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Utilization of virtual microscopy in cytotechnology educational programs in the United States

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Abstract

Background: Our cytotechnology (CT) program has been utilizing virtual microscopy (VM) as an adjunct educational resource since 2011. **Aims:** The aim of this study was to identify the utilization of VM in other CT programs across the United States (US). **Subjects and Methods:** A cover letter was sent to the program directors of all accredited CT programs in the US (excluding our program), requesting their participation in an online survey. After 2 days, the participants were sent an online link to the survey. The survey results were analyzed using descriptive statistics. **Results:** There were a total of 25 respondents to the survey. Among the 25, three CT programs use VM. Two of the three programs have been using VM for <2 years while another program for "2–4" years. The respondents found that VM's side-by-side comparison feature helped to demonstrate differences between diagnoses and preparation methods, and VM helped to preserve the important slides by digitizing them. Respondents believed that teaching with glass slides was very important. The reasons for not using VM were that VM is expensive and time-consuming to incorporate into the program, and lack of manpower resources to create digitized teaching files. **Conclusions:** The CT programs that use VM found it to be a valuable educational tool. Even though many were not using VM, responses from the survey indicated they will likely use it in the future.

Key words: Cytotechnology education, digital images, virtual microscopy

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INTRODUCTION

Cytotechnologists examine cellular samples under a microscope to determine the presence of disease.[1] Cytotechnology (CT) educational programs traditionally use light microscopy (LM) and glass slides to train their students to become entry-level cytotechnologists. However, this traditional method has some disadvantages. To mention a few, the glass slides may fade over time, coverslips may separate from the glass slides, and unfortunately, some are broken. Hence, periodical replacement of the glass slides is necessary. This replacement becomes challenging if the broken or faded slide is of a rare or unique cytology specimen. Because of

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these disadvantages in the traditional teaching method, several health professions education programs that use LM to train their students have adopted Virtual microscopy (VM) in their educational curricula in recent years.[2-5] VM is a digital imaging technology, in which the specimen on glass slides are scanned and converted into digital/VM images. VM has been found to be advantageous in many medical, dental, and veterinary schools. Since VM teaching involves using a computer monitor, it is possible for several students to view the same image at the same time.[6] This can potentially reduce the repetitive multi-head microscope sessions in which only a limited number of students can view the glass slide at the same time. The VM images can be accessed from anywhere at any time.[7] Students can compare the slides side-by-side, take screen shots and save them under their personal folders to prepare their own study materials.[8] Converting glass slides into VM images can reduce the maintenance of aging microscopes and glass slide storage space.[9] VM can potentially reduce or eliminate the need for new microscopes.[7] Digitizing glass slides can preserve quality and prevent breakage. More importantly, VM images can be used to develop teaching modules in which the VM images are annotated with the description of the cytomorphology, additional clinical information, and patient history. In contrast to medical histology and pathology educational programs, however, the incorporation of VM into the CT educational curriculum has been slower and is still limited.

After recognizing the advantages of VM, it has been added as an adjunct educational resource in our CT program.[10] At this time, over two thousand glass slides have been digitized using iScan Coreo Au scanner (Ventana, AZ, USA) scanner to create, virtual teaching modules, daily screening practices, and slide screening tests. VM has been enthusiastically used by our CT students and the pathology residents for educational purposes. This study reports the results of a survey conducted in early 2014 with an interest to identify the utilization of VM in other CT programs across the United States (US).

SUBJECTS AND METHODS

Once the Institutional Review Board approved the study, the educational coordinator of the American Society of Cytopathology was approached to send the E-mails regarding this survey's cover letter, survey link, and reminder/thank you letter to the Program Directors of all accredited CT programs in the US except our CT program (There were 29 accredited CT programs when the survey was conducted). Thus, at first, a cover letter was sent to all the CT Program Directors describing the purpose of this study and requesting their participation in a voluntary, anonymous online survey. After 2 days, the program directors were sent an online link to the survey. After a week, a reminder/thank you letter was sent requesting and appreciating their participation in the survey. The online survey created on the website, www.surveymonkey.com consisted of a total of ten questions. The first question required a "Yes" or "No" response to answer whether the respondents were using the VM in their educational program. The respondents who answered "Yes" for the first question were asked to answer questions 2–9, and the respondents who answered "No" were asked to skip to question ten. The questions 2–8 were constructed to collect the information regarding the duration of utilizing VM, the slide scanner, and software usage, method of slide scanning (two-dimensional [2D] or three-dimensional (3D)), number of slides scanned so far, and how VM is utilized within the curriculum. Question nine, which had eight statements intended to collect the faculty's opinion about using VM in their educational curriculum, was constructed as a 5-point Likert scale in which the respondents were to answer strongly agree, agree, neutral, disagree, or strongly disagree. Question ten contained the following two propositions as potential reasons for not using VM: Too expensive to incorporate into curriculum, and time-consuming to develop the teaching module. It was also constructed as a 5 point Likert scale. The survey also featured an open comment section in which the respondents were given an opportunity to provide any additional suggestions, to explain/justify their responses, and to add any other comments.

RESULTS

This study's survey received a total of 25 responses from the CT programs in the US, for a study response rate of 86%. Three of the respondents indicated the use of VM in their program.

The individual responses of the survey indicated that out of 25 respondents: (a) Sixteen respondents followed the directions to answer the survey as requested to provide their responses, i.e., respondents (n = 2) who answered "Yes" for the first question, also answered questions 2–9; and the respondents (n = 14) who answered "No," skipped to question 10; (b) five respondents answered "No" to the first question, but had given their opinion on VM, by answering question 9. Assuming that these respondents have had some sort of experience using VM even though not in their own program, their opinions were included in analyzing the results; (c) one respondent who answered "Yes" to the first question, did not answer the questions from 2 to 9, and answered only the first statement of the 10th question. Hence, this respondent was not considered as using VM in his/her curriculum, however, his/her response to the first statement of the 10th question was considered in analyzing the results; (d) one respondent who answered, "No" to the first question, answered the rest of the survey. This respondent, however, provided all information on how VM was utilized in his/her program. Hence, we believe that this respondent's answer, "No" to the first question was an oversight. Since the information provided by this respondent is valuable as the CT programs are slowly attempting to adopt VM, this respondent was considered as using VM in their program and the responses were considered in the result analysis except for his/her response for one of the eight statements in question number nine for the reason that he/she had answered twice; (e) one respondent answered, "No" for the 1st question, but selected Aperio-image scope viewing software as the software used in their program. This respondent stated in the open comment that they have an Aperio scanner available to them but not for use in cytology education. Since they were not using the scanner at the time of the survey, their response to the usage of software was not considered in analyzing the results; (f) one respondent who answered, "No" to the first question, but answered the 10th question, also selected Aperio as the scanner they use to scan their slides. Since this respondent did not mention any additional information regarding the scanner in the open comment section, this respondent's responses to the 10th question were considered, but the response to scanner was not considered in this study's results. In summary, out of 25 respondents, two definitely used and one appeared to use VM in their curriculum. Out of the respondents who did not use VM in their curriculum ($n = 22$), five appeared to be familiar with VM.

All three respondents who utilize VM in their curriculum use Aperio to scan their slides, and Aperio ImageScope viewing software (Leica Biosystems, Buffalo Grove, Il, USA) is used to view the digitized images. Two of the three respondents have been using VM for <2 years while another respondent for 2–4 years. Two of the three respondents scan their glass slides using a single focal plane level (2D), while one program uses multiple focal plane levels (3D). So far, <500 glass slides have been scanned by two programs, and 500–1000 glass slides by the other program. The respondents, who utilized VM, used annotated images for teaching, and unannotated images for daily slide screening purposes.

For the question, "If you are only using 2D, do you hope to use 3D in the future," the answer choices were: Yes; No; Maybe; N/A (already using 3D). For this question, among the two respondents who were using 2D VM, one answered, "Yes," and the other, "Maybe." In addition, one respondent who was not using VM in their program answered, "Yes" for this question. We believe that this person would use 3D images if VM were an option in the future.

Survey Respondents' Opinion of Using Virtual Microscopy in their Educational Curriculum

There were a total of eight statements that comprised question 9. The statements were intended to collect the opinions of survey respondents on using VM in their educational curriculum. Based on the responses to question nine of the survey [Table 1], six out of seven respondents strongly agreed/agreed that unlike LM, VM's side-by-side comparison feature helps to demonstrate differences between diagnoses, preparation methods, and stains; and unlike LM, VM allows not only to digitally mark the cells but also helps to add written criteria. Five out of seven respondents strongly agreed/agreed that the annotation features of VM help to organize the content well. All seven respondents strongly agreed that VM helps to preserve the important slides by digitizing them. All eight respondents still believe that teaching with glass slides is very important. Furthermore, only two out of seven respondents strongly agreed/agreed that they believe the CT programs will teach using only VM in the future. Five out of six respondents strongly agreed/agreed that they prefer teaching cytomorphology with LM, while two out of seven respondents strongly agreed that they prefer teaching cytomorphology with VM.

Reasons for Not Currently Using Virtual Microscopy

Fourteen out of 20 respondents strongly agreed/agreed to the reason that VM is expensive to incorporate into the curriculum; and 10 out of 19 respondents strongly agreed/agreed that it is time-consuming to develop the teaching module using VM, and hence, VM is not currently utilized in these CT programs. There was a maximum of 20 responses to these statements [Table 2].

DISCUSSION

The main objective of this study was to determine the utilization of VM in CT programs across the US. As the results indicate, currently VM is not a widely used tool in CT education across the US for the reasons that VM is expensive to incorporate into the curriculum and that developing the VM teaching modules requires a large amount of time. These reasons are logical. Creating a VM teaching module involves many steps such as selecting appropriate glass slide specimens to digitize, digitizing the glass slide specimens, uploading the images to the software, annotating the VM images, and creating test modules using the VM images. CT programs in the US are mostly short-term (12-month) programs with limited number of faculty members and students, which makes the practicability of investing in VM technology, questionable as this investment pertains not only to finances but also to time from educators, technicians, and students for perfecting this technique and incorporating

Table 1: Respondents' opinion in using light microscopy in their cytotechnology educational curriculum

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Total respondents
Unlike LM, VM's side-by-side comparison feature helps to demonstrate differences between diagnoses, preparation methods, and stains	2	4	1	0	0	7
Unlike LM, VM allows to not only dot (digitally mark) the cell but also helps to add written criteria	3	3	1	0	0	7
The annotation features of VM help me to organize the content well	3	2	2	0	0	7
VM helps me to preserve the slides by digitizing them	7	0	0	0	0	7
I still believe teaching with glass slides is very important	7	1	0	0	0	8
I believe the CT programs will teach only using VM in the future	1	1	1	2	2	7
I prefer teaching cytomorphology with LM	3	2	1	0	0	6
I prefer teaching cytomorphology with VM	2	0	3	2	0	7

LM: Light microscopy, VM: Virtual microscopy, CT: Cytotechnology

Table 2: Respondents' reasons for not using virtual microscopy in their cytotechnology educational curriculum

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Total respondents
We are not using VM because it is expensive to incorporate into our curriculum	5	9	4	2	0	20
We are not using VM because it is time-consuming to develop the teaching module using VM	5	5	6	2	1	19

VM: Virtual microscopy

it in the curricula. In our experiences, though, we found that investing the time and money on VM has reaped dividends because we found VM to be extremely helpful in: Demonstrating the differences in the cytomorphology/stains/preparation methods in two to four VM images at the same time by utilizing the split screen feature; preserving rare cases; recording virtual scope sessions; going over the VM images with our distance students; and ultimately standardizing the course content among our campus and distance sites.

The results of survey respondents' opinions and open comments on VM and its incorporation in CT curriculum were positive.

Positive Opinions on Virtual Microscopy in Cytotechnology Education

VM in CT education was found to be useful: In demonstrating the differences between diagnoses, slide preparation methods, and stains by having the side-by-side comparison feature; digitally marking the cells in the slide with written criteria added; organizing the content well; and preserving the glass slides by digitizing them. Some of the open comments were "VM is awesome," "It does seem like a great tool to bring to the program in the near future," "I think VM is extremely useful and important in teaching the diagnostic criteria along with special stains," "Personally, I think it would be a useful tool for educational purposes."

Survey Respondents' Beliefs in Virtual Microscopy

According to the open comments, one survey respondent believes that it will be easier for students to learn from VM and transfer skills to LM rather than starting with LM and moving to VM. This application of knowledge from VM to LM has been already demonstrated in a previous study and verified that the students were able to apply cytologic criteria learned through VM to glass slide screening.[10] Another open comment was "Having z-stacking is the last part of the VM technology that will take the education into a distance learning platform. This will be very useful for international education as well as for students who find it difficult to move to a program for a year." We agree to this point. Cytology specimens often have 3D cell groups, and focusing through these groups is often helpful in interpreting the cases. Focusing through 3D cell groups is not possible in cytology specimens scanned using a single focal plane level (2D). Hence, multiple focal plane level scanning, also known as Z-axis scanning, would greatly benefit for interpreting cytology specimens. This Z-axis scanning consists of multiple scans of the same slide, taken at different focal planes, stacked into a final composite image.[11,12] It is also possible to set the distance between the focal planes (interval level) while scanning the glass slides. As mentioned in the previous studies, Z-axis scanning has its own disadvantages including an extended scanning time, large file size, and the need for large storage server space.[13,14] To overcome these disadvantages and to make the most use of the VM images, the optimal scanning parameters for the cytology specimens need to be determined. A previous study described the optimal scanning parameters for the gynecological cytology specimens to be three focal planes and one-micron interval.[15] We believe that this would be helpful in scanning GYN specimens with Z-axis with less expense and less storage space, especially for the educational purposes. We suggest that future studies should investigate such scanning parameters in various cytology specimens to fully utilize this technology in cytology.

Willingness to Incorporate Virtual Microscopy in Cytotechnology Education

Because of the survey respondents' positive opinions on VM in CT education, they are willing to incorporate VM in CT education. Some of the open comments on these aspects were "Will be developing our own series of modules in the future, once we figure out which resources to use– scanner, software, etc.," "Will be introducing VM to the students in the near future," "VM use would need to be coordinated with clinical usage, curriculum development, archive file storage, etc," "we would like to incorporate this into our curriculum," "As the profession continues to evolve, we will be looking at options of providing this experience for our students," "We would like to use VM in the future and I am currently looking at our options."

In our experience, determining the resources (scanner and software) to use can be challenging and time-consuming. We believe purchasing a scanner for CT use may not be cost-effective as once all the teaching modules, daily screening slides, and screening examinations slides are scanned, the scanner will not be needed frequently. The scanner will be needed only for scanning random slides to update the already developed modules. In addition, there are scanners and software introduced in the market regularly. In our opinion, it is difficult to select the most user-friendly and economical one and perhaps contracting with a vendor to have the slides scanned may be prudent. Nevertheless, experiencing the advantages of VM and receiving the positive feedback from the students on the virtual teaching modules, we created definitely has more than justified the extensive amount of time and cost required to create the virtual teaching module. Therefore, we encourage the other CT programs to incorporate VM in their curriculum. We also believe that incorporating VM in CT programs would be beneficial to expand the distance education using VM internationally.

Seeking Help in Incorporation of Virtual Microscopy

According to the open comments, it is also evident that some faculty need help to incorporate VM in their curriculum. A few of the comments in this regard were "The scanner is not located nearby and is a shared system with access issues. It is a big Leica scanner that is technically challenging. We just do not have the manpower resources to create digitalized teaching files and the curriculum to go with them," "We would very much like to have the technology in our program. Please help us."

We suggest that the programs who have already incorporated VM can work with the programs that have not. The programs that do not have a facility for scanning can send the glass slides to the one with a scanning facility. Once the slides are scanned, the images can be shared not only among those two programs but also among all the other CT programs in the US. An open comment stated that the respondent is using the Aperio system, and they are definitely interested in working with other programs that do not have the technology available and would be able to share materials. Our CT program has access to a Ventana scanner, and we are willing to work with other programs to share images/slides as well.

Importance of Glass Slides

While the faculties recognize the advantages of VM, they still believe that teaching with glass slides is very important. The open comments in this regard were "Glass slides are the best, and we have an extensive collection. Glass slides are also necessary for students in learning locator/screening skills." Even though the success of VM has already been demonstrated in cervicovaginal (gynecological) and nongynecological telecytology,[16-24] clinical cytopathology,[25] and in proficiency testing,[19,26-28] VM in cytology in a clinical setting is still at a rudimentary stage. This was reflected in another open comment as, "Although not an over-riding reason, this type of interaction with slides material is not standard of practice in working labs, therefore the motivation to move to this technology has not been a very high priority." Until VM is used in the clinical setting, cytotechnologists will be screening the glass slides in the laboratory. Hence, it is important that the CT students learn the glass slide screening.

At the same time, it is evident from the literature that the digital methodologies are changing the practice of cytology.[29] Hence, even though it seems difficult right now, due to continuously improving technology, the possibility of VM being used in clinical settings in the near future has been acknowledged. As one of the open comments states "In order to use VM technology successfully in clinical cytopathology, it is very essential for the future CT students to be trained with VM."

This study is limited in that some of the respondents did not follow the directions (skip pattern) to answer the survey questions as requested; so, it was challenging to analyze the results. Considering the importance of sharing the most information possible collected in this survey, the results were analyzed and reported accordingly. Another limitation of this study is that the survey was not able to measure all the CT programs, as four programs failed to participate in the study. It is possible that their participation could have yielded different results.

CONCLUSION

Our results indicate that VM is not currently used for teaching in many CT programs across the US that responded to this survey. Responses from programs currently using VM suggest that the technology provides many advantages, but teaching with glass slides remains very important. According to the survey results, the reasons for not using VM currently in their programs were that incorporation of VM was too expensive and time-consuming for the programs' demands. Open comments from the participants, however, provide optimism for VM in future CT education. VM and its related educational tools have become an integral and highly valued component of our CT program and have exceeded our expectations of the return on expended resources and effort. Collaboration by CT programs in the US that currently have access to scanners by providing scanning services to all the CT programs that are interested will provide this innovative technology in training competent entry-level cytotechnologists.

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Conflicts of Interest

There are no conflicts of interest.

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