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ORIGINAL ARTICLE

Learning cytology in times of pandemic: an educational institutional experience with remote teaching

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Introduction As the coronavirus pandemic swept across national and state borders, institutions of higher learning, including cytology, began closing campuses and moving instruction online. We have described a method of remotely teaching cytology in our institution, including using the telecytology concept used with rapid onsite evaluation and remote conferencing and educational tools to conduct eCytology learning. This is a cost-effective method to transition a traditional in-classroom program into online teaching for cytology. It can also be implemented quickly.

Materials and methods In March 2020, our cytology program developed a method for teaching cytology remotely. The distance-learning teaching method included the use of remote conferencing (Zoom platform) and learning management platforms (Canvas) to present lectures and administer tests. Remote multihead sessions were conducted by adapting the telecytology rapid onsite evaluation concept, which attaches a mobile device to the microscope to transmit live video to remote learners.

Results When asked about their experience with online learning, the students had responded positively. All the students indicated a willingness to attend classes remotely in the future, even when the traditional in-classroom learning option is available.

Conclusions We have presented a method for educating students remotely using existing technology that is affordable and can be implemented quickly by nearly all cytology education programs.

Introduction

As the coronavirus disease 2019 (COVID-19) pandemic spread across national and state boarders, governors and health officials began instituting stricter rules to flatten the

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curve of the spread and reduce the incidence of new COVID-19 cases. Nonessential business entities were instructed to close and nonessential workers were instructed to remain at home as much as possible. Thus, colleges and universities began closing their physical campuses and moving instruction online.[1] COVID-19 is caused by the severe acute respiratory coronavirus 2 virus. The coronaviruses are named for the spikes that protrude from their surfaces, resembling the sun's crown.[2,3] In 1918, the H1N1 Spanish influenza pandemic occurred and was responsible for 50 million deaths globally and infected as much as one third of the world population over a long period.[3-5] At present, both the magnitude and the duration of the viral effects on global economy remain mostly unknown. However, speculation has been increasing that limited shelter-in-place rules will remain in effect and that remote learning for students will become the new normal. It is, therefore, important to address the best practices for remote cytology learning and pathology education. Although the field of cytology has seen many technological advances in recent years, including telecytology and whole slide imaging (WSI), a dearth of studies is available regarding the best practices for remote teaching in the profession in the United States. Furthermore, even fewer schools have moved entirely online, making this sudden transition challenging for most cytology training institutions.

Digital imaging and WSI

The larger pathology sector has benefited from the recent increase in computing processing power, storage capability, and broadband speed. One decade ago, digital cytology referred to the use of cameras to acquire static images; however, it refers to so much more at present. Digital cytology has shifted from static images toward WSI, which involves scanning a glass slide at various magnifications to form a digital slide. The evaluation of the digital slide is performed, not by using a microscope but by using a large computer monitor or tablet computer with a mouse or stylus. The advancement in the field in recent years has had enormous positive effects, including interactive virtual continuing education, electronic proficiency testing, and the development of artificial intelligence tools for greater pathology laboratories.[6,7]

Challenges associated with WSI in cytology

The progress in the digitalization of cytology specimen has been more challenging than that of biopsy or histologic samples because of technical difficulties. In essence, histopathologic specimens have been easier because they are relatively flat and can be captured digitally via a single-plane digital scanner. Cytology preparations, however, have been more problematic owing to the intrinsically 3-dimensional nature and the special technical requirements required to produce digital renditions of the specimen.[8] Other barriers to the adoption of digital cytology include the steep learning curve, regulatory issues, the cost of the initial adoption, bottlenecks, the lack of common standards, and the complicated return on investment calculations.[9]

Telecytology

Telecytology, or the remote transmission of real-time cytology videos, is a very different application than WSI. Instead of a digital re-creation of the entire slide, telecytology is simply the sharing of what can be seen under the microscope in real time. This technology was problematic previously owing to slow internet connectivity and the limited usage of small mobile devices. At present, the issues with image quality and transmission have largely been resolved by the technological advancements in the internet bandwidth, increased prevalence of sophisticated mobile devices, and availability of real-time mobile communication applications.[10-12] This approach has become more commonly used in the performance of fine needle aspiration adequacy assessments, and interest appears to be increasing in the laboratory community for cytotechnologists proficient in telecytology and rapid onsite evaluation (ROSE).[13,14]

Despite the advancements in imaging technology, only 3 cytotechnology programs are available that use virtual microcopy (VM) in a limited capacity, because WSI can be an expensive proposition for many programs and laboratories. Many cytology schools and laboratories have not been interested in digital cytology and have not considered these skill sets to be important because of the upfront investments involved in the implementation and setup.[13] In 1 recent survey, when schools were asked why they had not embraced VM, they reported cost as a major reason for not adopting it.[15] Additionally, the scanning and conversion of glass slides into digital VM images is a resource-intensive and time-consuming process, requiring personnel, which many schools with a tight budget simply do not have. In the present report, we have described our experience with online cytology instructions, which uses a digital platform similar to telecytology to teach remotely. This can be a low-cost alternative to digital scanners for online teaching. In the present environment in which many campuses remain closed, this cost-effective remote teaching approach in cytology can be implemented quickly. Moreover, our experience can serve as an inexpensive exploratory foray into electronic teaching in cytology for many training programs before committing the immense resources and funds to the development of a complete digital VM library.

Materials and methods

The key to our cytotechnology remote teaching experience centered on the use of easy and intuitive video teaching and communication platforms. At our institution, we use Zoom

Figure 1 Smartphone adaptor attached to a microscope eyepiece to capture images for sharing on the video conferencing platform.

conferencing (San Jose, Calif) and Canvas (Salt Lake City, Utah) as our online and learning management teaching tools for lectures, microscopy sessions, and tests.

Teaching

Lectures

The lectures were prepared using Power Point (Microsoft, Redmond, Wash) and shared in real-time through the Zoom platform. In the weeks leading up to the migration to online teaching, the faculty attended a Zoom for teaching orientation webinar to learn the basic operations, such as how to record and post the teaching sessions into learning modules for the students who had missed class. During our first synchronous online lecture, we explained internet etiquette to the students, including the need to keep their video on at all times during class to encourage engagement and classroom participation. The students were also instructed to dress and behave as if on campus, with professional attire and behavior (ie, no pets or friends in the background).

Microscopy

In our remote synchronous microscope sessions, we used the low-cost mobile smartphone interface that allows for connection between a personal mobile telephone with our microscope. The platform we used for our microscope is LabCam (Figs. 1 and 2A). The concept is similar to telecytology in that we attached our smartphone to a microscope head to share live microscope fields of view with remote students who had logged in through the Zoom platform. This low-cost approach allows the instructor to conduct a multihead session and share what is visible under the microscope live for ≤300 students at any given time. The remote session was recorded and posted to the cloud and can be posted to our learning management platform (Canvas) for those who had missed class. Zoom uses both front and rear cameras on our smartphone, which allows the teacher to switch the focus from the images under the microscope to face the students as needed.

Interactive resources

Also, public educational digital cytology websites are available on the internet, which we had shared with our students and had asked them to review as supplemental teaching aides to our online lectures. Some of the interactive cytology websites are commercially available through private vendors such as Hologic, and others are available from cytopathology associations, such as the International Academy of Cytology. These sites provide educational digital slides, and instructors can zoom into areas of interest on a virtual slide using the click of a mouse or scroll wheel to discuss the information with the students in real time. These resources were helpful for students and were used routinely in our remote teaching (Table 1).

Glass slides

In addition to lectures, synchronous multihead sessions, and interactive digital cytology resources, we created study-set glass slides available for students to pick up. These study slides, normally available in our classroom slide library, were packaged and divided evenly for the students to take.

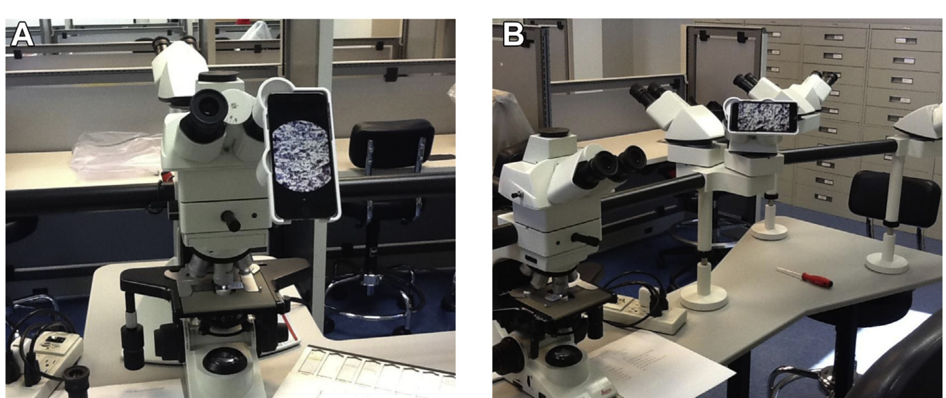

Figure 2 Various methods of using a microscope adaptor. A: Placing iphone adapter on the primary head. B: Placing iphone adapter on a separate head, allowing instructor to operate regularly.

Table 1 Traditional teaching activities compared with remote equivalent.

Traditional teaching activities	Remote equivalent activities	Comment
Lectures	Lecturing via educational platform Zoom	Remote equivalent comparable to traditional teaching
Multihead sessions	Method 1: using telecytology technology to broadcast microscope session with assistance of mobile phone, adaptor, and Zoom	Use of telecytology to multihead requires practice but is easy to learn; it is important to slow down to allow for the lag and to watch the broadcast while using the microscope
Multihead sessions	Method 2: using existing digitalized cytology websites to share with students, including the evaluation process through Zoom	These commercially available or free predigitalized slides can be a very useful teaching aid for cytology students, as complement to online learning

Each student was also given a microscope on loan and 150 study set slides initially. Add and drop areas for the slides were designated on campus should the students require additional glass slides. The students were asked to submit their weekly cytology screening log to the education coordinator to ensure they were making acceptable progress in their screening.

Tests

Tests mostly of theory were administered through our learning management platform, Canvas, to test the students' knowledge through short answer essays and multiple choice questions. The time allotted was shortened to ensure that the students would not have time to review their notes during the test. Additionally, the order of the test questions was randomized such that the questions were different for each student, minimizing the risk of 1 student sending a text to another other for quick answers. In addition to the Canvas platform tests, we also used weekly image quizzes in which the students were asked to apply diagnostic criteria to the image of the unknown cytology entities appearing on their screens, similar to the American Society for Clinical Pathology's board examinations. Images and questions relevant to the week's lecture were displayed one at a time through the Zoom platform. To preserve the integrity of the examination, the amount of time allowed per question was shortened (compared with in-classroom time allotted per question), and students were asked to send their answers to the instructors as private messages directly at the end of each question. At the completion of the test, the students were also asked to submit their entire test to the faculty before they reviewed the test as a class.

Test slides were administered using LabCam and Zoom, using the same methods used to teach remote microscopy. The faculty shared what was seen under the microscope, in real-time, with the remote students and asked for their diagnosis. To test the students' locator skills, the instructor screened a given area and asked for a diagnosis. Other question types included the reviewer showing a few dotted areas of interest for the students' to provide an interpretation. To preserve the integrity of the test, we have also asked

Table 2 Traditional testing activities compared with remote equivalents.

Traditional testing activities	Remote equivalent activities	Comment
Image testing	Sharing testing images on Power Point slides through Zoom platform	Remote equivalent comparable to traditional testing but current process of asking students to private message their answers after each question is labor intensive
Microscope testing	Method 1: using telecytology technology, instructors screen areas of interest or review dotted areas for students to simulate screening	Use of telecytology approach to testing is fine with testing recognition of entities under the microscope but not great for testing locator and screening skills
Microscope testing	Method 2: using existing digitalized cytology websites to test students	Works well if a digital scanner is available to create a library; otherwise, it would difficult to prevent students from looking up answers
Theory testing	Using learning management system, Canvas	Comparable to in-class experience because questions can be randomized to allow for different tests for each student

Table 3 Informal polls posted on Zoom (anonymous).

How are you enjoying remote learning?	Response, n (%)
Excellent, absolutely enjoying it!	2 (67)
Good, really enjoying it!	0 (0)
It's okay, it is what it is.	0 (0)
Not really enjoying it.	0 (0)
No response.	1 (33)

the students to private message, via the Zoom platform, their answer after every question. At the end of the slide test, the students compiled their responses into a single document by copying and pasting the answers from their private message log to an e-mail to the instructor before the class reviewed the tested slides together (Table 2).

Throughout the course of remote teaching, the students were asked regularly, via anonymous polls on Zoom, their reflections regarding the efficacy of the transition. They were asked specifically to report their thoughts regarding their remote learning experience and whether they would consider attending online sessions, if both traditional and distance learning options were available in the future.

Informal polls

Before the start of each class, informal anonymous polls were generated using the Zoom platform as a method to interact with all the cytology students as they logged into the online classroom platform. Most of the weekly poll questions asked how they were coping with the stressors related to the pandemic. Questions such as the frequency of exercise during the week and the number of virtual interactions with others were posted and discussed to determine whether the students were coping successfully with the pandemic. Two informal polls, taken during the second and third weeks into the lockdown, were related to the students' experiences with online learning. The students were free to take the poll at any point it was open until the conclusion of the Zoom session at the end of the class. Only the results of the 2 polls relevant to online learning were recorded (Tables 3 and 4).

Results

The students were asked twice to compare their remote learning experience to their in-classroom experience, and they indicated that the 2 were comparable. We had transitioned instruction to online classes during the ninth week of the semester. The remaining 6 weeks of instruction, or 40% of the semester hours, were conducted entirely remotely. According to our informal Zoom poll, when the students were asked, "How are you enjoying remote learning?," of the 3 respondents, 2 (67%) chose the response "Excellent, absolutely enjoying it" and 1 (33%) declined to answer (Table 3). When asked, "Would you consider listening to lectures online in the future if given the option of both traditional and online learning modules?", all 3 students responded positively, with 1 (33%) indicating they would often log in remotely and 2 (67%) suggesting they would do so occasionally (Table 4).

Furthermore, when we compared the results of the students' course evaluations from the spring semester versus the same course for the autumn semester, the average score for the "course content and structure" was the same for both semesters at 4.67, using a scale of 1 to 5, with 1 the lowest and 5 the highest rating. The course content and structure category measures a student's overall evaluation of the program, asking questions such as whether the course objectives were clearly stated in the syllabus, whether the course content delivered met the course objectives, and whether lessons had been presented logically.

Discussion

As telemedicine has become more widely accepted, so too has the possibility of educating cytotechnologists remotely. A few telecytology reports have shown the efficacy of the use of mobile devices, such as the iPhone, for telecytology.[16-18] The COVID-19 pandemic has increased the evolution of our profession to become more digitally competent as we evaluate creative methods to bring education to our students in the midst of social distancing and physical classroom closures. The following 5 points are reflections from the implementation of our remote learning program, which could be helpful to others seeking to teach remotely:

1 Slowing down: a split millisecond of lagged time is required for the image to be transmitted live to remote learners, depending on the connection speed. Therefore, the faculty behind the microscope must be cognizant at all times when conducting the synchronous multihead session to slow down when moving the stage or after

Table 4 Informal polls posted on Zoom (anonymous).

Would you consider listening to the lectures remotely or logging in online in the future if given the option of both in-classroom and on-line learning together?	Response, n (%)
Yes, I would log-in remotely often instead of attending in person	1 (33)
Yes, I would log-in occasionally instead of attending in person	2 (67)
Yes but I would log-in but only when I cannot make it in person	0 (0)
No, I would not login online	0 (0)

adjusting the magnification. A rule of thumb would be to count to 2 after changing the field of view or when switching objectives from lower to higher magnification or vice versa.

2 Reviewing the Zoom screen often: users might prefer to use the regular head and place the LabCam on a separate multihead; thus, it is important to review both often (Fig. 2B). Because what the remote learners will be seeing in real-time during microscopy sessions will be reflected on the presenter's Zoom screen, the faculty should periodically review the screen to ensure the items are centered or that the electronic pointer's light intensity has been set appropriately.

3 Reducing labor-intensive practices: because the act of requiring remote students to private message the instructor in Zoom after every question could be labor intensive, a more elegant method would be to explore the option of setting up 2 cameras, 1 behind and 1 in front, which would allow the instructor to see the student's screen and their face. Some of the other allied health programs have used this model and the school issued iPads that were used as the second camera for the students.

4 Coming to campus: the students had been sent home with slides to review and asked to return to campus to pick up more as needed. In the future, it would be good to explore other methods to delivering slides and practicum tests, including a protocol for packaging and sending slides to the students' homes for review, instead of asking them to return to campus.

5 Incorporating active learning activities: studies have shown that students enjoy interactive activities. Moreover, the results from meta-analyses have shown that active learning activities will increase the average examination score by 6% and students were 1.5 times less likely to fail.[19,20] In the future, it would be good to incorporate more interactive online tools, such as Zoom Polling, Poll Everywhere, Kahoot!, which are readily available and easy to incorporate into remote teaching.

Although the results of the present study will be beneficial for cytology teaching programs moving to distance education, the findings have limitations. First, a bias could have been present on the part of respondents wishing to please the questioner. Second, the framing of the questions could also have created a bias and influenced the choice of responses because the questions had not been validated to ensure they would be easily understood. Third, we had a small sample population. Fourth, we have reported the online experience of 1 cytology institution, and the results might not be directly generalizable or applicable to all geographic regions of the United States.

Future iterations of online teaching will incorporate many of the practices we have described. Our program hopes to collect more information about how other cytology programs are adapting to their new pandemic environment. Many colleges and universities across the states have become creative in their content delivery, although others have struggled with technical issues. Medical students at Cleveland Clinic began using augmented reality programs as a substitute for the cadavers used in anatomy classes.[21] Because institutions are exploring whether and how to move from traditional in-classroom teaching to remote teaching, our experience can serve as an inexpensive exploratory foray into electronic teaching for cytology before committing immense resources and funds to develop a complete digital VM library. Although obtaining a digital scanner might eventually be necessary, the use of a LabCam or similar device could be the preferred interim step in the current pandemic environment, with campuses remaining closed or open with restrictions.

Conclusions

The availability of a strong remote educational platform and adequate familiarity with telecytology instruction are essential because the world is becoming increasingly digitalized in the aftermath of the coronavirus pandemic. Laboratories and cytology schools, in particular, must also evolve to stay relevant.

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