with instructions and demonstrations. This method was added to the course after the instructor read a study in which students who carried out a streak plate technique using the virtual simulation (Figure 3) successfully carried out the technique in the laboratory without instructor intervention. The students' performance was comparable to students who did not complete the virtual simulation and only received a demonstration from their instructor (Makransky et al., 2016). This method will continue being used for future online instruction.

Figure 3

Virtual Streak Plate Method to Practice Technique Prior to the Physical Laboratory Exercise (Michigan State University, 2010)

Once shelter-in-place orders were in effect, the instructor and students were no longer afforded the physical laboratory space to carry out laboratory exercises. At this point in the semester, students had learned all necessary techniques and protocols to begin the bacterial unknown identification. Unfortunately, they were not able to apply those techniques. The instructor developed an alternative online assignment that involved students interpreting and describing biochemical reactions on various media that were unique to a list of gram positive and gram negative bacteria. Each student had their own set of unknown bacteria to prevent academic dishonesty. Students applied their results to bacterial flow charts and listed the name of the bacteria that aligned with their results. Future microbiology courses will likely utilize the same bacterial unknown identification alternative. However, the instructor is considering using an open access virtual bacterial identification laboratory exercise (Howard Hughes Medical Institute, 2020), which includes a molecular biology component.

As described for the Anatomy & Physiology course, the instructor also chose to adopt at-home kits for Microbiology. THECB learning outcomes for Microbiology laboratory require students to engage in hands-on laboratory exercises that go far beyond the scope of other science courses (Epstein & Perez, 2018). Within Microbiology labs, students use microscopes more frequently, work with a number of reagents, prepare stains, and aseptically transfer bacteria from stock to sterile growth media. At home science kits allowed the instructor to adhere to the THECB guidelines, increased chances of credit transfer for students, and better engaged students using a hands-on approach. Some problems associated with the use of at home kits for microbiology include students having biologically hazardous materials in their homes and the high cost of kits. Prior to this, all laboratory materials were provided by the laboratory at no extra cost.

Conclusion

When developing an online instructional environment for community college students enrolled in Anatomy & Physiology and Microbiology, the instructor had to consider three important factors: cost, quality, and access. Much of the population is struggling financially due to the COVID-

19 pandemic. The instructor worked to adopt alternatives that were either open access or highly affordable to save students from the financial burden of purchasing curricular materials. Instructors should ensure materials are not only affordable, but of good quality, meaning they do not reinforce misconceptions, as well as contain accurate 3-D models and textual content. Instructors should also consider the importance of providing additional support to students with regard to race, age, and gender, as many may have difficulty navigating an online learning environment (Wladis et al., 2015). Despite the challenges faced by institutions of higher education and the science courses taught within them, science instructors have a multitude of instructional resources to provide their students with high quality, cost-effective, accessible online courses.

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