

# Implementation and Evaluation of Virtual Laboratory Tours for Laboratory Diagnosis of Hematologic Disease

Teresa A. Scordino, MD,<sup>1,\*</sup> and Alix G. Darden, PhD<sup>2</sup>

From the Departments of <sup>1</sup>Pathology and <sup>2</sup>Pediatrics, University of Oklahoma College of Medicine, Oklahoma City, OK, USA.

## ABSTRACT

**Objectives:** There is often limited time allocated to teaching laboratory medicine to medical students. Without adequate time and context, it can be difficult for students to learn appropriate uses and limitations of laboratory tests. Introducing students to the laboratories and test methods may help them learn these concepts, but physical laboratory tours are difficult to organize for large groups, especially during the coronavirus disease 2019 pandemic.

**Methods:** We created virtual laboratory tours consisting of short video clips and voiceover PowerPoint slides to teach students about the laboratory tests used to diagnose hematologic malignancies. We assessed the impact on student performance on laboratory medicine-themed quiz questions and surveyed the students to determine their attitudes about the activity.

**Results:** In total, 129 first-year medical students participated in the study. The average score on the preactivity quiz was 59.8%, and the average score on the postactivity quiz was 92.2%. Students were more confident in their ability to answer quiz questions after completing the activity. Postactivity survey data indicated that the students enjoyed the activity and felt it was an effective way to learn the material.

**Conclusions:** Virtual laboratory tours show promise as a method of incorporating more laboratory medicine content into medical school curricula.

## INTRODUCTION

Diagnosis of hematologic malignancies requires integration of multiple types of laboratory tests, including flow cytometry, cytogenetics, and molecular diagnostics. These tests are performed in several different specialty laboratories; however, “the laboratory” can seem like a single black box to students and trainees. The recommended competencies for graduating medical students put forth by the Association of Pathology Chairs and the Academy of Clinical Laboratory Physicians and Scientists include understanding the method and proper use of these laboratory tests<sup>1,2</sup>; however, the wide variety of diagnostic methods can be confusing to medical students. Confusion about ancillary testing can present an obstacle to learning and retaining the diagnostic criteria for hematologic diseases. When knowledge gaps in laboratory medicine persist into the resident and fellow training stages, they may manifest as laboratory ordering errors and overutilization or underutilization of diagnostic tests, resulting in

## KEY POINTS

- Medical students may struggle to learn laboratory medicine concepts in a classroom setting.
- Virtual laboratory tours allow students to learn about the method, proper uses, and limitations of laboratory tests.
- Virtual laboratory tours improved student performance on laboratory medicine-themed test questions, and student feedback about the laboratory tours activity was positive.

## KEY WORDS

Medical education; Laboratory medicine; Hematopathology; Education; Flow cytometry

*Am J Clin Pathol* June 2022;157:801-804  
[HTTPS://DOI.ORG/10.1093/AJCP/AQAB209](https://doi.org/10.1093/AJCP/AQAB209)

Received: September 1, 2021

Accepted: November 12, 2021

Advance publication: December 22, 2021

Corresponding author: Teresa A. Scordino MD; [Teresa-Scordino@ouhsc.edu](mailto:Teresa-Scordino@ouhsc.edu).

delayed diagnoses.<sup>3,4</sup> Previous publications have highlighted a need to improve coverage of laboratory medicine topics in medical school curricula<sup>2-5</sup> and have cited a lack of time as a major limitation to improving education in laboratory medicine.<sup>4</sup>

Familiarizing learners with the distinct laboratories and test methods is a potential way to help learners distinguish between the laboratory tests used to diagnose hematologic diseases and to learn the proper indications for these tests. Laboratory tours are a way to provide this kind of exposure<sup>6</sup>; however, physical tours can be logistically difficult to arrange even in the best of circumstances due to large class sizes and limited staff availability. Additional barriers were present during the coronavirus disease 2019 pandemic, including the need to use remote learning methods and limited visitor access to hospital facilities.

We propose that virtual laboratory tour videos can be used to teach laboratory medicine concepts to students. We designed this study to assess the educational impact of virtual laboratory tours based on student performance on laboratory medicine-themed test questions and student responses to qualitative survey questions.

## MATERIALS AND METHODS

First-year medical students ( $n = 164$ ) were required to complete a laboratory tour activity as part of their 4-week hematology course. Students were provided with an instruction sheet that included the learning objectives for the activity. The laboratory tour activity consisted of a preactivity test, three laboratory tour videos (flow cytometry, cytogenetics, and molecular laboratories), and a postactivity test. In previous years, information about these test methods was provided to students as a Word document for independent study.

The course director (a hematopathologist) developed the laboratory tour content and created the videos. An iPhone 8 (Apple) camera was used to film laboratory technologists as they completed key specimen processing and testing steps. These video clips were combined with voiceover PowerPoint presentations to outline the indications, limitations, specimen requirements, basic test method, data collection, data analysis, and correlation with morphologic results for each test **FIGURE 1**. Selected tests were presented in detail for each laboratory. The flow cytometry video followed a B-lymphoblastic leukemia peripheral blood specimen through the laboratory. The cytogenetics video showed a karyotype being performed and fluorescence in situ hybridization slides being analyzed. The molecular diagnostics video covered general principles of nucleic acid extraction and polymerase chain reaction (PCR) and showed examples of methods used to detect point mutations (allele-specific PCR, Sanger sequencing) and qualitative and quantitative *BCR-ABL1* testing. The molecular laboratory video relied on animations to show tests not available at our institution. The three videos took a total of approximately 18 hours to create, including filming, creation of PowerPoint slides, voiceover recording, and video

editing. The finished videos ranged from 10 to 15 minutes in length. The videos were hosted on the university's media site, and timestamped user data were used to ensure that students watched the videos in their entirety.

The pre- and posttests were created by the course director. Test questions were aligned with the learning objectives for the activity and with the video content. The questions focused on selection of the most appropriate laboratory test method given a clinical question and/or specimen type; these details were covered by the laboratory tour videos but not presented elsewhere in the course. The questions on the pretest and posttest were not identical but similar in format, content, and difficulty. Example test questions are shown in the **Supplemental File** (all **supplemental materials** can be found at *American Journal of Clinical Pathology* online). The tests also included questions about the students' level of confidence with their answers. The tests were delivered remotely using the test function on the course Desire2Learn page. The students did not receive the correct answers to the pre- or posttests until after the posttest was complete. The average scores of the pre- and postactivity tests were compared using a *t* test.

The activity took approximately 1 hour for the students to complete. Students received 5 points (5% of the course grade) for completing the activity; performance on the tests did not affect the students' grade.

Students completed an anonymous survey to assess their attitudes about the activity. Students answered each question based on a 7-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = somewhat disagree; 4 = neither agree nor disagree; 5 = somewhat agree; 6 = agree; 7 = strongly agree).

The students' performance on a separate low-stakes quiz question about indications for laboratory testing was compared with historical performance data.

## RESULTS

The study was approved by the university's institutional review board. In total, 129 students consented to participate in the study. The average score on the preactivity test was 59.8%, and the average score on the postactivity test was 92.2% ( $P \leq .0001$ ).

The students' degree of confidence with their answers improved after completing the activity. The number of students reporting that they were either confident or highly confident with their responses was 6% for the preactivity test and 85% for the postactivity test **FIGURE 2A**.

Student responses to the quantitative survey questions are shown in **FIGURE 2B**. Student narrative feedback about the activity was uniformly positive. Selected student responses to the prompt "please provide 1-3 attributes of the laboratory tours that contributed to your learning" are shown in **TABLE 1**.

Of the students, 91% correctly answered the low-stakes quiz question about laboratory test indications, compared with 48% of students the year prior to implementation of the laboratory tour activity.

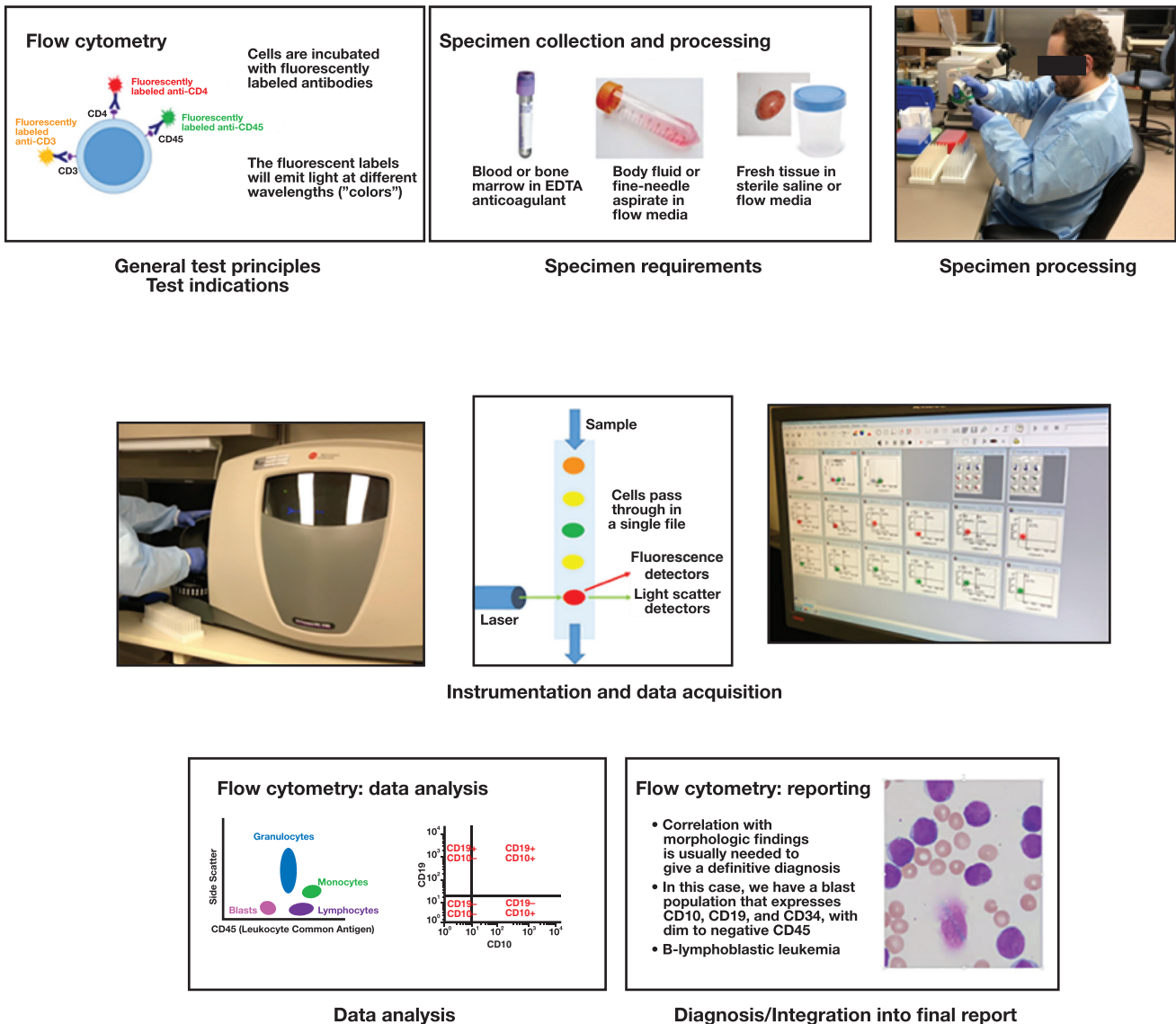


FIGURE 1 Format of the virtual laboratory tour videos.

## DISCUSSION

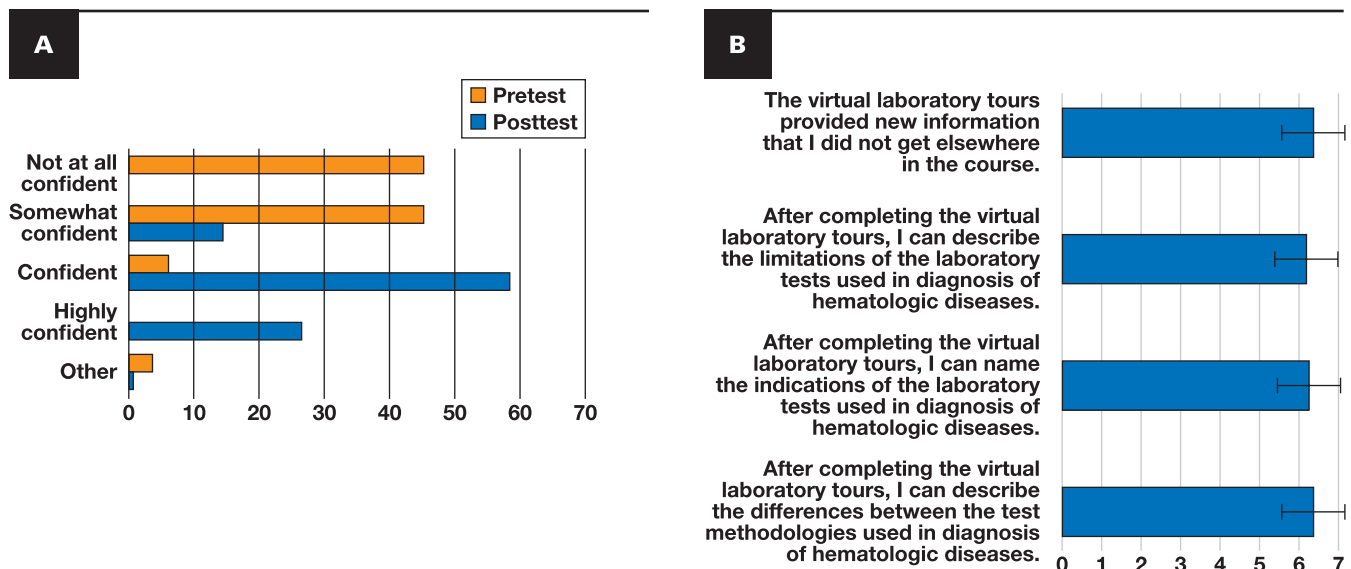
Appropriate and cost-effective use of laboratory testing is a key competency for medical learners. In a 2013 to 2014 survey of 98 medical schools, Smith et al<sup>4</sup> found that lack of time was the most frequently cited barrier to optimizing medical student education in laboratory medicine. Therefore, it is desirable to identify efficient methods to incorporate these topics into medical school curricula. This activity took approximately 1 hour for the students to complete and was easily incorporated into the course schedule. While creation of the three videos required approximately 18 hours of faculty time, the finished videos were reused in subsequent classes with no additional faculty time investment.

Our data indicate that the laboratory tours improved student performance on laboratory medicine-themed test questions and their confidence in the ability to answer these questions. The survey data indicate that the students felt they learned new information from the activity that was not covered elsewhere in the course and thought the

activity was helpful to their learning. The students also felt that the activity helped them understand the indications and limitations of the laboratory tests that were presented.

We considered the possibility that other course activities may have contributed to the observed improvement in test scores. However, the material tested by the pretest and posttest focused on general indications, specimen requirements, and test methods that were not covered elsewhere in the course. Furthermore, 68% of students completed the laboratory tour activity before any content on hematologic malignancies was presented in the rest of the course.

The current study has several limitations. It is limited to one class of medical students at one institution and does not provide any information about the students' long-term knowledge retention or the impact on future test-ordering practices. Future directions include repeating the study for subsequent classes, assessing student knowledge retention as they enter their clinical rotations and residency years, and implementing this activity for



**FIGURE 2 A**, Student confidence in their quiz responses before and after completing the laboratory tour activity (percentage of students). **B**, Student responses to survey questions. Responses were recorded on a 7-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = somewhat disagree; 4 = neither agree nor disagree; 5 = somewhat agree; 6 = agree; 7 = strongly agree). Error bars = standard deviation.

**TABLE 1** Student Responses to the Survey Prompt “Please provide 1-3 attributes of the laboratory tours that contributed to your learning.”

The visual, almost hands-on nature of the tours helped cement the information regarding the various tests in a way that an explanation alone could not.
The lab tours activity helped me understand the information that was taught in lecture even better. We talked about many of these lab tests in other courses but this time I was finally able to understand them more in depth, so I think this was a great addition to the course that will continue to be useful in future courses.
I found it extremely helpful to be able to visualize components of the testing lab at the same time as hearing the procedures explained. This helped solidify the material in a new and effective way.
I liked being able to watch at my own convenience.
Seeing the actual lab techs work through the steps was really cool and helped me to retain the information!
It helped me understand the tests better. I liked how we could actually see how the tests are actually done.
Actually seeing the tests demonstrated helped me to grasp the concepts a lot better.
I enjoyed the lab tour. It helped put a lot of stuff that we had been learning into perspective. I also liked that the videos were concise.
It provided clear and more in-depth knowledge about different lab tests and their possible uses. It helped me to finally be able to differentiate these tests and when they would be best used. I think it might be ideal to do a similar activity in [a previous course] for all of the genetic testing we learned. I found this activity helped me understand these tests much better.
Having videos that walked through how the lab tests were done and what they were looking for was helpful. Hard to find that clear-cut information online.
I enjoyed actually getting to see video within the lab. That was totally unique and gave instant context for the material.

hematology-oncology fellows to evaluate for an impact on test utilization.

Virtual laboratory tours are a distance-learning method that can be easily tailored to teach relevant laboratory testing topics in other systems courses or to students in other health professions. While they cannot replace the experience of an in-person rotation through the laboratory, they do provide a glimpse into the laboratory and introduce students to some of the laboratory professionals and technical knowledge that are essential to generating reliable laboratory results. We believe this method shows promise as a teaching tool and a way to incorporate more coverage of laboratory medicine topics into medical school curricula.

**Acknowledgments:** We thank the faculty and participants of the 2019 cohort of the American Society of Hematology Medical Educators Institute.

## REFERENCES

- Knollmann-Ritschel BEC, Regula DP, Borowitz MJ, et al. Pathology competencies for medical education and educational cases. *Acad Pathol.* 2017;4:2374289517715040.
- Smith BR, Aguero-Rosenfeld M, Anastasi J, et al; Academy of Clinical Laboratory Physicians and Scientists. Educating medical students in laboratory medicine: a proposed curriculum. *Am J Clin Pathol.* 2010;133:533-542.
- Laposata M. Insufficient teaching of laboratory medicine in US medical schools. *Acad Pathol.* 2016;3:2374289516634108.
- Smith BR, Kamoun M, Hickner J. Laboratory medicine education at U.S. medical schools: a 2014 status report. *Acad Med.* 2016;91:107-112.
- Wilson ML. Educating medical students in laboratory medicine. *Am J Clin Pathol.* 2010;133:525-528.
- Molinaro RJ, Winkler AM, Kraft CS, et al. Teaching laboratory medicine to medical students: implementation and evaluation. *Arch Pathol Lab Med.* 2012;136:1423-1429.