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Teaching microbiology via distance education

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Abstract
Few reports exist on moving microbiology lectures from face-to-face to online instruction. This paper presents different instructional strategies used at a regional university to minimize cognitive overload, where students feel overwhelmed accessing and learning the material presented. Content modules were presented asynchronously, including videos with captions, "Read Me First" documents to orient students, and pre-quizzes with key access for the entire semester. Emojis provided cues to students to minimize the feelings of isolation. This approach of instruction may decrease student concerns but requires additional assessment.

Introduction

The SARS Coronavirus Type 2 or COVID-19 virus pandemic necessitated changes in delivery of instruction (Ng et al., 2020). As instruction moved from face-to-face (F2F) to online education, the number of biology online university courses increased since spring 2020 (Dhawan, 2020). The pandemic has affected 1.6 billion learners or 87% of the world's student population in 165 countries as of March 2020 (UNESCO 2020). The rapid transition to remote learning had major ramifications. For example, students, faculty and staff had to quickly adjust to online instruction regardless of familiarity and comfort with technology, platforms, and training, especially science instruction at the college level. One discomfort that students have with online learning is described by cognitive load theory (Sweller, 1994), which describes the difficulty students have in learning, which requires placing information into packets or schema that are easily integrated and assimilated. Few reports address this problem with science courses on how to minimize student cognitive load and simultaneously navigate online technology. The purpose of this paper is to describe a format for transitioning the lecture component of a majors' microbiology course from F2F to effective online delivery. The significance of this work is that it provides useful strategies for biology instructors in teaching online science courses.

Background

Texas A&M University-Corpus Christi (TAMUCC: https://tamucc.edu) is a Hispanic-serving institution of about 10, 300 students (48% Hispanic) in Corpus Christi, Texas, a city of 320,000 located on the Gulf Coast 240 miles southeast of Houston. The Department of Life Sciences

(LSCI) within the College of Science and Engineering instructs nearly 1150+ students in biology, biomedical sciences and teacher education majors for STEM. Prior to the COVID-19 shutdown, most courses in LSCI were F2F, and blended courses (26-49% online) consisted of 18 of 206 courses, but no courses were fully online. The microbiology course, BIOL 2421, is one of the required core science courses taken by sophomores in the aforementioned majors. Moving this fundamental course from F2F to remote learning was critical and challenging to ensure continuity of student learning. In spring semester, this course normally has 60-80 students and consists of a lecture section meeting in three 50-minute meetings per week along with a 150-minute laboratory section meeting once per week. The major consideration for teaching a microbiology lecture online is that students may feel overwhelmed with the amount of information presented in class, and subsequently learning this information, as defined by cognitive load theory (Sweller, 1994). This report provides context on how to specifically transition college-level microbiology lectures to online platforms and how to present the information to decrease cognitive load, while making online learning ”user-friendly.”

Literature Review

Several reports in the literature describe how to transition from F2F to online for general biology courses but few for microbiology lectures. An earlier report compared student performance between full-time, part-time and online students in a nursing microbiology course in Canada (Carbonaro et al, 2006). A mini-review of e-learning stated how content from informal microbiology education (blogs and public dissemination) could be done virtually and used in college-level microbiology courses (Guarner and Nino, 2016). Students find difficulty in placing the information into schema, or constructs that will allow the information to be organized in an order that enables students to categorize knowledge (Sweller and Chandler, 1994). If students feel all information presented are included in schema, they will quickly reach “limits in processing capacity” (Sweller, 1994, 310) and thus reach cognitive load, where they feel “overwhelmed” (Sweller, 1994, 310; Sweller and Chandler, 1994, 187). Online learning has been identified in a report as placing more cognitive load on learners because the activities used to access the internet and navigate any site are unrelated to processing the schema required for learning the material actually presented within the site (Chang and Ley, 2006). Other investigations focused on general teaching adaptations of online human anatomy courses and online microbiology labs (Vasquez, 2020); a few reports mentioned how to make students feel more comfortable with online microbiology in general, and on making that course more accessible (Herzog and Mawn, 2020). Another report focused on utilizing six general strategies for making online instruction accessible to students (Bao, 2020), but specific methods for actual implementation were neglected. The gap in knowledge was how to transfer lecture information in microbiology to an online format during the pandemic to minimize cognitive load and mitigate difficulty of learners with the navigation of the Blackboard course management system. Prior reports were unclear on which effective pedagogy to follow to maximize student online learning objectives. Instructors quickly adapted and developed new strategies for online teaching. Such strategies aimed to ensure that students would not feel inundated by science content, but also to how to navigate the learning management site to obtain the information.

Adopted instructional framework

Student access to materials. Changes in this course took into consideration the "multiple factors of cost, quality and access" (Vasquez, 2020), computer skills of the learners and their ability to acquire technical skills and master e-learning on their own. By teaching the majors' microbiology course asynchronously, students could access pre-recorded lectures, and the ease of access prevented student frustration with unexpected technical issues during live lectures, allowed use of videos giving students the flexibility to self-pace (Ng et al., 2020) and enabled students to repeat portions of the lecture they did not understand (Bao, 2020).

Organization of course materials. Second, the course was divided into modules, with independent and non-sequential units to assist students in maintaining focus, providing them with a road map to guide and target specific concepts (Bao, 2020). Each module contained between three to four chapters with a "*Read Me First*" document stating all the activities to be completed in the module, featuring descriptive slides, animations, recorded videos, interactive quizzes and a section exam.

Use of pre-quizzes and keys throughout semester. Another useful aspect of this online transition method was the inclusion of a comprehensive pre-quiz assessment for each chapter with questions covering most topics in that chapter. After the due date, a key was provided for student use for the rest of the semester. In addition, students were informed that questions on the videos would be placed on the comprehensive quizzes and on the section exam to motivate students to watch them. The interactive multiple-choice quizzes and keys functioned as a guide for exam review.

The keys allowed students to strengthen their capabilities for active learning beyond the classroom and motivated them to undertake pre-class study preparation. This important course assessment factor has provided students with a study guide, revealed examples of what material would be tested on class exams and how it would be evaluated. Furthermore, pre-quizzes provided social presence in substituting for face-to-face assurances seen with questions normally asked after class (Ng et al., 2020). Weekly online quizzes enhanced both student engagement and active learning (Cook and Babon, 2017). Additional evidence indicates pre-quizzes provided more student-instructor feedback (Bao, 2020), and that students feel that online pre-quizzes increased understanding of course material (Evans et al., 2021). The weight of the pre-quizzes as a percentage of the final course was adjusted to reflect the increased importance on the total grade.

Accessibility for disabled students and use of emoticons and emojis. Courses were designed to be accessible to students with disabilities through the addition of captions or transcripts for video and audio files, adding alternative text to images or charts, and using Power Point slide layouts to maintain reading order. As distance learning lacks personal speech, eye contact and facial expressions, the emotional tone of the messages and passages was clarified by using expressive language, highlighting phrases, inserting emojis and using capital letters or quotation marks. Keystroke-based emoticons are used as nonverbal cues and icon-based emojis depict human expressions (Dunlap et al, 2016). Since online instruction cannot convey cues that can be seen in F2F teaching, these nonverbal actions inform students of important material, and provide social presence to students that the instructor is an actual person (Ng et al., 2020). This strategy decreases the feeling of psychological distance, isolation and disconnection that students report with hybrid and online learning (Adams et al., 2015; Dunlap et al., 2016; Dixson et al., 2017; Ng et al., 2020), Moreover, such methods assist in building a community of learning between the students and the instructor (Dunlap et al., 2016).

Discussion

Recent published reports (Vasquez, 2020; Bao, 2020; Herzog and Mawn, 2020) provided timely and excellent suggestions on how to better transition the teaching of microbiology from F2F to online formats and thus provided valuable online teaching method of transition during the Covid-19 pandemic. However, these short reports lacked specific details on how to make this transition, and why their suggested strategy should be followed. This current report describes the mitigation of cognitive load as the major focus on why their practical suggestions should be followed with moving microbiology lecture courses from F2F to online instruction. Several factors limit the success of this strategy for online transition. First, the level or the rank of the students enrolling in the online microbiology course during the pandemic affects the efficiency of successful learning outcome. A previous study (Adams et al., 2015) compared learning in a traditional versus hybrid microbiology course taught by the same instructor and found that students in the hybrid section did less well than in the traditional section but having more junior and senior students in the traditional section may have been a major contribution to the difference. Moreover, the study mentioned that more sophomores and freshmen were in the hybrid section. First and second year students were also reported to have been less engaged in the course, as measured by the lack of use of handwritten notes brought to class, decreased use of the recorded audio component, and less frequent use of extra credit assignments (Adams et al., 2015). Second, students failed to use the audio component of the online course, which correlated with the anecdotes mentioned by several students to one of the authors of this study. The pre-quizzes appeared to motivate and engage students. The prediction was that the pre-quiz keys were utilized as exam study guides and to enable students to place the material into context of what would be tested on exams. Also, the study guides would indicate to students how to navigate the Blackboard course management system, decreasing cognitive load. In turn, the presence of study guides enabled students to perform better.

One strong element of the online transition strategy that influenced student performance is the use of Starfish, a proprietary software package consisting of an undergraduate student case management system that integrates into the course management system (Blackboard) and the student information system (SIS). Starfish was acquired by Hobsons in 2015 (Gambino 2017; Wan 2021) and designed to seamlessly link and connect advisors, faculty, university support staff and services and students (https://www.hobsons.com/solution/starfish/enterprise-student-success-system/). Starfish involves faculty completion of Course Progress Reports every four to six weeks, in which they raise warnings (“Flags”), give praise (“Kudos”) or create referrals to student support advocates (SSAs) for resolving student problems with attendance, substance abuse, academic support, financial aid, personal or family concerns (Gambino, 2017; Velasco, 2020). Initially mandated by the Provost, Starfish allows students to feel personal connections, which contributed to better student- instructor interaction, and may have increased their positive learning experience. Starfish reporting would also serve as a “traffic signal”, informing students that they needed to refine their study approach (redoing pre-quizzes, paying more attention to the videos, or taking more notes). Velasco (2020) noted that another early warning software used at Purdue University employs that graphic symbol.

Limitations

While not formally assessed, anecdotal evidence suggested that for spring 2020 and both sessions of summer 2020, students highly appreciated adding quiz assignments as a study guide

and considered these quizzes to be the best aspect of the course. The guides enabled students to focus on details to be learned due to the amount of information covered in the lecture portion of the microbiology course. Future work would involve a study comparing online learning with F2F learning to confirm the anecdotal responses received from students as described in a previous report (Sweller and Chandler, 1994).

Conclusions

To summarize, instructors can overcome the transition challenges by careful planning and appropriate utilization of technological tools. This paper provides different strategies for microbiology educators to ensure a seamless transition from traditional in-class (F2F) to distance learning. The goal was to relieve students' anxieties, mitigate students' cognitive load in accessing information, and prepare successful microbiology students during the current pandemic. While each of the methods are not novel, their combined use in the emergency adaptation of in-person microbiology lectures to online presentation has been reported here. These methods, along with use of the Starfish early-warning system software, suggest a possible modified approach to microbiology instruction.

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