Implementing a Virtual Midterm to Identify Unknown Bacteria in a Microbiology Lab Course

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Identification of unknown bacteria is an integral module in most introductory Microbiology laboratory courses. This laboratory activity typically involves identifying bacteria based on Gram staining for morphology and gram reaction followed by studying their biochemical characteristics. When instruction moved to online mode earlier this year due to the pandemic, we faced the challenge of moving this hands-on, skill-intensive laboratory activity to remote mode. Here we describe the modular approach we designed to implement the midterm practical of bacterial identification remotely while trying to keep the online format as close to the in-person format as possible in a multi-section synchronous laboratory course. This virtual module was implemented successfully in the summer and fall 2020 semesters.

INTRODUCTION

Queensborough Community College (QCC) is an open-enrollment urban community college located in Queens, New York. The Microbiology laboratory class format in QCC’s Department of Biological Sciences and Geology is similar to contemporary course syllabi at many 2- and 4-year schools (1, 2). As in most Microbiology lab courses, practical exams are administered to assess students’ abilities to perform the techniques and skills they learned in the laboratory and apply their theoretical knowledge to practical laboratory situations. This became challenging with the transition to virtual instruction as the pandemic hit the world.

Identification of unknown bacteria is an integral module in most introductory Microbiology laboratory courses that typically involves identifying bacteria based on the morphology, Gram reaction, and biochemical characteristics of bacteria. Most of the literature regarding virtual microbiology instruction is focused on the use of online simulations, used either to enhance learning in an in-person lab or to replace in-person lab exercises (3–5). A web-based virtual bacterial identification process (6) also has been described. Here we describe how we transitioned the in-person Microbiology lab practical of identification of unknown bacteria to a fully virtual format using the resources that we already had in place for our in-person lab course.

PROCEDURE

As in most Microbiology lab courses, the first 4 weeks, i.e., Labs 1 to 4, cover an introduction to microscopy, microorganisms, growth media, aseptic technique, and Gram staining (1). The midterm practical was designed as an open book activity spanning Labs 5 through 8 (see Appendix 4 for a lab schedule outline). Grading was scaffolded, and a final lab report was required where the students described the entire identification process (Appendix 3). Though virtual, our classes met synchronously at scheduled times, so the midterm practical exam was conducted synchronously. However, with little modification, this practical could be conducted asynchronously; if using a platform such as Blackboard, specific elements of the practical exam could still be presented as time-restricted activities (e.g., Gram stain analysis) on Blackboard asynchronously.

Virtual practical exam

To ensure the investigative format of the practical, we wanted to retain the same general format for the virtual lab practical (see Appendix 1 for a table summarizing the in-person practical format) and tried to maintain the “feel” of the physical lab practical exam as much as possible.

Lab 5. Students were provided with two images of their unknown Gram-stained bacteria. The images were displayed in the “Course Documents” folder of the course Blackboard site for 15 min. Students were asked to note the morphology and Gram reaction of their “Unknown A and B” and submit their answers in the “Assignments” section.
of Blackboard within 15 min. The time limit was enforced to assess students’ visual memory skills and conceptual knowledge about bacterial morphology and variations in Gram reaction. The Gram stain results were graded and returned to the students by Lab 6. During Lab 5, students also learned about the biochemical tests (lab schedule, Appendix 4) that would later be used to identify their unknowns.

**Lab 6.** No changes to this process were necessary for the virtual format. Students constructed a dichotomous key and provided a list of selected media for the tests they chose to “perform” based on their dichotomous key. The dichotomous key/media selection was graded and returned to students by Lab 7.

**Lab 7.** If students were doing a physical lab practical, obtaining accurate results would require that they know how to inoculate the media for their selected biochemical tests, and what procedures needed to be done postinoculation prior to analyzing their results. Instead of performing inoculations in this lab, students were asked to submit an assignment describing the pre- and postinoculation procedures that they would normally do for the in-person practical (Appendix 2). This was graded and returned to the students by Lab 8.

**Lab 8.** Results of the biochemical tests were provided to students as images in Blackboard, which they analyzed. They then filled out the same form used for in-person labs (Appendix 2).

**Lab 10.** Students wrote a lab report describing the entire process of bacterial identification (Appendix 2).

**DISCUSSION**

We implemented the above virtual midterm practical exam during the summer and fall 2020 semesters. Although it worked well for the most part, there are challenges inherent to online learning that are not an issue with in-person classes. In the virtual lab practical, students missed the valuable experience of handling and culturing bacteria aseptically and performing Gram staining; videos of procedures (which we used extensively) do not adequately make up for this loss. In addition, we could not assess students’ technical prowess with the microscope or their ability to perform aseptic technique, grow bacteria aseptically, correctly prepare bacterial smears, and perform a Gram stain.

We came up with some solutions to conquer the ongoing issue of technical difficulties. When presenting pictures to students through Blackboard, it was prudent to have a backup plan (e.g., PDFs that can be emailed to students), ready just in case a student’s Internet connection fails or Blackboard is disrupted. We also found it was especially important to provide the students with clear instructions early on in the process about how the virtual practical would be conducted. It helped relieve some of their anxiety about online learning and made everything run more smoothly for both instructors and students.

Implementing our virtual practical exam required a significant time investment by faculty and the course coordinators. To facilitate the process, we organized Gram stain and metabolic test results into separate PowerPoint files for each bacterium. This helped the faculty to provide students with individualized results. We created a Blackboard course site for students enrolled in this multi-section course where all the resources, such as images and videos covered in the lab course, were available to students asynchronously (Appendix 3). Student’s feedback told us that this go-to resource site was extremely useful. We also have a faculty-only Blackboard site where faculty teaching the course exchange ideas and resources useful for transition to virtual instruction.

**CONCLUSION**

Although implementation of our virtual practical exam was done out of necessity, this approach could make online instruction more accessible (e.g., to deployed members of the military; to those with physical disabilities that may prevent them from participating in a physical lab). In these special circumstances, these individuals could take part (either synchronously or asynchronously) in the theoretical aspects of a practical exam. Though no virtual experience can completely replace an in-person hands-on laboratory experience, this midterm module attempted to provide students with an experience that closely resembled our in-person practical exam.

**SUPPLEMENTAL MATERIAL**

Appendix 1: Schedule and format for in-person practical exam
Appendix 2: Practical forms submitted by students
Appendix 3: Grading for practical exam
Appendix 4: Microbiology laboratory outline
Appendix 5: Resources used for the virtual midterm experience

**ACKNOWLEDGMENTS**

The authors have no conflicts of interest to declare.

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