Approaches for teaching forensic body fluids analysis for remote learning

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Abstract: Serology and body fluids analysis is an important piece of the curriculum for forensic biology students in forensic education programs. In the spring and fall 2020 semesters, we pivoted to provide our laboratory curriculum online in response to the global COVID-19 pandemic. In this paper, we report upon our development and implementation of approaches for teaching forensic serology, forensic molecular biology, and body fluids analysis course lab content for remote learning. We report on five strategies we employed to teach laboratory content via remote instruction: prerecorded lab videos and content modules, decision dependent response PowerPoint slides, lab testing data for virtual review and reporting, student driven mock case testing in synchronous class with web-based conferencing, and Labster virtual lab simulations. The approaches integrated seamlessly into our course management platform. The virtual labs and approaches opened new learning opportunities for our students.

Keywords: Forensic science, serology, body fluids, teaching methods, remote instruction, inclusion

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Introduction

The Forensic Science Education Programs Accreditation Commission (FEPAC) requires laboratory experiences for students in accredited programs (1). In the spring 2020 semester, many colleges and universities across the United States and abroad quickly moved to remote learning models to keep students and faculty safe from the threat of infection with the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), most commonly referred to as COVID-19, after it emerged in Asia in 2019.

Prior to the spring 2020 semester, all Towson University (TU) chemistry courses were taught in person face-to-face. The forensic faculty team has utilized a studio lecture/lab approach for most forensic courses including forensic chemistry, forensic serology, forensic body fluids analysis, DNA technologies, and forensic analytical methods. TU shifted to remote instruction in March 2020 just prior to the scheduled spring break in the academic calendar. For the fall semester of 2020 most instruction was moved online, although the university permitted some laboratory experiences as well as undergraduate research, internships and clinical practices to be conducted in person with safeguards in place following the United States Centers for Disease Control (CDC) guidance. The modifications included faculty taking the Collaborative Institutional Training Initiative (CITI) Program Back to Campus Course, spacing student work stations at least 6-feet apart in teaching labs, requiring masks to be worn, wiping surfaces with antiseptic wipes, and complying with new, reduced occupancy room limits.

Additionally, in the fall 2020 semester, students and instructors ultimately were allowed to decide if they wanted to learn or teach in person based upon their risk circumstances for the disease (HyFlex). In the HyFlex environment, even if an instructor offered a traditional campus laboratory experience, students could request and would be offered an equivalent virtual learning experience. TU courses, including forensic courses, were offered using the HyFlex model.

As a result of the shift to online instruction, instructors needed to develop lab experiences that could be delivered remotely. While medical training programs have long included simulation and virtual exercises in their curriculum (2) and some forensic education programs have been offered online, our programs have been taught using traditionally methods consisting of classroom lectures and hands-on laboratories in the classroom on our main campus. Other programs have developed and implemented online courses and curricula. Very recently, a one-week standalone curriculum for medical residents was published (3). The trainees were provided eight online case-based simulation modules and four mini cases to solve, although

ultimately the residents were taught medical lab techniques and serology testing at the bench (3). Previously, *in silico* lab experiences were developed to teach PCR primer design (4), cloning (5), manipulation of DNA sequence data (6), and DNA statistics (6-8) to forensic and biochemistry students.

In the spring 2020 semester, we offered FRSC 420 Body Fluid Analysis required for undergraduate students pursuing the Bachelor of Science degree in Forensic Chemistry - DNA track option. In the fall 2020 semester, we offered FRSC 601 Forensic Molecular Biochemistry and FRSC 610 Forensic Serology for students enrolled in our Master of Science in Forensic Science graduate program. We employed the flipped classroom model and provided all students pre-recorded lectures uploaded to the course management site to view prior to the synchronous class time. We created and used several approaches for teaching forensic biology, forensic serology and body fluids analysis lab content for remote leaning for students in our courses. The approaches were designed to be educationally rigorous and inclusive. The approaches for teaching forensic body fluid analysis for remote lab experiences is the topic of this paper (**TABLE 1**).

TABLE 1 *Five approaches for teaching serology content using remote instruction*

Prerecorded lab videos and content modules
Decision-dependent response PowerPoint slides
Lab testing data for virtual review and reporting
Labster virtual lab simulations
Student driven mock case testing in synchronous class

Prerecorded Lab Videos and Content Modules

In the spring 2020 semester, modules were created in our course management system, Blackboard, to teach all remaining body fluids analysis course content virtually. Modules were created for all laboratory exercises that the students were scheduled to perform during the last half of the semester when the University pivoted to online instruction. The content modules in Blackboard are a convenient way to organize materials around subject areas. In this way, the instructor grouped readings, videos, PowerPoints and activities in a centralized location for each topic. Owing to the course coverage of forensic biology including both serology and the DNA typing process and interpretation, modules included standard forensic biology material: DNA extraction, DNA quantitation, DNA Amplification, DNA separation, electropherogram interpretation, Genetics, DNA statistics and Forensic DNA report writing. The serology portion was completed in person earlier in the semester in spring 2020. The virtual serology module was created when TU continued to offer online options in the spring 2021 semester.

The students were provided specific instructions and materials to review and activities that needed to be completed at any particular time. Each module contained readings from the textbook used for the course and readings from the primary literature. Videos of relevant lab activities were imbedded into PowerPoints and an activity was provided that was designed to mimic the setup activities needed for the particular laboratory exercise.

The students were instructed to view the videos and complete report forms based upon the results they observed in the videos. When they had questions, faculty guided the students through the modules and responded to concerns in video conferencing sessions. Student classwork was graded on completion and accuracy. The forensic serology course module is shown in **FIGURE 1**. Included in the module is instruction in report writing followed by a serology case and notes for processing and interpretation by the students. Also included in the serology module are protocols for blood, semen, saliva, and other body fluid testing and interpretation. The students were assigned to upload their completed report directly into the course management system.

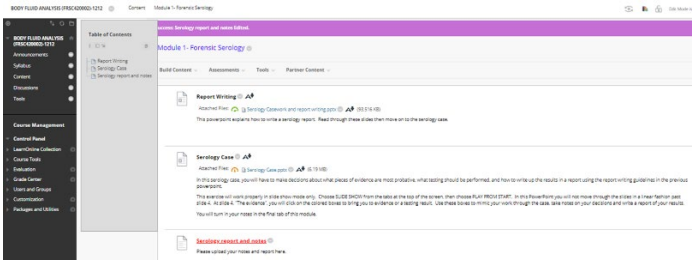

FIGURE 1 *Screenshot of the serology course module*

Decision Dependent Response PowerPoint Slides

It is a critical goal of TU's undergraduate and graduate body fluids analysis courses that students are taught to not only memorize terms but also understand the lecture content and demonstrate that understanding by applying their knowledge to analyze evidence and evaluate a case scenario. These are three of the higher levels of learning and understanding on the Bloom's Taxonomy scale (9). In order to assess student critical thinking skills using a case scenario, the hyperlink function in PowerPoint was used to develop a student-driven decision-dependent response slide show for a virtual case exercise (**FIGURE 2**). The slides were piloted with students in a forensic molecular biochemistry course and used by students in the body fluids analysis course in the serology module.

The students are presented with a case scenario and evidence submitted in a mock case. Following some introductory slides, the students are presented with the scenario as shown in **FIGURE 2**. The students simulate

analyzing the case and performing testing by clicking on the text boxes describing the evidence and then choosing the testing to perform on the items. The students must consider what evidence is available and where body fluids might be present.

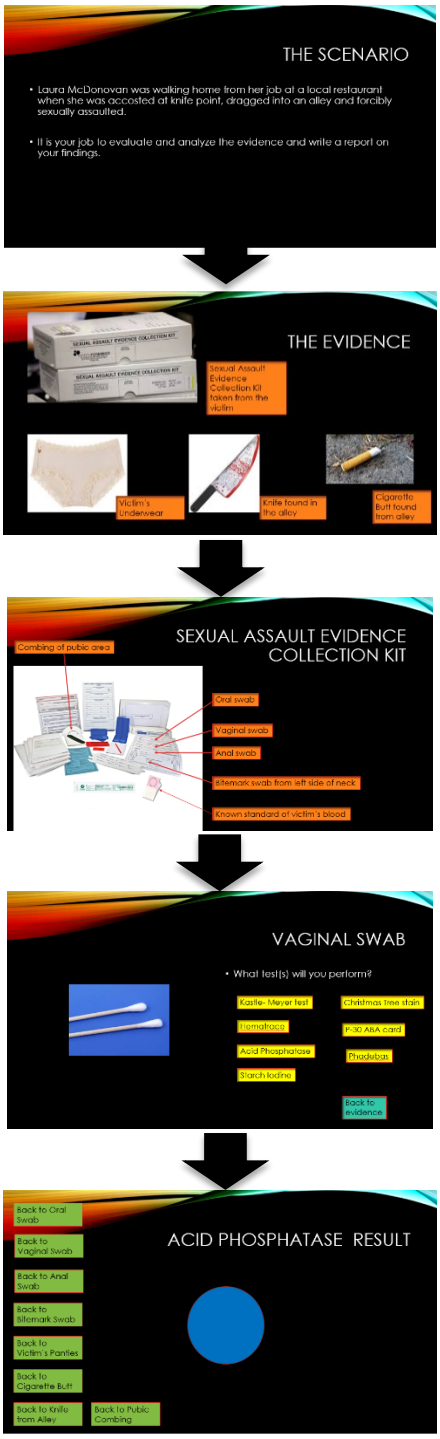

FIGURE 2 *Flow of slides and decisions*

The most probative evidence comes from closest to the scene of the crime. The students decide their plan of attack. For example, after being shown the evidence, if the student selects "Sexual Assault Evidence Collection Kit," they are presented with the "Sexual Assault Evidence Collection Kit" slide. If the student selects "Vaginal swab" or another item, they are presented with options of tests to perform on that evidence item. For example, upon selecting the slide for "Vaginal swab" the student must decide which test to perform based upon the scenario. If the student selects "Acid Phosphatase," the result is shown and the student can record the "data" and interpret the result. On the results slide, the student can select from the options to navigate back and the link will bring them back to the linked slide.

Even in the absence of an in person lab experience, the focus of our courses was on understanding case testing methodology, decision making of what evidence to test, analysis of results and preparing a report.

In their applications of the tool, the students were instructed to take notes on their selections and "findings" and write a report of those findings using the appropriate reporting statements and submit these in the Blackboard course management system. The students were instructed to indicate the priority of the evidence by listing them in order of greatest priority in their reports. The students were instructed that all tests did not need to be performed on each item but test results were included in the slides for blood, semen and saliva testing for every piece of evidence, in case that was their plan. Students were graded on the logic of the plan of their evaluation of the evidence, the completeness of their notes, and the accuracy of their report.

Lab Testing Data for Virtual Review and Reporting

In the fall 2020 semester, some of the students in our forensic serology course opted for a virtual learning experience for the laboratory portion of the course. To provide all students instruction on the testing methods and a laboratory experience, students were offered in person and virtual lab experiences. All students were instructed to view prerecorded prelab lectures on the theory and practice of the lab testing asynchronously prior to coming to the in person or virtual lab session.

In the HyFlex environment, the instructor taught students in person and online. The students who attended the in person lab performed serology tests on purchased body fluid samples to simulate quality control sample testing and prepared serial dilutions for each body fluid. This included testing neat samples, a negative control, and the serial dilution series for the relevant body fluid using each test and viewing purchased, prepared slides of human and animal blood, semen and hairs using a compound light microscope. For the students who selected the virtual learning option, the instructor recorded photographs of the pipet settings, process, and lab testing data results for the

chemical tests described above, images of alternate light source testing results, and microscope ocular field of view with magnification settings and slide specimen labels. For this module focused on learning the serological testing procedures and interpreting the results, the faculty member compiled the photographs into PowerPoint slides that were shared with all students using the course management system and the students viewed the slides asynchronously. All of the students were instructed to document the reagent recipes, testing procedures, test results, and microscope observations in their lab notebooks as we routinely require. The lab notebooks were graded for accuracy and completion.

Labster Virtual Lab Simulations

The University of Maryland (USM) system offered all faculty the opportunity to use Labster (10) in their fall 2020 courses at no additional cost to our students. The Labster Simulations seamlessly embedded into the Blackboard course management system contracted by the university (**FIGURE 3**) and the adopted modules populated in the gradebook.

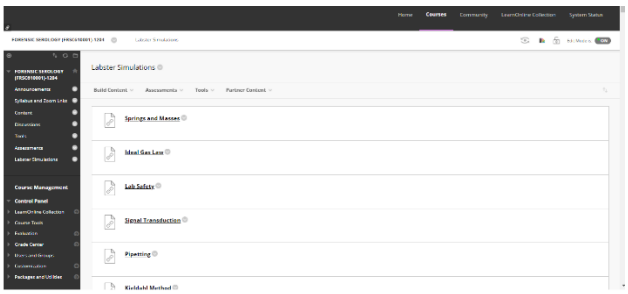

FIGURE 3 *Snapshot of Labster integration in Blackboard course management system*

Six modules most closely aligned to the course objectives were assigned including: Lab Safety, Biosafety, Solution Preparation, Pipetting, Antibodies, and ELISA. Students were required to complete five of the six modules; if they completed all of the modules, their five best scores were used in the computation of their grades. Students could take the additional modules visible in Blackboard from the Labster suite if they desired. Students could work at their own pace to progress through the modules. The module due date was set for late in the course so students had ample time to access and complete the simulations. Screenshots of frames from the Labster ELISA module are shown in **FIGURE 4**.

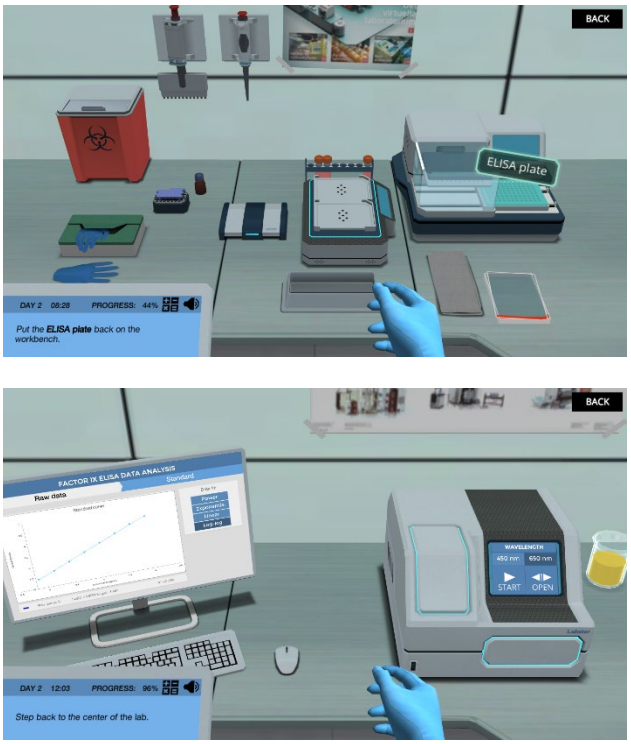

FIGURE 4 *Two screenshots of frames in the Labster ELISA module (Used with permission)*

Student-Driven Mock Case Testing in Synchronous Class

While an asynchronous learning model was used to introduce and deliver introductory lab testing procedures and quality control data in the forensic serology course, a synchronous model was used to deliver and involve students in the mock crime scene case testing course module. The instructor created the mock case but the students on the virtual session directed the case testing. The instructor or a graduate assistant acted as their "hands" in the lab. Since this module was synchronous, the students were able to decide upon the steps and direction for the testing process and the quantity of each reagent to add and the order. Since there were multiple students in the session, the case was directed by several students as compared to the in person option in the classroom in which each student worked on their own individual cases. The mock case testing for the online and in person groups spanned three weeks and culminated in a case report and expert witness testimony in a mock trial. The mock trial was synchronous during class time using a web-conferencing meeting platform.

Discussion

We developed and tested five modes of virtual instruction options for our forensic serology, forensic molecular biochemistry, and body fluids analysis courses. We found that most students were engaged and most were able to learn the theory and decision making skills similarly to the traditional model and in some cases, the theory was reinforced better using the virtual model than the traditional in class approach. Even in the absence of an in person lab experience, the focus of our courses was on understanding of cases, testing methodology, decision skills, analysis of results, and preparing a report.

While most of the students opted for the traditional in person laboratory experience in fall 2020 in the forensic serology course, two students opted for the fully remote option and five opted for the in person option for the introductory testing module and remote option for the mock case testing. The student lab notebooks for the students learning remotely were of equally high quality as the students who performed the testing in person. The variation in quality was more a factor of the individual student than the learning mode selected. Another option would have been to stream the class testing synchronously or record videos of the lab testing. The photographs were adopted due to the limits of the recording and streaming technology available to the instructor and need to simultaneously teach the in person students. While the virtual students were provided with all of the lab data for interpretation after class, the students did not get to experience locating reagents, performing the tests, pipetting, and even experiencing the smell of the fluids and reagents from working in lab.

Student feedback on the simulated serology case using the PowerPoint slides was positive. The slides utilized an advanced tool in the software, the hyperlink function. The faculty benefited from being able to assess student understanding and decision making in a remote environment.

Student feedback on Labster was also positive. The students especially liked that it introduced them to lab activities and environments we cannot offer at Towson University, including working in a biosafety level three (BSL-3) lab. They also liked that they were able to simulate performing an ELISA. We do not include ELISA testing in the course lab experiences due to the long waiting times including overnight and hour-long incubations needed to carry out the testing procedures. A strength of the Labster lab experience were the frequent explanations of theory and 'quizzes' of what to do next. As the students were working independently, as opposed to with a lab partner, in the online environment, they needed to fully engage and make decisions on which reagents to use, what step to do next, and which equipment and settings to use. The software also 'catches' potential errors of using the wrong reagent before the student performs the step. There are some drawbacks of the online lab modules. Students do not set the volume in the pipette replicates, load pipette tips after each pipetting step, pour reagents into multi-pipette troughs, and prepare reagents and dilutions for an experiment except in the introductory module on the topics. Additionally in traditional labs, they do not have an assistant to do tasks like pipetting for them although lab assistants certainly do prepare reagents, perform preliminary preparation steps for experiments, and repeat steps that did not work in lab between lab sessions to ensure a quality lab experience for the students.

Students provided positive feedback about the virtual, synchronous mock case experience. Students responded that they felt it went well and they liked that they were able to control the decision-making process. It was helpful for the instructor to have assistance of a graduate assistant to also serve as the "hands" on camera for the students while also teaching another group of students simultaneously in person in lab. They were able to view and record the results from an external camera set-up attached to the computer.

In the courses, we employed many modalities for learning serology content and multiple alignments to gauge student learning. All assessments were conducted using electronic testing synchronously or via take-home exams.

Conclusion

The virtual lab experiences developed to teach TU students body fluids analysis provided students an opportunity to actively participate, learn and continue their educations while remaining safe off-campus during a pandemic. While there are some drawbacks to remote learning in that students do not get the hands-on experience of learning the mechanics and realities of laboratory testing, the approaches we developed are options for instructors to provide students with content, assessment, and the ability to develop higher order skills and apply them to mock casework, while working from their desktops at home.

Acknowledgements

The authors thank the students in our spring 2020 Forensic Body Fluid Analysis and fall 2020 Forensic Serology and Forensic Molecular Biochemistry courses for their patience, feedback and enthusiasm for learning, Sonia Vagues for assisting with the mock cases, and Emily Zeller for her expertise with PowerPoint and educational design. Thanks to Labster and USM for technical support of the online labs and Sam Butcher of Labster for permission to use the images of the labs.

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