Utilizing SARS-CoV-2 to teach PCR and gel electrophoresis in a pair of asynchronous distant learning laboratory exercises

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Abstract
Amidst the COVID-19 pandemic, many colleges shifted to online learning, creating a need for teaching materials that could be deployed in the online setting. A pair of virtual laboratory exercises with a COVID-19 theme were created for first year Biology majors to introduce students to the topics of polymerase chain reaction and gel electrophoresis. The exercises were effective in promoting student learning of both topics in an online asynchronous setting, and could easily be adapted for use in other courses or in a synchronous online setting.

KEYWORDS
asynchronous lab activity, COVID-19, gel electrophoresis, online biology laboratory, PCR, remote learning, SARS-CoV-2

1 | INTRODUCTION
Challenges and benefits to online learning in Biology laboratory courses have been discussed, and some studies have shown that when properly implemented, online learning in these courses can be as effective as face to face learning. During the initial wave of the COVID-19 pandemic, many institutions were forced to transition to remote learning during the spring 2020 semester. Regardless of their preferred pedagogies, many instructors found themselves scrambling to rapidly deliver online course content to students.

This article describes a pair of fully online laboratory exercises designed for students in a first year introductory Biology lab course. The exercises were deployed to students early during the COVID-19 pandemic, when little was known about the science of the virus, and our knowledge was rapidly evolving.

Abbreviation: PCR, polymerase chain reaction.

2 | DESCRIPTION OF ONLINE LABORATORY EXERCISES
In the first exercise, students are tasked with optimizing a fictitious PCR protocol to detect SARS-CoV-2 (Figure S1). The exercise briefly describes the virus and early progression of the pandemic, and directs students to a free virtual simulation of disease progression. Next, polymerase chain reaction (PCR) is introduced, with emphasis on how primers are used to define the amplified region. Students are given a sequence from the RNA-dependent RNA polymerase gene (RdRp) of the SARS-CoV-2 genome and asked to determine where the primers will bind to the sequence. Students are then asked to design short primers that could be used to amplify a different viral sequence, directed to NCBI’s Primer-BLAST tool to check the specificity of their primers, and asked to consider the relationship between the length of the primer and its specificity. Finally, students visit a virtual PCR simulator to learn more about the ideal conditions for running a PCR reaction.
In the follow-up exercise, students learn about gel electrophoresis to analyze PCR samples to determine whether patients are infected with SARS-CoV-2 (Figure S2). Students begin by estimating the size of various bands on the gel. Next, students work to attain a more precise measurement, creating a standard curve by measuring the distance each band in the DNA ladder traveled in the gel. Finally, they apply these skills to obtain a precise size for the PCR products for six fabricated patient samples, and determine whether each patient tests positive for COVID-19.

3 | OUTCOMES

To determine whether the laboratory exercises were effective in promoting student learning, students completed a pre- and post-assessment on the learning topics (Figure 1). Students significantly improved their scores from 60.4% to 80.3% after completing the laboratory exercises.

Because students completed these activities early during the pandemic, we measured whether they learned more about COVID-19 by completing the exercises (Table 1). Only one COVID-19-related question showed a significant increase in students’ scores. Students scored high on three COVID-19 questions on the pre-test, which is likely a reflection of their prior knowledge from the previous weeks of media coverage and education through the university.

These laboratory exercises provide an experiential learning opportunity, and could be adapted for various courses and delivery methods.

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CONFLICT OF INTEREST

The author declares no potential conflict of interest.
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SUPPORTING INFORMATION
Additional supporting information may be found in the online version of the article at the publisher’s website.

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