Research article

Using Simulation to Introduce Students to a Medical Laboratory Information System

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Purpose: **The incorporation of simulation-based learning activities is not a new concept in the field of medical laboratory science. Studies have shown that simulation experiences incorporated into academic curricula provide students with a safe learning environment while developing their skills and boosting self-confidence. Currently, no studies are available in the literature related to exposure to or experience with Laboratory Information Systems (LIS) for Medical Laboratory Science students during their program coursework. This study focused on using an LIS to supplement the education of Medical Laboratory Science students at a large public university in the United States.**
Materials & Methods: **The LIS simulation activity was integrated into the students' hematology laboratory course during two separate sessions. The first part of the activity served as an introduction to the purpose and function of the LIS in the clinical laboratory. The second part focused on result entry and manual review of the hematology instrument into the LIS. To assess the effectiveness of the simulation activity, student responses from pre- and post-activity surveys were analyzed using the Wilcoxon signed-rank test and thematic analysis.**
Results: **The results obtained from the Wilcoxon signed rank test showed a significant improvement in students' understanding of LIS functionality after completing part 1 of the activity. Results also indicated that students' understanding of how diagnostic tests are ordered in the laboratory significantly improved. Student responses were overwhelmingly positive when asked if students were looking forward to using this LIS for future laboratory courses.**
Conclusion: **The LIS simulation activity effectively introduced students to the purpose and functionality of an LIS in the clinical laboratory. Future recommendations for research include incorporating additional simulation-based learning experiences into the curriculum to prepare students for workforce entry upon graduation from the program.**

Keywords: Simulation, Medical Laboratory Science (MLS), Education, Laboratory Information System (LIS), Student Experience

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Accepted: January 18, 2024

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Introduction

The incorporation of simulation-based learning activities is not a new concept in the field of medical laboratory science (MLS). Studies have shown that when simulation activities are incorporated into the curricula, student confidence and self-perception increase following the activity.[1] Virtual simulation provides students with a safe learning environment where there can be no direct harm to patients.[2] Although the incorporation of simulation has been on the rise in various areas of education, the inclusion of simulation in MLS education is still a growing area of study.[3] The COVID-19 pandemic drastically changed the method of delivery for higher-level education, in which most coursework was presented in a face-to-face format. E-learning education methods were adopted throughout many educational systems to protect students and the greater community against possible infection. Studies have shown that students had a positive perception of the e-learning format.[4] E-learning has become widely adopted following the COVID-19 pandemic due to educators' positive results and students' positive perceptions of this method. Other studies have shown that synchronous distance education did not differ greatly from traditional education, resulting in higher satisfaction rates among students enrolled in these online courses in some cases.[5] A flexible learning environment allows students to take in material at their own pace, without the stressors of time and space constraints. As e-learning methods continue to expand in health science curricula, there is a growing need to provide students with a new way to learn material away from the classroom. Simulation-based laboratories may provide the solution to fill the gap when students are not actively engaged in a traditional classroom setting.

Simulation is a method to expose students to concepts that can be further elucidated in a real-world scenario. These simulation experiences have become quite advanced, providing students with an effective means of honing their skills online, incorporating the concepts of e-learning and laboratory simulation.[2,6] Experiential learning through practice with simulation has been recommended for students in the field of nursing as preparation for new graduates.[7] The concept of simulation has been shown throughout the literature as an effective means of enhancing student knowledge, and it can be a valuable tool to support student retention and lead to higher exam scores.[8]

No studies related to Laboratory Information System (LIS) exposure or experience for MLS students during program coursework were found in the literature. While students may feel ready to engage with new and different technology, their understanding of the use of technology in a hospital setting and medical laboratory is extremely limited. Feedback from prior graduates indicated a need for more information and experience related to the purpose and use of an LIS before their clinical practicum experience. This study focuses on the effectiveness of an LIS simulation to supplement the education of senior MLS students.

Materials and Methods

The Institutional Review Board approved this project (STUDY00019137). A simulation activety using the LIS was developed and integrated as part of the coursework for the hematology laboratory course. Students completed preparatory work online and then engaged in a hands-on LIS simulation activity during two separate laboratory sessions. The first part of the activity introduced students to the LIS and pre-analytical components of the laboratory exercise, where students were tasked with creating a requisition, documenting the collection time of their specimen, and printing a laboratory barcode label. The second part involved post-analytical components of the laboratory exercise, which was a continuation of the first part of the LIS simulation activity, where students used the LIS to manually enter and review patient results. Both parts of the LIS simulation activity were accompanied by a short video and a written procedure that the students were instructed to review before

attending the laboratory session associated with each part. The video for part 1 and part 2 of the simulation LIS activity, along with the written procedure for each part, demonstrated how to use our LIS program and provided additional information on the functionality of LIS. The goal of providing materials for students before the lab session was to help them feel prepared and more comfortable using the LIS, having already been exposed to it through video presentations and written procedures.

The effectiveness of the preparatory work and the overall simulation experience were assessed using a mixed methods approach. Survey questionnaires were developed using Qualtrics™ to assess students' understanding of the role of the LIS in the medical laboratory. Relevant research studies on student perceptions of simulation activities in health or science courses were used to guide the development and design of the pre and post-surveys, including how the survey questions were written and presented to the students.[1,2,9] Pre- and post-activity surveys were integrated as part of the coursework for the students currently enrolled in the hematology didactic course. The surveys were developed for the course to understand prior student experience and their understanding of LIS in the laboratory and assess their learning and confidence using it following the simulation activity. These surveys followed a five-point Likert scale, with five indicating a response of strongly agree and one indicating a response of strongly disagree. Surveys also included open-ended questions where students could provide additional information about their experience in the LIS simulation.

Table 1: Wilcoxon Signed Rank Test of Student Responses
This table shows selected questions from pre- and post-activity surveys, Z-scores, and corresponding p values.

	Negative Ranks			Positive Ranks					
	n	Mean rank	Sum of ranks	n	Mean rank	Sum of ranks	Ties	Z	p
(Activity helped me understand purpose/ function after Part 1)-(Before Part 1)	2	6	12	20	12.05	241	6	-3.788[b]	<0.001[a]
(LIS activity helped select/order tests after Part 1)-(Understanding lab test ordering before Part 1)	3	8.67	26	22	13.59	299	3	-3.725[b]	<0.001[a]
(Self-confidence after Part 2)-(After Part 1)	4	11.25	45	13	8.31	108	11	-1.576[b]	0.115
(Desire to use LIS after Part 1)-(Before part 1)	5	5	25	4	5	20	19	-0.333[c]	0.739
(Understanding reference ranges after Part 2)-(Before Part 2)	17	10.94	186	3	8	24	8	-3.189[c]	0.001[a]
(Activity helped better understand LIS after Part 2)-(After Part 1)	2	5.5	11	9	6.11	55	17	-2.138[b]	0.033[a]
(Understanding of Critical Values after Part 2)-(Before Part 2)	17	10.29	175	2	7.5	15	9	-3.386[b]	<0.001[a]
(Desire to use LIS after Part 2)-(After Part 1)	5	5.5	27.5	5	5.5	27.5	18	0.000[d]	1

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks
c. Based on positive ranks
d. The sum of negative ranks equals the sum of positive ranks

Due to the small sample size and non-parametric nature of the data, analysis was performed using the Wilcoxon signed-rank test through the statistical analysis software IBM SPSS (v 28). A total of 29 students were enrolled in the course and participated in the LIS simulation activity. However, one student was excluded from this study as they had not completed all the assigned surveys as part of the course requirements, so the sample size for this study was 28 students.

Results

Prior to data analysis, inclusion criteria were established. Data was de-identified to allow for correlation of student responses between the pre and post-survey data. Students who did not complete all assigned pre and post-surveys related to the LIS simulation were excluded from any data analyses. The final sample size for this project included 28 students.

Students responded very well to the activity, and they demonstrated an improved understanding of the value of the LIS in the laboratory and a desire to use it for future laboratory activities, as shown in Table 1. In particular, there was a significant improvement in their understanding of the purpose and function of the LIS, laboratory test ordering processes, and their understanding of reference ranges and critical patient results. The majority of students found the simulation activity useful and agreed that it integrated well into the hematology laboratory course (Table 2).

The surveys assigned to the students as part of the laboratory course also included open-ended questions where feedback on the LIS simulation activity could be provided. Many of the students touched on similar themes. Students particularly enjoyed the manual entry of their complete blood count (CBC) results, allowing them to apply the concepts they learned in their MLS lecture courses in the laboratory. Many students mentioned that the length of time between both parts of the activity may have been detrimental to their learning, suggesting that the two parts be scheduled in a closer timeframe. Other students suggested working with multiple samples instead of one, which would provide additional evidence to evaluate students' comfort level working with the LIS

Table 2: Median Student Responses to Survey Questions

Students responded to survey questions using a Likert scale, with 5 indicating strongly agree and 1 indicating strongly disagree. Most students agreed the activity was useful and integrated well with the hematology lab session.

Survey Question	Median ± SEM (IQR) -	Survey Question
I am looking forward to using this LIS for my future laboratory courses in the MLS program	4 ± 0.107 (1)	4 ± 0.107 (1)
The pre-lab handout and tutorial video effectively prepared me for the LIS activity	4 ± 0.104 (0.25)	4 ± 0.108 (1)
The LIS simulation experience integrated well with the laboratory course material	4 ± 0.104 (1)	4.5 ± 0.109 (1)
The LIS simulation experience helped my self-confidence as a future MLS	4 ± 0.166 (1)	4 ± 0.132 (1)

Discussion

In general, students responded very well to the LIS simulation activity. Participation in the activity significantly improved students' understanding of the purpose and function of the LIS in laboratory practice. Regarding the self-confidence ratings in their skills as Medical Laboratory Scientists, student opinions did not differ much between both parts of the simulation activity. Students felt confident in their skills, as noted during the simulation activity. The MLS faculty indicated that the students appeared well-prepared to complete the simulation activity, and their responses to the pre-activity materials were also positive.

Limitations of this study include the sample size and time constraints. This simulation activity involved 28 students in a Medical Laboratory Science program. Future recommendations include expanding this study to incorporate additional universities and MLS programs to increase the sample size. Another limitation was not validating the surveys used to assess student learning outcomes due to time constraints associated with the project. Survey questions for the pre and post-simulation assignments were developed using previous research studies as a guide. Validation of these surveys in the future may help standardize student responses and minimize any confusion students may have had regarding questions. Obtained results in this study may have also suffered from distortion effects, such as central tendency bias or social desirability bias. Different survey methods may also be explored in the future to mitigate any perceived biases by students in their responses.

Many students mentioned that the length of time between both parts of the activity (3 weeks) may have been detrimental to their learning and suggested that the two parts be scheduled in a closer timeframe. Other students suggested working with multiple samples instead of on a single sample, providing additional evidence to evaluate students' comfort level working with the LIS.

Students provided valuable feedback and suggestions to improve the activity and assignments for future students in the course. The data demonstrated that most students agreed that the activity incorporated well into their current MLS program curricula. Most students agreed that the opportunity to engage in the LIS simulation activity improved their confidence in using an LIS and helped them look forward to future opportunities using it.

Conclusion

The findings suggest that incorporating a simulation-based learning activity to introduce students to the purpose and function of an LIS was effective.

Acknowledgments

This paper and research project would not have been possible without the support of Christine Maleck and Andrew Yue. Thank you for your work to integrate the LIS simulation in the hematology laboratory course and for providing this beneficial experience to our students. We thank Dr. Janice Conway-Klaassen for supporting this research project and completing a manuscript review. Finally, we would like to acknowledge the engagement and enthusiasm of the MLS program students who participated in the LIS simulation. Dr. Alpaugh was awarded the American Society of Clinical Pathology (ASCP) Program Director's Grant to purchase a LIS for the MLS student laboratory in 2021. This LIS system was used during the simulation activity described in this research project. Existing MLS student laboratory equipment was used as the LIS simulation project took place during the required MLS hematology laboratory course.

References

1. Goolsby CA, Goodwin TL, Vest RM. Hybrid simulation improves medical student procedural confidence during EM clerkship. Mil Med. 2014 Nov;179(11):1223-7. doi: 10.7205/MILMED-D-14-00072.
2. Kok YY, Er HM, Nadarajah VD. An analysis of health science students' preparedness and perception of interactive virtual laboratory simulation. Med Sci Educ. 2021 Sep 8;31(6):1919-1929. doi: 10.1007/s40670-021-01364-1.
3. Webb TL, McGahee J, Brown MR. A scoping review of medical laboratory science and simulation: promoting a path forward with best practices. Lab Med. 2022 May 5;53(3):e51-e58. doi: 10.1093/labmed/lmab087.
4. Naciri A, Radid M, Kharbach A, Chemsi G. E-learning in health professions education during the COVID-19 pandemic: a systematic review. J Educ Eval Health Prof. 2021;18:27. doi: 10.3352/jeehp.2021.18.27.
5. He L, Yang N, Xu L, Ping F, Li W, Sun Q et al. Synchronous distance education vs traditional education for health science students: A systematic review and meta-analysis. Med Educ. 2021 Mar;55(3):293-308. doi: 10.1111/medu.14364.
6. de Vries LE, May M. Virtual laboratory simulation in the education of laboratory technicians-motivation and study intensity. Biochem Mol Biol Educ. 2019 May;47(3):257-262. doi: 10.1002/bmb.21221.
7. Mabry J, Lee E, Roberts T, Garrett R. Virtual Simulation to Increase Self-efficacy Through Deliberate Practice. Nurse Educ. 2020 Jul/Aug;45(4):202-205. doi: 10.1097/NNE.0000000000000758.
8. Donkin R, Askew E, Stevenson H. Video feedback and e-learning enhances laboratory skills and engagement in medical laboratory science students. BMC Med Educ. 2019 Aug 14; 19(1):310. doi: 10.1186/s12909-019-1745-1.
9. Olson J, Rinehart J, Spiegel JJ, Al-Nakkash L. Student perception on the integration of simulation experiences into human physiology curricula. Adv Physiol Educ. 2019 Sep 1;43(3):332-338. doi: 10.1152/advan.00202. 2018