# Crafting an Effective Virtual Classroom in the COVID-19 Pandemic

**Catherine C. Connon, Ph.D. [1]*, Susan A. Greenspoon, Ph.D. [1,2], Tal Simmons, Ph.D. [1]**

[1]Department of Forensic Science, Virginia Commonwealth University, 1015 Floyd Ave, Box 34018, Richmond, VA, 23284
[2]Virginia Department of Forensic Science, 700 N 5th St, Richmond, VA, 23219
*corresponding author: cmconnon@vcu.edu

**Abstract:** Transforming hands-on laboratory activities to a meaningful virtual experience was truly challenging during the spring and fall semesters of 2020 due to the COVID-19 pandemic. Needless to say, the task was daunting. Even under normal circumstances, many instructors are not technological gurus. Despite Virginia Commonwealth University's fortunate position of having additional technological resources available to its instructors, many of these resources could not be utilized effectively, if at all, given the extreme time constraints to develop virtual courses and/or activities. VCU's Department of Forensic Science realized that virtual laboratories were not the only option to replace in-person activities. At home lab activities were appropriate for some forensic science courses, like crime scene investigation, but not appropriate for others, like forensic serology, due to safety concerns associated with the use of biohazardous body fluids, difficulty storing and transporting sensitive reagents, as well as challenges associated with the practical aspects of delivering/dispersing take-home laboratory kits. The forensic science department did its best to effectively and creatively adapt all courses for virtual learning in the spring and made additional modifications to accommodate social distancing to allow for in-person laboratory courses with some virtual components for the fall (though all lecture courses were still taught virtually). These included at-home, do-it-yourself crime scenes; virtual labs for forensic serology; a heavy reliance on Zoom for a variety of applications aside from online lecture delivery; and anti-cheating strategies for online tests. Even once the COVID pandemic subsides, some of these modifications will likely remain integrated into these courses because they were so effective.

**Keywords:** forensic science, virtual labs, do-it-yourself labs, crime scene investigation, forensic serology

## Introduction

Like many entities, higher education was hit hard in the spring of 2020 due to the COVID-19 global pandemic. Colleges and universities were faced with unprecedented challenges to move to a virtual classroom with only one- or two-week's notice, a task that would normally take months of preparation for a single course. Armed with few resources, instructors had to get creative and stay motivated to successfully face the challenges at hand: maintain student interest and effectively deliver course content and assessments with the appropriate rigor, all the while thwarting cheating and collusion (or at least be able to detect the latter).

This paper discusses several tactics utilized by Virginia Commonwealth University's (VCU) Department of Forensic Science to handle coursework in the midst of the pandemic. In the spring of 2020, all VCU courses rapidly switched to a virtual platform in late March. In the fall, all lecture courses continued virtually, while laboratory courses were either all in-person or a hybrid of virtual and in-person. Many of the strategies employed by our instructors were successful in maintaining student interest and effectively delivering content and assessments. From do-it-yourself crime scenes to virtual forensic laboratories, our faculty found creative ways to conduct their courses. Zoom was a critical platform used for virtual lecture delivery, but we quickly discovered other uses for Zoom, including recording lectures, providing remote access to software, software demonstrations, offering a virtual collaborative space, and even allowing for simultaneous instructor presence in two classrooms.

Not surprisingly, developing virtual activities to replace in-person activities was more challenging for hands-on laboratories than it was for lecture-only courses. Similarly, combating cheating on tests and exams delivered online was more challenging than other assessments like traditional homework assignments, written papers, etc. Fortunately, many instructors were able to quickly adapt to these challenges before the end of the spring 2020 semester, or at least in time for the fall 2020 semester.

In the sections that follow, we expand on our experiences at VCU in the Department of Forensic Science during the spring and fall semester of 2020, including some strategies, challenges, and successes. All in all, it was a success for a most unusual year.

## Do-it-yourself crime scenes

At the time VCU announced its lockdown order due to COVID-19, the undergraduate course in Scientific Crime Scene Investigation had one remaining lab exercise for the semester, which, unfortunately, was the major incident investigation. This was not only scheduled as a day-long exercise in full personal protective equipment (PPE), but made up half the students' semester grades. With only one week to come up with a suitable at-home substitution, the major crime scene investigation exercise ultimately relied on limited tools available to them – for example, their cell phone's camera (instead of digital SLRs), flour applied with a paint brush and lifted with cellophane tape (instead of fingerprint powders and lifting tape), rulers, tape measures, etc. – rather than the standard crime scene tools they had learned to use earlier in the semester.

The exercise was designed to occur in stages, allowing them time to plan and stage the scene. In the end, each student was responsible for undertaking all the activities that the whole CSI team would normally accomplish.

### *Part I: Making a crime scene*

In the assessment brief, the students' first task was to create a crime scene in a single room of their living space and really think through the details of the scene ahead of time, so that they knew what the perpetrator did at the scene. They were instructed that this had to be a homicide. It was presumed that they were all at home, or living somewhere with at least one other person, whom they would need to involve in the activity, posing as a victim (if they were truly self-isolated, they were allowed to use a pet or a stuffed animal/doll as a victim substitute). It was stressed that they had to explain to the individual helping them what they intended to do, what would be required on the part of the victim, and to obtain their consent to use them in that context for ca. 60-90 minutes. When they had determined what they wanted to stage (and how it had happened), they were to stage the scene. Students were asked to keep it simple so as to not disrupt their living space too much, but in an effort to keep it consistent with what they would have been asked to do in a group exercise on campus, they were instructed that the scene must contain the following elements:

1) Deceased individual (pet, doll, stuffed animal)
2) Weapon
3) Probable DNA containing evidence
4) Some type of patterned evidence (patent or plastic shoe print, fingerprint, or blood pattern)
5) Piece of clothing or trace from perpetrator

They also had to compose the First Responding Officer's (FRO's) report that they received as a briefing when they arrived at the scene.

### *Part II: Documenting your crime scene*

Once their scene was set and the FRO's report written, they were required to fully document their scene correctly via:

(1) A series of sequential photographs (using their phone) including evidence quality photographs (EQPs) of appropriate evidence (at the very least with some sort of scale – a ruler would suffice – and a label) as well as photographs of the body. They had been taught in previous labs the proper sequence of crime scene photography, from establishing the location, to establishing entrances and exits, four corners, using mid-range photographs to establish relationships of evidence to permanent features, etc. A photo log was also required.

(2) Sketches, including bird's eye view and two walls (measuring tapes were to be used if available, but if not estimates would have to do).

(3) And, of course, contemporaneous notes.

Although they were not required to formally collect and package the evidence, they were required to provide an evidence log with numbered exhibits, descriptions, and times collected/received. They were required to electronically hand in the FRO's report, their photos, scans of sketches and notes, as well as the photography and evidence logs.

### *Part III: Reconstructing the crime scene*

Each student then received all the materials of another student. Their assignment then changed to that of assuming the role of another individual in the task force, who was *not* at the scene, to reconstruct what occurred at the scene.

With the new crime scene, they were allowed to formally request (via a form on Blackboard) the appropriate lab personnel (the instructor assumed the role of all other lab personnel) to run additional tests on evidence they had received from the scene, the results of which would be provided to them. They then had to produce a narrative reconstructing the crime scene based on the materials they received.

 

*Part IV: The trial*

Lastly, the students were provided a virtual expert witness experience. Before this activity, they were asked to have available to them: a photograph of a piece of evidence from their scene, their photo log, their evidence log, and their contemporaneous notes and sketches. All were asked the same series of questions based on their activities whilst investigating their own scene. In particular, they were asked if the photograph/evidence in question was taken/collected by them, and if so, what identified it as such.

Overall, the students rose to the challenge and did a great job – and enjoyed themselves in the process. Their individual crime scenes exhibited a lot of creativity with limited means, including appropriate use of hairs, fibers, fake blood (**FIGURE 1**), the creation of plastic impressions, etc. Most students had enticed a relative or friend to play the part of the murder victim and one student had his dog as the murder victim – how he got the Husky to lie still for all those photographs was a testament to training – and one used a teddy bear who was "wearing" a towel and had been stabbed to death in the bathtub (**FIGURE 2**). Grading of photographs was, of necessity, lenient, as they couldn't really control exposure and depth of field well with cell phone cameras. An unexpected problem (instructor lack of forethought was to blame, not the students) was the lack of standardization in the format in which photographs were submitted, ranging from PowerPoints with cut and pasted photographs, a link to a Google folder, an endless chain of emailed photograph attachments, etc. which posed difficulties in rapidly sharing these with both the TA helping to grade and the student doing the reconstruction. The most common errors related to evidence labeling, evidence and photo logs (not coincidentally the same mistakes that occur frequently with in-person CSI exercises), with lack of personal unique identifiers being given to recovered evidence. Of course, this came up in the expert testimony portion of the exercise, where they could not prove the identity of photographs or pieces of evidence as having been collected by them.

Following the success of this platform in the spring 2020 semester, the exchange of scene documentation among the groups was incorporated into the in-person offering of this course in the fall 2020 semester, as it taught them more than reconstructing their own crime scenes.

**Virtual Forensic Serology Lab**

Given all the pros and cons of the various modes of delivery, we opted to try our best at adapting the hands-on serological laboratories to a virtual environment using whatever resources were readily available. The goal was to make virtual activities for each of the serological tests

**FIGURE 1** Three examples of student creativity with blood pattern evidence in the make your own crime scene exercise from Spring Semester 2020

**FIGURE 2** The teddy bear bathtub murder and the murdered Huskie from the make your own crime scene exercise from Spring Semester 2020

that were normally performed in-person and for the student to interactively complete the tests by following the standard operating procedures (SOPs) provided in the same laboratory manual used for in-person activities. This included luminol, fluorescein, combined phenolphthalein tetramethylbenzidine (PTMB), Takayama, and ABAcard® HemaTrace (Abacus Diagnostics, West Hills, CA) for blood testing, as well as longwave UV enhancement, alternate light source enhancement (UltraLight ALS), acid phosphatase, sperm slides with KPICS® staining, and ABAcard® p30® (Abacus Diagnostics) for semen testing. The end result was a sophisticated, interactive virtual laboratory for blood and semen detection/identification operated through none other than Microsoft® PowerPoint® using complex animations (see **FIGURE 3 and 4**).

Aside from the obvious challenges associated with making realistic, interactive lab activities in PowerPoint, additional challenges surfaced. First, the size of the PowerPoint file was excessively large, which interfered with the ability of the slide show to progress smoothly. To overcome this, the file was partitioned into numerous smaller PowerPoints (usually 7-15 slides) that were linked via embedded hyperlinks. Given the complexity of the virtual lab (i.e., number of slides), numerous sample options (>20 for each test), and number of serological tests (ten), this resulted in hundreds of small PowerPoints strung together via embedded hyperlinks for the final product. In order to avoid confusion regarding which file to open, a single PowerPoint file was visible to the students and numerous other peripheral files were hidden.

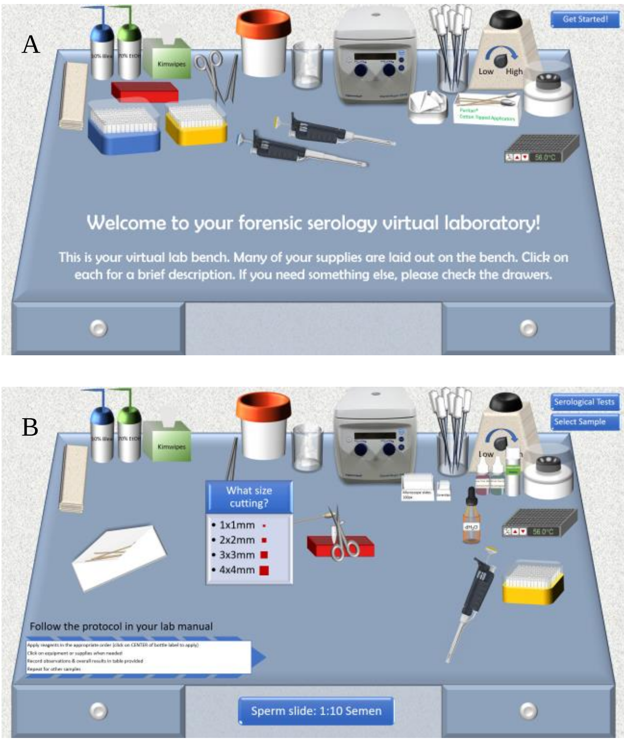


**FIGURE 3** The virtual forensic serology lab A) consisted of a workspace similar to what a student would find in a face-to-face classroom; B) Lab exercises were prepared to mimic the in-class experience as much as possible, including interactive questions regarding sample cutting sizes, as shown for the exercise in which slides were prepared for sperm searches

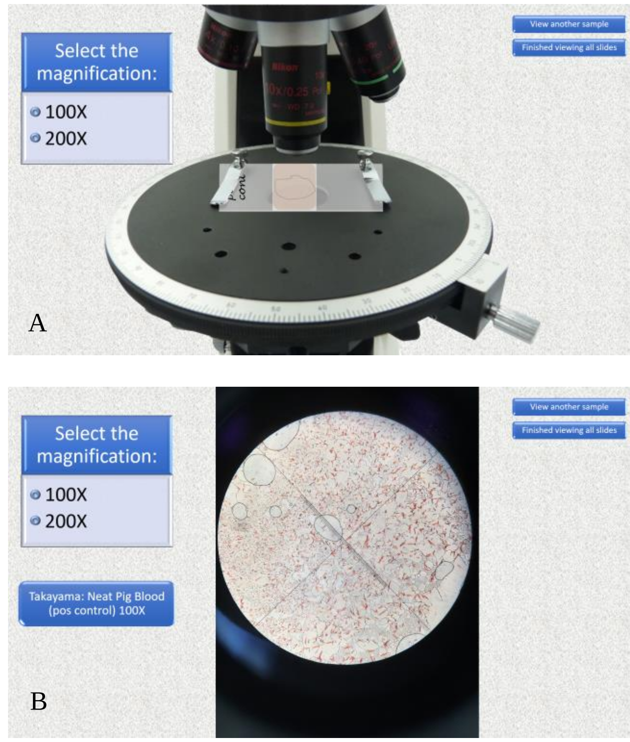


**FIGURE 4** Attempts to keep the virtual lab realistic for exercises involving microscopy, such as the confirmatory blood test Takayama, utilized A) still images of the microscope stage and offered students a choice regarding magnification; B) Real images from actual test samples were also incorporated at each of the specified magnifications

The next challenge stemmed from how to keep the PowerPoint secure and prevent students from viewing the slides outside of presentation mode. With a little research, this was easy to overcome by saving the desired PowerPoint file in slide show mode (.ppsx). With all other files hidden, students could then only open the .ppsx file and only view the virtual lab as intended. This worked for PC users but unfortunately for Mac users, all hidden files were visible, so students were instructed to only open the .ppsx file and to ignore the others.

Delivery of the virtual lab files to the students was another challenge. With a little research coupled with some trial and error, this was readily resolved by providing the students with a Zip file on Blackboard containing all of the PowerPoint files. Students simply had to extract the folder, save it on their personal computer, and then open the .ppsx file. From their personal computer, they could complete the virtual lab activities using the SOPs provided in the same lab manual that would normally have been used for in-person labs.

Numerous learning outcomes were tied to the virtual labs. Following completion of the virtual labs, students should be able to:

1) Describe the mechanism of the serological test for the body fluid being tested.
2) Summarize the procedures for the serological tests.
3) Describe general precautions for contamination prevention.
4) Describe when and how to process controls, including what specifically serves as a control for the serological test.
5) Discuss the importance of following a standard operating procedure.

Formal feedback was solicited from graduate and undergraduate forensic science students that had access to the virtual blood laboratory (feedback is pending from the virtual semen laboratory and not included in this paper). As a reminder, this virtual laboratory was prepared in preparation for having completely virtual serology labs but VCU was able to provide face-to-face learning for the fall semester of 2020 (for labs). The virtual labs were therefore made available as supplemental material to all students (43) enrolled in a forensic serology course. Please note that 11 of these students were not taking the laboratory course at all, and this virtual lab was the only

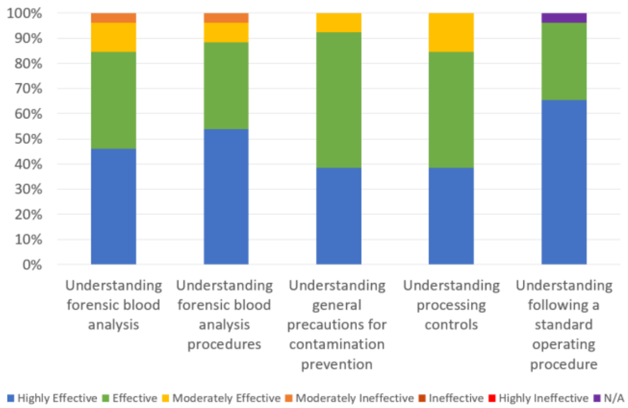


**FIGURE 5** Students' perception of the effectiveness of the virtual lab with respect to the learning outcomes is reported below. Students rated the virtual lab as either Highly Effective or Effective 85-96% of the time for each of the outcomes (n=26)

laboratory experience they had access to. Twenty-six of the students provided feedback (62% graduate and 38% undergraduate), eight (32%) of which were only enrolled in the lecture course, not the in-person laboratory. Overall, 85-96% of all responding students rated the virtual lab as either highly effective or effective at meeting each of the five learning outcomes noted above (see **FIGURE 5**). When broken down between those that were also enrolled in the in-person laboratory versus those that were not, there was not a substantial difference seen between the two groups (data not shown).

Twenty-two (85%) of the 26 students that provided feedback also left open ended comments: 41% of these comments were entirely positive; 45% were a mix of positive comments, technical issues encountered and/or things they didn't like about the virtual lab; and the remaining 14% only reported technical issues. Altogether, 86% of the commenting students left one or more positive remarks, which included key words like: amazing, cool, awesome, fun, helpful, informative, beneficial, enjoyed, detailed, etc. These students commented that it is a great tool to visualize the labs if not co-enrolled in a face-to-face lab, study/review, and irritate key points, all in a fun environment. Several that were co-enrolled in the face-to-face laboratory indicated that it was "very similar to" or even "exactly like" their in-person lab experience. Some also commented that they liked that the virtual lab would ask questions about the procedure: for example, what cutting size should be used, at what temperature should be the sample incubate, which pipette should be used, how to set the pipette, etc.

The comments that mentioned technical errors and/or things they didn't like about the virtual lab primarily commented that it was slow, that there were too many files, and that the lab would not advance appropriately because a subsequent file would not open. Nearly all of these errors were attributed to the students not extracting all the files from the Zip file that was downloaded from Blackboard and/or compatibility issues using a Mac operating system. Some Mac users had no problems whatsoever, so more information needs to be gathered to identify which Mac operating systems and versions of PowerPoint will work/not work. Students were forewarned to close out other programs, especially other PowerPoint presentations to prevent the virtual lab from progressing slowly.

This feedback was extremely encouraging and insightful. It was used to improve the virtual semen lab prior to being released to the students (feedback still pending). Knowing that these virtual labs are beneficial to those co-enrolled in the face-to-face forensic serology lab, as well as those in lecture only, additional virtual labs are being planned for other serology exercises that are a normal part of the in-person laboratory.

## Zoom: More than an online lecture delivery platform

COVID-19 skyrocketed the video conferencing platform, Zoom, to an unprecedented level. At this point, it would be difficult to find someone that hasn't heard of Zoom. This platform allowed instructors to virtually deliver lectures and reach students via their personal computers, tablets, or even cell phones. However, Zoom proved to be more than just an online lecture delivery platform. From recording lectures to remote access to software to providing a collaborative space, Zoom proved to be a robust, versatile tool essential to the success of any virtual educational environment.

### *Recording lectures*

Whether live or in advance, many options exist for recording lectures. One long standing option has been to use PowerPoint embedded with audio files in order to provide narration as students advance through the presentation. This approach is relatively easy, and one of the major advantages is that the instructor can replace select segments of the narration. Other screen capture recording softwares, like Kaltura, allow for the instructor to record their screen as they are giving their lecture. This seems to be used more for pre-recording lectures, rather than recording live lectures, though the latter can be done. Kaltura also includes some editing options prior to finalizing the recording. However, personal experiences with Kaltura prior to the COVID-19 pandemic left many looking for other options because it was rather clunky and somewhat temperamental.

Zoom made things a breeze. You need a camera and a microphone. It truly seemed as though somehow the software figured out the rest. Lectures could be easily prerecorded or recorded live during synchronous lecturing. Recording could be paused and later resumed without issue. What was so wonderful was that aside from this dependable platform (assuming dependable internet connection), there were other features that made Zoom even more versatile for the virtual classroom. These are described in more detail below.

*Remote control: From software access to virtual troubleshooting*

Zoom's remote control feature was a true Godsend - to put it bluntly - for two main reasons: it allowed students to have access to software installed on university computers and it allowed for virtual troubleshooting from folks other than the IT department.

One of VCU's upper level undergraduate courses in forensic biology normally involves hands-on experience with two different softwares from Applied Biosystems: *SDS 7500 Software System* for analysis of real-time qPCR data and *GeneMapper® ID-X* (GMIDX) for analysis of human DNA profiles. The SDS 7500 software is available for free download on Applied Biosystems website, and it is feasible for students to install it on their personal computer but it doesn't always work due to a variety of reasons (incompatibility with the operating system, etc.). On the other hand, GMIDX requires a software license, so students would not be able to have it on their personal computer even if they wanted to. Zoom's remote access feature allowed students to have essentially the same hands on experience using each of these softwares from their own computers as they would normally have in the classroom. It was simple. Initiate Zoom from the university computer that has the desired software, grant the student remote access, and viola, they can use the software. Multiple computers could be set up simultaneously and accessed through independent Zoom sessions. We took advantage of this process at least three times during the virtual portion of the spring 2020 semester. It worked great, and the students appreciated the hands-on experience.

The remote-control feature also came in handy on numerous occasions when trying to troubleshoot an issue for a student or fellow instructor. We no longer had to rely on an IT tech remoting into our computers to assist us. If a peer or colleague knows how to help, both parties can meet via Zoom and one can be granted remote access to the computer of the person needing assistance.

One example included an in-class (virtual) exercise regarding data analysis and displaying data in tables/charts. Students were given a fabricated data set and asked to work in small groups to analyze it and create an appropriate table/figure. When sharing their work with the rest of the class, one of the groups indicated that they wanted to add standard deviations to the bar graphs they created but unfortunately, they couldn't figure out how to do that. Easy enough - remote control was granted to the instructor, who then demonstrated how to add in the desired information. Even better was the fact that all participants had an up-close view of exactly what was going on because they were watching it from their personal computer or other device.

Along the same lines is assisting a colleague in need. Regardless of our years of teaching experience, we are all at various levels of technological competency. Some instructors had never set up an online exam before. Rather than relying solely on emailed instructions or phone calls, two instructors could meet on Zoom to facilitate one helping the other setup the exam (or troubleshoot another technological issue). It really wasn't that much different than both individuals being physically huddled around one computer with one helping the other.

*Touring TrueAllele: Mixture deconvolution software*

The VCU graduate level course *Emerging Molecular Applications for Forensic Biology* involves a tour/demonstration of TrueAllele® Casework (Cybergenetics, Pittsburgh, PA), a probabilistic modeling program that utilizes raw capillary electrophoresis (CE) short tandem repeat (STR) data to produce the most likely genotypic explanation for each contributor to a forensic DNA mixture. The TrueAllele® Casework (TA) system trials many thousands of different explanations for the DNA mixture data and objectively derives DNA profiles for the unknown contributors to the mixture. To utilize the system, users undergo a fairly extensive training program and thus, it is not a "plug and play" software program.

The Virginia Department of Forensic Science (VDFS) currently has four TA workstations all connected to a dedicated collection of servers for data processing and provides live in-person demonstrations of the TA probabilistic modeling software to VCU's graduate forensic science students. To do so requires some logistics, even in normal, non-pandemic situations, given that the primary workstation used for teaching is located in a small office. Even during semesters that do not require social distancing, the graduate level class needed to be split into small groups so that students could not only fit into the small space, but also be able to *view* the computer screen for the demonstration, specifically the operation of the program and the data output on the computer screen. Moreover, students needed to hear the explanations for the process and be able to pose questions in order to better understand the system. An example of a data process during the probabilistic modeling process that would have been explained as part of the process is shown in **FIGURE 6**.

Given these demands under normal circumstances, there were concerns as to whether or not conducting this live demonstration via Zoom (to adhere to additional constraints encountered because of the pandemic) would provide the same level of instruction and degree of clarity.

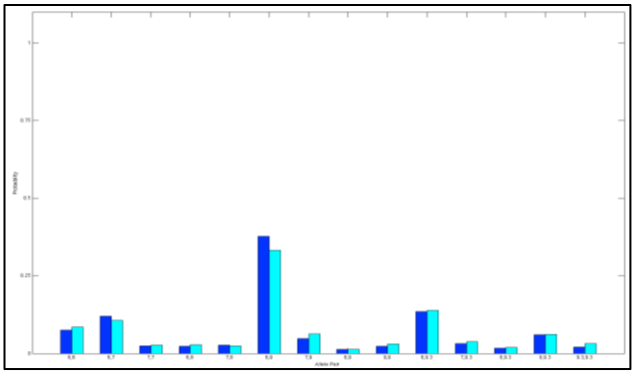

**FIGURE 6** Genotype concordance at a single locus for two independent TA analyses shown in lighter and darker shades of blue. The minor (11%) contributor to a three-person mixture is displayed which shows a wide distribution of genotype combinations to explain the mixture (x-axis) and the corresponding posterior probabilities of those genotypes on the y-axis

Those fears were unfounded. The utilization of Zoom allowed for sharing the workstation desktop itself, providing all participants with a clear view of the software modules, how they were employed, and the resulting data produced by the TA system. Students posed questions in real time and those questions were answered, frequently by opening a new window on the desktop or addressing data that was displayed for all to view.

With a software system such as TA that requires extensive training for its operation, teaching remotely may be the most efficient mechanism for educating students on the process.

*Collaborative space*

In addition to offering a virtual lecture platform and remote access to other participants' computers, Zoom also lent itself as a virtual collaborative space. Students could work together in small breakout rooms during class, the instructor could float from room to room to check in on students to see how they were doing, and students could ask for help even when the instructor was not in their breakout room - all very similar to how things would operate in a physical classroom. Collaborative space was available outside of regular class hours, whether for students to work on a group project, form a study group, or for instructor/student office hours.

Probably one of the best uses of Zoom in this fashion was to offer a simultaneous presence in two classrooms. Given the social distancing requirements, many physical classrooms had reduced capacities. For example, many of VCU's teaching laboratories could normally accommodate 24 students. Due to COVID restrictions, we had to limit to 12 students. One of our workarounds was to utilize two adjacent classrooms at the same time, with half of the students in one classroom and half in the other. A Zoom session would be in progress for both classrooms, with one of the classrooms set up to broadcast the video feed of the instructor talking and giving direction; the adjacent classroom was set up to receive that video feed. After the main set of instructions had been given, the instructor could then move freely between the two classrooms to assist individual students/groups.

**Online testing & combating cheating**

Online testing was unavoidable following the mandate to shift to virtual courses. Instructors had two main choices: old-fashioned take home tests/exams and/or those administered through an online platform such as Blackboard. Many at VCU in the forensic science department opted for the latter for a variety of reasons. For many, this meant a personal crash course in composing and facilitating Blackboard exams.

For some, online test development and administration went off without a hitch, including expected student performance based on previous semesters and their own abilities. It was a completely different story altogether for others. Some instructors noted universal and clearly blatant cheating for entire courses; one such instructor reported that 2/3 of her class earned an A on the first online exam following the campus shut-down in spring 2020, a substantial increase from the usual 5-7% as normally seen in past semesters for that test. The majority of students did not even try to cheat subtly, and instead cut and pasted large swathes of text directly from the PowerPoint pdf's posted on Blackboard after each lecture. After considerable personal deliberation, discussion with appropriate colleagues, and explanations to the class, the instructor decided to drop that particular exam from semester grade calculations because it clearly did not reflect their knowledge. Those in the class who had cheated were angry with this decision, while those who had completed the exam fairly (including both those who had and had not scored well) were not angry.

Other instructors experienced limited cheating with online tests, isolated to a few students repeatedly collaborating with one another. Detection of this type of cheating was less obvious and the offending students appeared to be somewhat skilled, knowing to change their free response answers just enough to avoid suspicion. Ultimately, repeated nearly identical scores and start/submit times for testing, etc. led to these students being found responsible for this honor code violation.

From these initial experiences, many of our instructors chose to alter their testing platforms and/or strategies. Some made changes towards the end of the spring 2020 semester, while others waited until fall 2020. Changes included but were not limited to harsh consequences for cheating clearly spelled out in course syllabi; use of anti-cheating resources for virtual exams provided by VCU, namely Respondus Lockdown Browser with webcam monitoring; randomizing the order of the test questions; preventing backtracking to previous questions; compiling multiple versions of the tests; etc. To curtail use of course materials posted on Blackboard, one instructor also chose to remove all PowerPoint pdf's 15 minutes before the start of the exam.

Unfortunately, one of the first experiences the forensic science department had with Respondus LockDown Browser was not a positive one. Despite carefully following all the instructions and providing notification to the students well in advance of the exam time, the exam immediately and fatally crashed for every single student in the class, booting them out of the exam and not letting them re-enter. Immediate, frantic attempts to correct the error were futile, and the instructor ultimately emailed out a version of the exam in Word and instructed all students to complete and return the exam within two hours. Despite the disaster, there were no signs of cheating and grades were as expected.

VCU's IT department never could figure out what had caused the crash for the entire course. This situation definitely shied some away from using Respondus LockDown Browser within the forensic science department, but with time many gave it a chance with positive results. Use of the lockdown browser and webcam for monitoring appear to be an efficient deterrent for cheating.

No matter what anti-cheating strategies were employed, one of the most frequent student complaints regarding online testing was that their browser unexpectedly closed/became unresponsive due to a loss in internet connection or some of technical issue. There is no denying that this is legitimate compliant, but as time went on, it appears as though students would use this known problem to their advantage for any number of reasons, including, but not limited to, getting a sneak peek at the test questions so that they could more adequately prepare while they were awaiting a resolution from the instructor, which was especially effective if they contacted the instructor at a time in which they weren't likely to respond right away (e.g., in the middle of the night). Instructors should be very careful regarding the settings they employ for online tests, including availability of the test, when students can review their test, etc.

## Conclusions and final remarks

Everyone knows that the COVID-19 pandemic was and continues to be an unprecedented and extremely challenging time. As educators, we are proud to say that we rose to the occasion to put together the best effort that we could for our students. We got creative, crossed new bounds, and stepped outside of our comfort zones. We know that in-person, face-to-face courses are better in the long run, but we have also learned so much that is good. Virtual teaching can be done effectively. It doesn't have to be hard and it doesn't have to be tricky. It *can* be an extremely efficient supplemental tool. We can be brought together virtually anywhere at a moment's notice, much like picking up the phone to make a telephone call. Perhaps the most important thing that we have learned is how we can make face-to-face learning even better by supplementing the good things we have discovered and developed in this time of necessary and drastic change. It is doubtful that education will return to how it was pre-COVID, but that is a good thing because it will only get better.