

# Initial Assessments of E-Learning Modules in Cytotechnology Education

Maheswari S. Mukherjee<sup>1</sup>, Amber D. Donnelly<sup>1</sup>

<sup>1</sup>University of Nebraska Medical Center, Cytotechnology Education, College of Allied Health Professions, Omaha, Nebraska, USA

Received: 22 September 2017

Accepted: 11 January 2018

Published: 14 February 2018

## Abstract

**Background:** Nine E-learning modules (ELMs) were developed in our program using Articulate software. This study assessed our cytotechnology (CT) students' perceptions on the content of the ELMs, and the perceived influence of the ELMs on students' performance during clinical rotations. **Subjects and Methods:** All CT students watched nine ELMs before the related classroom lecture and group discussion. Following that, students completed nine preclinical rotation surveys. After their clinical rotations, students completed nine postclinical rotation surveys. **Results:** Statements on the content of the ELMs regarding the quality of the video and audio, duration, navigation, and the materials presented, received positive responses from the majority of the students. While there were a few disagreements and neutral responses, most of the students responded positively saying that the ELMs better prepared them for their role, as well as helped them to better perform their roles during the clinical rotation. The majority of the students recommended developing more ELMs for cytology courses in the future. **Conclusions:** This study has given hope that the ELMs have potential to enhance our online curriculum and benefit students, within the United States and internationally, who have no easy access to cytology clinical laboratories for hands-on training.

**Keywords:** Cytotechnology, E-learning, online learning

## INTRODUCTION

The cytotechnology (CT) education program at our institution is one of the twenty-four CT programs in the United States (US) accredited by the Commission on Accreditation of Allied Health Education Programs.<sup>[1]</sup> It is currently the only program in the nation that offers synchronous distance education, serving three satellite sites: Carle Foundation Hospital in Urbana, Illinois; The Ohio State Wexner Medical Center, Columbus, Ohio; and the University of California Davis Medical Center, Sacramento, California. Responding to the demands from potential online students for asynchronous training within the US and internationally, the feasibility of a complete online curriculum using virtual microscopy (VM) was assessed in our program.<sup>[2]</sup> The results indicated that the students were able to learn cytomorphology using VM and apply their learning to screening glass slides, providing assurance that CT students can be trained online to accurately screen glass slides. That said, in addition to being required to screen glass slides, certified cytotechnologists are required to attend and assist in procedures such as fine needle aspiration (FNA), rapid on-site evaluation (ROSE), and prepare cytology specimens on employment in a cytology

laboratory. Therefore, at present, there is a need for the online CT students trained using VM to have additional in-person training in a cytology laboratory to observe and learn the hands-on techniques such as cytology specimen preparation, FNA, and ROSE. The long-term goal of our CT program is to reduce or eliminate this need for additional in-person training in the cytology laboratory by adding E-learning modules (ELMs) to our current online curriculum.

E-learning, also known as web-based learning, online learning, computer-assisted instruction, or Internet-based learning, is becoming popular among health-care education programs.<sup>[3-12]</sup> Because of its substantial benefits, such as learning at anytime from anywhere at one's own pace and convenience and supplementation of the faculty at institutions,<sup>[3]</sup> E-learning

**Address for correspondence:** Dr. Maheswari S. Mukherjee, 984142 Nebraska Medical Center, Cytotechnology Education, College of Allied Health Professions, Omaha, NE 68198-4142, USA. E-mail: mmmukherj@unmc.edu

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

**For reprints contact:** reprints@medknow.com

**How to cite this article:** Mukherjee MS, Donnelly AD. Initial Assessments of E-learning modules in cytotechnology education. *J Pathol Inform* 2018;9:4. Available FREE in open access from: <http://www.jpathinformatics.org/text.asp?2018/9/1/4/225492>

### Access this article online

#### Quick Response Code:



**Website:**  
[www.jpathinformatics.org](http://www.jpathinformatics.org)

**DOI:**  
10.4103/jpi.jpi\_62\_17

has recently become a promising alternative to traditional classroom learning.<sup>[6]</sup>

From the literature, it is evident that E-learning has proven to be advantageous in many other health sciences education programs. For that reason, we believed ELMs developed by our CT program would add benefits to our online educational curriculum by reducing or eliminating the need for additional in-person training in the cytology laboratory; therefore, ELMs that demonstrated hands-on techniques in cytology were developed. This study was a first step toward thorough evaluation of these ELMs. The main purpose of the present study was to assess our CT students' perceptions of the ELMs that were developed by our CT program.

## SUBJECTS AND METHODS

A total of nine ELMs used in this study were developed over the span of 4 years, using funding from the Office of the Vice-Chancellor for Academic Affairs at our institution. The ELMs were developed in the following sequence: "FNA Techniques," "Preparatory Techniques in Cytology," (which included separate ELMs of "Initial Handling," "Centrifugation," "Cytocentrifugation," "Papanicolaou Staining," "Diff-Quik staining," and "Coverslipping Technique;") "ROSE;" and "Tele-cytology." The software used to develop these ELMs was selected depending on the availability at our institution at that time. Accordingly, Articulate Presenter was used to develop the ELMs: "FNA Techniques," "Preparatory Techniques in Cytology," and "ROSE;" and Articulate Storyline was used to develop the "Tele-cytology" ELM. Regardless of software type, similar methodology was followed in the development of all ELMs as described below. Content developers (certified cytotechnologists and CT students of our institution) decided that each ELM should include the following: A title, specific learning objectives, video clips, interactive self-assessments, references, and acknowledgments. The video clips included either a demonstration of a technique/procedure or a pathologist explaining relevant subject material of the ELM.

### Development of E-learning modules

Content developers developed a script for each ELM. The script included the title, specific objectives, scenarios for the video clips, dialogs for the video clips, and self-assessment questions. On the peer-reviewers' (certified cytopathologists and cytotechnologists of our institution) approval of the content in the script, the steps described below were followed in developing the ELMs. Step 1: video clip scenarios were captured and saved as mp4 files. Step 2: voice over dialog was recorded and saved as audio.wav files. Among these audio clips, some of them were incorporated into the appropriate video clips, using iMovie and finally saved as mp4 files. Step 3: The interactive self-assessment questions tied back to the content were created in Articulate Quiz maker. The self-assessment questions that were part of the ELM included, but were not limited to, true or false, multiple-choice questions, multiple response questions, and rearranging

sentences. Step 4: a PowerPoint presentation was created for each ELM in Articulate software (Presenter or Storyline), and the corresponding video and audio clips, and interactive self-assessments were embedded into the PowerPoint. Step 5: to address the Americans with Disabilities Act, either closed captioning or a written transcript of the contents was added in the ELMs. Finally, once the peer-reviewers approved the final version of ELMs, they were uploaded to the institution's server to generate the URLs. Specific components of the ELMs are detailed in Table 1. These ELMs are currently not accessible for public. On correspondence with the authors, however, access may be granted to view the ELMs.

## Evaluation

Surveys assessed students' perceptions of the content of the ELMs, and the perceived influence of the ELMs on their performance during clinical rotations. For this purpose, two surveys – preclinical rotation and postclinical rotation for each ELM were created on the [www.surveymonkey.com](http://www.surveymonkey.com) website. In total, there were nine preclinical rotation surveys and nine postclinical rotation surveys. Each survey was in Likert scale format, i.e., responses ranged from strongly agree to strongly disagree. Additional categories such as not applicable (N/A) and open comments were added as choices to the statements.

### Preclinical survey statements

Each preclinical rotation survey of the ELMs had three sets of statements, with which participants were asked to rate their agreement on a Likert-scale. The first set of statements related to the quality of the ELM regarding the video clips, audio, duration, navigation, materials presented, and the self-assessment. The second set had statements regarding understanding of the steps involved in the various techniques shown in the ELM. Hence, the total number of statements depended on the total number of objectives of the ELM. In addition, this set had statements regarding viewing the ELM before the classroom lectures to effectively interact/participate during the classroom discussion, and whether to recommend future students view this ELM before the classroom discussions. The last set had two statements: "I believe this ELM will better prepare me for my role in during my clinical rotation," and "I believe this ELM will help me better perform my role during my clinical rotation."

### Postclinical rotation survey statements

Each postclinical rotation survey had statements with which participants were asked to rate their agreement on a Likert scale. The statements were designed to compare it with the last set of preclinical survey statements. Therefore, the statements were, "This ELM better prepared me for my role during my clinical rotation" and "This ELM helped me in better performing my role during my clinical rotation." The last statement was "Overall I recommend developing more ELMs similar to this for other cytology courses."

## Data collection

Once our Institutional Review Board approved the study, a cover letter was E-mailed to all CT students ( $n = 7$ ) at our

**Table 1: E-learning module components**

ELMs	Number of specific learning objectives	Number of video clips	Number of self-assessment questions	Duration (min:s)
Preparatory techniques in cytology				
Initial handling	1	1	2	2:56
Centrifugation	1	1	3	2:14
Cytocentrifugation	1	1	2	3:49
Papanicolaou staining	1	1	4	4:09
Diff-Quik Staining	1	1	2	1:53
Coverslipping technique	1	1	2	1:59
Fine needle aspiration technique	4	5	7	12:23
Rapid on-site evaluation	3	6	9	8:52
Telecytology	5	5	13	10:00

ELMs: E-learning modules

institution and its satellite sites explaining the purpose of the study and requesting their voluntary participation in two anonymous online surveys (preclinical rotation survey, and postclinical rotation survey) for each of the ELMs. Later, the URLs to each ELM were E-mailed to the students and requested they watch the ELM before the related classroom lecture and group discussion. After each classroom lecture and the group discussion, students completed the preclinical rotation surveys for the corresponding ELM. The link to the postclinical rotation survey was E-mailed to the students after they completed their clinical rotations. A summarized version of the methodology is shown in Figure 1.

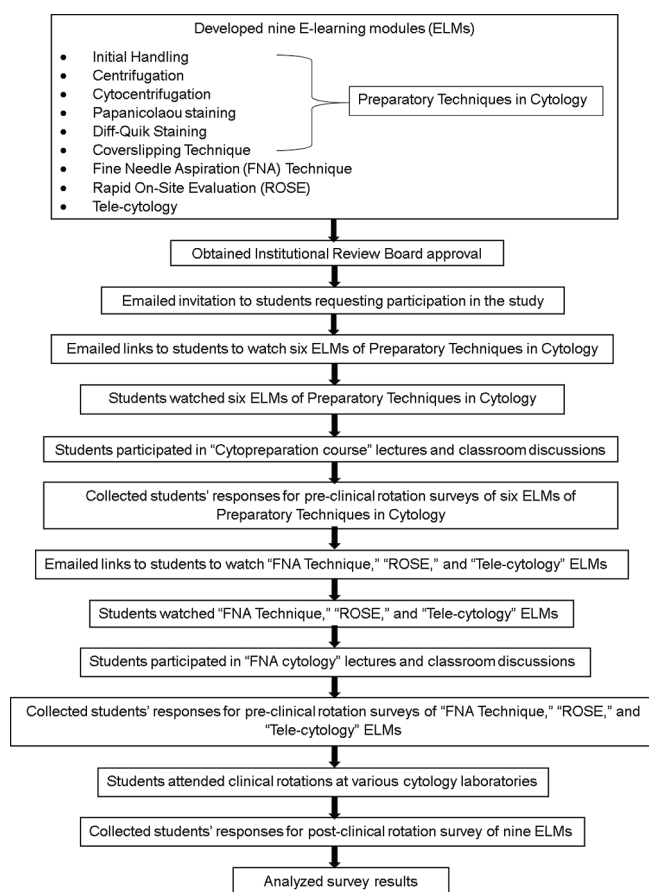
## RESULTS

All seven students responded to the nine preclinical rotation surveys. One student, however, went on leave of absence during the course of the year leaving only six responses for the nine postclinical rotation surveys. The data were analyzed using descriptive statistics.

### Survey responses on the content of the E-learning modules

For all nine ELMs, all seven students responded, “strongly agree,” or “agree” for the statements, “the quality of audio of the ELM was excellent,” “the duration of the ELM were excellent,” and “the materials presented in all the ELM covered the objectives.” Three ELMs received a few responses of “neutral” “disagree” and “not applicable” for the statements, “the quality of video clips used in the ELM was excellent,” “navigation through the parts of ELM was easy,” “the self-assessments appropriately tested the materials presented in the ELM,” “Viewing the ELM before the classroom discussion gave me knowledge so that I could interact/participate during the classroom discussion effectively” [Table 2]. For the rest of the ELMs, all seven students responded either “strongly agree” or “agree” to the above-mentioned statements.

All seven students either strongly agreed or agreed that by watching the ELMs, they understood the steps involved in all the preparatory techniques in cytology. For the “FNA Technique” ELM, four out of seven students chose “strongly



**Figure 1:** Illustration of methodology. This figure illustrates the methodology of the study

agree” and the other three students chose “agree” to state that they understood the overview of FNA technique, as well as the patient interaction and preparation and staining of glass slides during an FNA procedure. Similarly, for the “ROSE” ELM, students stated that they understood the importance, as well as the basic procedure of ROSE in an FNA procedure by either choosing the response of “strongly agree” or “agree.” For the “Tele-cytology” ELM, five out of seven students chose “strongly agree,” and the other two students chose “agree” to report that they understood the basics of various methods of

**Table 2: Preclinical rotation survey responses of the cytotechnology students (n=7)**

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
ELM: Initial handling						
The quality of video clips used in this ELM was excellent	4	2	0	1	0	0
The self-assessments appropriately tested the materials presented in the ELM	3	3	1	0	0	0
ELM: Telecytology						
Navigation through the parts of ELM was easy	3	3	1	0	0	0
The quality of video clips used in this ELM was excellent	5	1	1	0	0	0
ELM: Fine needle aspiration technique						
Viewing the ELM before classroom discussion gave me knowledge to participate/interact during classroom discussion	5	1	0	0	0	1

Preclinical rotation survey statements that received responses in addition to “strongly agree” and “agree” from the CT students (n=7). ELM: E-learning module, CT: Cytotechnology

telecytology, such as static, robotic, whole slide imaging, and mobile devices. In addition, there was one “neutral” response and the other six responses were either “strongly agree” or “agree” for the statements, “I completely understood the evaluation of adequacy assessments” for the FNA Techniques ELM, and “I completely understood what an adequate thyroid specimen looks like under the microscope” for the “ROSE” ELM. The responses of all the students were positive (either “strongly agree” or “agree”) on recommendation that the future students view the ELMs before the classroom discussions for the corresponding topics.

### Students’ responses on E-learning modules influencing their performances during clinical rotation

There were seven responses for preclinical survey of all nine ELMs and six responses for the postclinical survey of all nine ELMs.

In the preclinical rotation survey, all seven students either “strongly agreed” or “agreed” to the statement, “I believe this ELM will better prepare me for my role in during my clinical rotation” for all ELMs except “Tele-cytology” which had one “neutral” response. The six students who attended the clinical rotations, however, had slightly varied responses for the statement, “This ELM better prepared me for my role in during my clinical rotation” in the postclinical rotation survey. For the ELMs, “Initial Handling,” “Centrifugation,” and “ROSE,” there were five responses of either “strongly agree” or “agree,” and one “neutral” response. For the ELMs, “Papanicolaou Staining,” “Diff-Quik Staining,” and “FNA Technique,” there was five responses of either “strongly agree” or “agree” and one “Disagree” response. There were two “neutral” responses for “Coverslipping Technique,” and “Tele-cytology” ELMs, but the rest of the four responses were either “strongly agree” or “agree.” For the “Cytocentrifugation” ELM, all six students’ responses were either “strongly agree” or “agree.”

For the statement, “I believe this ELM will help me better perform my role during my clinical rotation,” in the preclinical rotation survey, there was one “neutral” response for the

ELMs, “Initial Handling” and “Centrifugation,” and there were two “neutral” responses for “Tele-cytology” ELM. For the remaining six ELMs, the responses were either “strongly agree” or “agree.” The six students who attended the clinical rotations, however, had slightly varied responses for the statement, “This ELM helped me in better performing my role during my clinical rotation” in the postclinical rotation survey. There was one “Disagree” response and five either “strongly agree” or “agree” responses for the ELMs, “Initial Handling,” “Papanicolaou Staining,” and “FNA Technique.” There was one “disagree” response, one “neutral” response and there were four either “strongly agree” or “agree” responses for the ELMs, “Centrifugation,” “Diff-Quik Staining,” and “Coverslipping Technique.” There was one “neutral” response for the ELM, “ROSE,” and two “neutral” response for the ELM “Tele-cytology,” but the remaining four responses were either “strongly agree” or “agree” responses. The “Cytocentrifugation” ELM however, received “strongly agree” or “agree” responses from all six students attended the clinical rotations.

While there were few disagreements and neutral responses, most of the students responded positively, saying that the ELMs better prepared them for their role, as well as helped them to better perform their roles during the clinical rotation. The recommendations to develop more ELMs in the future for our education program had mixed responses [Table 3]. Yet, at least four out of six students recommended to develop more ELMs similar to the ones used in this study for the future cytology courses.

### DISCUSSION

Screening and interpretation of gynecological and nongynecological cytology specimens on glass slides, assistance in the collection and processing of specimens during procedures such as FNA and ROSE, and participation in basic laboratory techniques, such as glass slide specimen preparation are some of the requirements of an entry-level

**Table 3: Students (n=6) responses on recommendation to develop E-learning module in the future for other cytology courses**

I recommend developing more ELM similar to this for other cytology courses	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Initial handling ELM	1	4	0	1	0
Centrifugation ELM	1	3	1	1	0
Cytocentrifugation ELM	1	5	0	0	0
Papanicolaou staining ELM	1	4	0	1	0
Diff-Quik Staining ELM	1	3	1	1	0
Coverslipping technique ELM	1	3	2	0	0
Fine needle aspiration technique ELM	1	4	0	1	0
Rapid on-site evaluation ELM	1	4	1	0	0
Telecytology ELM	1	3	2	0	0

ELM: E-learning module

cytotechnologist. To excel in the job and to serve the patients effectively, CT students need to be well trained in these skills. In general, CT training programs have two main components, didactic coursework and clinical rotations. During the didactic portion of CT training, students learn cytomorphology to screen and interpret the cytology specimens of various body sites. The students are also sent to the cytology laboratory that is associated with the training program to observe: Glass slide specimen preparation and staining and clinical procedures such as FNA and ROSE. Depending on the facility and availability of the cytology laboratory, the students may or may not spend a long amount of time, or participate in these procedures more than merely observing. Later in the training program, students attend their clinical rotations at various cytology laboratories. At that time, they are given the opportunity to apply skills learned during didactic coursework to a real laboratory environment, under the guidance of a certified cytotechnologist. Even though students have had hands-on experience as part of their didactic coursework, it is common for students to be stressed and nervous during the initial few days of their clinical rotations.

Our CT program has been training students since 1996. For the last 11 years, our CT program has provided synchronous education to satellite sites. Satellite students receive the didactic part of training from our CT program at the same time as our campus students but get their hands-on experience from the cytology laboratory at their satellite location. Lately, there have been requests for our CT program to provide asynchronous education to students who do not have access to cytology laboratories. Although our existing online curriculum provides training in slide screening using VM, the online training in hands-on techniques such as preparing the cytology specimens, and participation in FNA and ROSE procedures was lacking. Previous studies conducted in medical, physiotherapy, nursing, and pharmacy education have shown that ELMs contributed to greater skills acquisition among students assigned to online learning versus traditional classroom education only.<sup>[13-15]</sup> For that reason, we believed that the ELMs demonstrating hands-on techniques in cytology through video would complement our existing online curriculum and eliminate or reduce the need

for in-person training in cytology laboratories. In addition, we believed that the ELMs would give students the opportunity to view the ELMs ample times to understand their roles in various techniques and procedures in cytology. By doing this, the students could prepare themselves and perform the techniques well by minimizing stress and anxiety during their clinical rotation. Therefore, we decided to develop ELMs in our program with hopes that the modules would complement and amplify student learning.

The main purpose of this study was to assess our CT students' perceptions of nine ELMs – "Initial Handling," "Centrifugation," "Cytocentrifugation," "Papanicolaou Staining," "Diff-Quik Staining," "Coverslipping Technique," "FNA Techniques", "ROSE," and "Tele-cytology" that were developed using Articulate software. As the results indicate, statements on the content of the ELMs regarding the quality of the video and audio, duration, navigation, and the materials presented received positive responses from the majority of the students.

We found that the majority of the students understood the steps involved in the techniques demonstrated in the ELMs. Similarly, the majority of the students also found that viewing the ELMs before the classroom discussion gave them knowledge about the topic so that they could participate effectively during the classroom discussion and therefore recommended future students to do the same. One student responded as N/A for the above-mentioned statement. It is possible that this student is one of our satellite site students who might have attended the FNA procedures before watching the ELM. From the preclinical survey results, it was apparent that a majority of the students believed that all nine ELMs would better prepare them and improve their performance during the clinical rotation period. A few students, however, had changes of opinion on this after completing their clinical rotations. This might be due to the various approaches of the clinical laboratory toward specimen preparations, or perhaps, the students did not get the opportunity to perform these techniques in the clinical laboratories to know the effect of ELMs on their performances during clinical rotations. This is

consistent with the conversations we had with graduates of our program saying that some of the clinical rotation sites were reluctant in allowing the students to do the hands-on techniques at their preparatory laboratory.

The preclinical rotation survey of the “Initial handling” ELM received three open comments from the students. One of the comments was, “The only problem I had with the ELMs was that if the slide leading to a self-assessment was short. It would go to the self-assessment before I finished with taking notes. Once the ELM gets to the self-assessments, you cannot continue until you answer the question.” It is possible that the student was unaware that the videos can be paused, rewind, or fast-forwarded. Therefore, it was decided that for the future ELMs, a video clip demonstrating the navigation will be created and added at the beginning of each ELM. In addition, when this ELM was developed, the self-assessments were set as a mandatory completion to make sure that the students understood the concept being tested. Once the self-assessments were completed, the students would be able to either review, retry, or complete the self-assessments. Perhaps, in the future, students should be given the choice whether to skip or participate in the self-assessments, given that they completed self-assessments at least once. Another comment was, “Could have more self-assessments.” This comment will be considered and more self-assessments will be added in future ELMs. One additional comment was, “The video would not fully load so it kept pausing in the middle”. Students who participated in the other research studies have also reported such comments.<sup>[9]</sup> The reasons could be inadequate internet access, or equipment that was outdated if the student used the computers other than the one provided in the classroom. The preclinical survey of the ‘Cytocentrifugation’ ELM had a comment, “Some of the details of putting the cytocentrifugation together were hard to see, a close up on the hands would fix this;” however, one of the postclinical survey comments for the same ELM was, “I was already knowledgeable about the cytocentrifugation and how to perform without having to have it re-explained by the clinical rotation staff.”

Some of the positive comments in both the surveys for other ELMs were, “I had a great understanding of what I would be needed for during an FNA procedure so I was prepared to do FNA during my rotation without much extra training;” “The ELM gave me an understanding of why the Pap Stain is done and how it is done;” “After watching the ELMs, during discussion I feel like I am better able to participate;” “Exposure to the campus institution’s protocols via ELMs is probably most beneficial to the distance students since they get to see two perspectives on the same technique;” “I find the ELMs very helpful;” and “I thought the ELMs were a great way to introduce topics without having to get together for lectures.”

Similar to a report of a previous study,<sup>[13]</sup> we also found the development of ELMs to be time-consuming and expensive. For the “FNA Technique” and “Preparatory Techniques in

Cytology” ELMs, the expense was more than the funding received. Most of the cost was spent on hiring a professional videographer, voice over recording, and editing of the video clips. After these ELMs were developed, an E-learning laboratory was made available in our institution that provides high-quality video cameras for shooting video clips for the ELMs. The E-learning laboratory also has a soundproof booth in which the audio recording can be done; therefore, the remaining ELMs used in this study were developed using the facilities available in our institution’s E-learning laboratory. This has reduced a considerable amount of our expenses. In addition, it was encouraging to find that students did not find any major difference regarding the quality of the video and audio clips between the ELMs developed using a professional videographer and the facilities from the E-learning laboratory.

### Limitations and future directions

One of the limitations in this study was not assessing the performances of the clinical skills of the students. Another limitation was the small sample size due to the fact that CT programs, in general, have comparatively fewer students than other disciplines such as, medicine, pharmacy, and nursing. To increase the sample size in the future studies, perhaps, the assessments of the ELMs on students’ performance skills should be extended to all the CT students in the US.

In the future, we have decided to use the facilities in the E-learning laboratory at our institution to develop more ELMs. In those, we plan to include an introduction slide narrating the duration, computer compatibility requirements, and demonstrating the navigation of the ELMs. We also plan to include more interactive self-assessment exercises in the ELMs.

### CONCLUSIONS

The majority of the CT students in our program had positive responses regarding the content of the ELMs and believed that ELMs prepared them as well as helped them to better perform their role during the clinical rotations. This study has given hope that the ELMs have potential to enhance our online curriculum and benefit the students, not only within the US but also internationally, who have no easy access to cytology clinical laboratories for hands-on training. With the suggestions for improvement and positive comments given from the students who participated in this study, we plan to develop more cytology ELMs.

### Acknowledgment

The authors would like to thank the Office of the Vice-Chancellor for Academic Affairs at our institution for funding to develop the E-learning modules used in this study.

### Financial support and sponsorship

This study was financially supported by Office of the Vice-Chancellor for Academic Affairs at our institution.

### Conflicts of interest

There are no conflicts of interest.

## REFERENCES

1. Available from: <https://www.cytotechnology.org/caahep-accredited-cytotechnology-programs/>. [Last accessed on 2017 Sep 20].
2. Donnelly AD, Mukherjee MS, Lyden ER, Radio SJ. Online education in cytotechnology programs: A pilot study. *J Am Soc Cytopathol* 2015;5:235-43. [doi: 10.1016/j.jasc.2016.02.001].
3. Ruiz JG, Mintzer MJ, Leipzig RM. The impact of E-learning in medical education. *Acad Med* 2006;81:207-12.
4. Sinclair PM, Kable A, Levett-Jones T, Booth D. The effectiveness of internet-based e-learning on clinician behaviour and patient outcomes: A systematic review. *Int J Nurs Stud* 2016;57:70-81.
5. Xiberta P, Boada I. A new e-learning platform for radiology education (RadEd). *Comput Methods Programs Biomed* 2016;126:63-75.
6. Pinto A, Brunese L, Pinto F, Acampora C, Romano L. E-learning and education in radiology. *Eur J Radiol* 2011;78:368-71.
7. Park JY, Woo CH, Yoo JY. Effects of blended cardiopulmonary resuscitation and defibrillation E-learning on nursing students' self-efficacy, problem solving, and psychomotor skills. *Comput Inform Nurs* 2016;34:272-80.
8. Parker S, Mayner L, Michael Gillham D. E-learning for critical thinking: Using nominal focus group method to inform software content and design. *Nurs Midwifery Stud* 2015;4:e30471.
9. Kelly M, Lyng C, McGrath M, Cannon G. A multi-method study to determine the effectiveness of, and student attitudes to, online instructional videos for teaching clinical nursing skills. *Nurse Educ Today* 2009;29:292-300.
10. Horiuchi S, Yaju Y, Koyo M, Sakyo Y, Nakayama K. Evaluation of a web-based graduate continuing nursing education program in Japan: A randomized controlled trial. *Nurse Educ Today* 2009;29:140-9.
11. Padalino Y, Peres HH. E-learning: A comparative study for knowledge apprehension among nurses. *Rev Lat Am Enfermagem* 2007;15:397-403.
12. Nesterowicz K, Librowski T, Edelbring S. Validating e-learning in continuing pharmacy education: User acceptance and knowledge change. *BMC Med Educ* 2014;14:33.
13. Buch SV, Treschow FP, Svendsen JB, Worm BS. Video- or text-based e-learning when teaching clinical procedures? A randomized controlled trial. *Adv Med Educ Pract* 2014;5:257-62.
14. Lu DF, Lin ZC, Li YJ. Effects of a web-based course on nursing skills and knowledge learning. *J Nurs Educ* 2009;48:70-7.
15. Arroyo-Morales M, Cantarero-Villanueva I, Fernández-Lao C, Guirao-Piñeyro M, Castro-Martín E, Díaz-Rodríguez L, *et al*. A blended learning approach to palpation and ultrasound imaging skills through supplementation of traditional classroom teaching with an e-learning package. *Man Ther* 2012;17:474-8.