



Impact of Low-Fidelity Simulation Based Learning in a Cardiovascular Pharmacotherapy Module


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Abstract: To determine the impact of low-fidelity simulation (LFS) on the comprehension of 5 major cardiovascular diseases in a pharmacotherapy module. Study population included pharmacy students enrolled in the cardiovascular pharmacotherapy from 2020-2022. Baseline knowledge was obtained by comparing practice quiz answers to corresponding exam questions. Near the course end, answers from the LFS patient case involving the 5 diseases were compared to corresponding final exam questions. The percentage correct was compared to see if LFS has more impact than practice quizzes on exam grades. All groups showed approximately the same percentage correct exam questions from practice quizzes. LFS was superior to practice quizzes in percentage correct on exam questions in 4/5 disease states for the class enrolled in 2021. However, opposite results were shown for the class enrolled in 2022, with practice quizzes showing a larger improvement over the LFS activity on exam questions in all 5 disease states. Although data was mixed, the use of LFS is a viable addition to classroom learning in complicated pharmacotherapy courses. There is a paucity of literature published to date in the health sciences literature on the use of LFS; therefore, this adds to the body of evidence to support learning via simulation.

Keywords: Simulation, Low fidelity simulation, Active learning strategies, Practice quizzes

Introduction

Simulation-based learning (SBL) is an interactive teaching method that provides the students with the type of hands-on experience that is similar to a real-life clinical setting. (Seybert, 2012) SBL can use a mannequin, a task trainer, virtual reality or a standardized patient to emulate a real device, patient or care situation or environment to teach therapeutic and diagnostic procedures, processes, medical concepts and decision making to a healthcare professional. (Sarfati, 2019) Problem based learning (PBL) uses a written case stem as the learner stimulus for the acquisition and application of knowledge in a clinical setting. PBL does not use a mannequin, medical equipment, physiologic monitors, or other medical personnel present. (Steadman, 2006)

Studies have shown that SBL is superior to PBL. (Seybert, 2012) In a study by Seybert and colleagues, SBL provided improved acquisition of assessment and management skills compared with PBL in medical students. (Seybert, 2012) In recent years, many health science programs, including pharmacy and medical schools, have adopted SBL as a tool to provide students with real-life scenarios to enhance their knowledge and comprehension of the didactic material. The majority of these studies published regarding SBL have focused on high-fidelity based simulations (HFS). HFS involves either actors who portray patients and healthcare professionals or simulation mannequins that would provide a real-life experience. (Tofil, 2010) HFS has been shown to be an effective tool for not only training and assessing learning and clinical performance, but also has been shown to reduce medication errors. (Sarfati, 2019 and Yang, 2019) HFS can include the use of computerized mannequins or real patients to provide students with an ability to manage a patient in real-time, which is as close as one can get to the clinical setting. (Seybert, 2012) Few studies have been conducted focusing on HFS in pharmacy students, but of the data that has been collected, HFS has shown benefit in knowledge and application skills. (Tofil, 2010)

There is limited data on the benefit of low-fidelity simulation (LFS) utilization in health science programs, specifically Doctor of Pharmacy (PharmD) programs. LFS is a form of simulation that is typically static and can either be electronic or on paper. LFS removes factors that the user may experience if they were in a real-time setting. (SIMStaff Technical Services, 2022) In one trial conducted by Massoth and colleagues, the authors determined that HFS proved not superior to LFS. In fact, HFS led to equal or worse outcomes in performance and gross knowledge compared to LFS and led to overconfidence in medical students. (Massoth, 2019) Benefits of LFS include more cost effective, easier to conduct, and real-time experience for students. The aim of this study was to determine if LFS improves application and comprehension of 5 major disease states (myocardial infarction, heart failure, hypertension, dyslipidemia and atrial fibrillation) in a cardiovascular pharmacotherapy course pre-simulation activity versus post-simulation activity and impact on course quizzes, exams and overall grades.

Methods

This IRB approved study took place at Wingate University School of Pharmacy in Wingate, North Carolina. Students enrolled in the Cardiovascular Pharmacotherapy course during their P2 year (Class of 2023 and 2024) or P1 year (Class of 2025) for the first time were included in this study. Topics focused on in this study included hypertension, dyslipidemia, myocardial infarction, heart failure and atrial fibrillation. A total number of 234 students were included in the study. Students completed practice quizzes on the learning management system prior to four exams in the cardiovascular course. Practice quiz questions were linked to exam questions by the concept covered in each question by the Cardiovascular Pharmacotherapy course coordinator to ensure consistency in matching. Practice quizzes (written as exam level questions) were available to students after a lecture topic was covered in class and were intended to be self teaching with feedback given on both the correct and incorrect answers. Students had unlimited attempts to take each quiz to master the material before the exam on the topic; however, only the first attempt was used in the data analysis. Quizzes included a variety of exam

type questions which allowed the students to better prepare for the examinations. Not all quizzes had the same number of questions per disease state topic. Students then completed a total of three examinations in ExamSoft. Each examination included multiple choice questions and 1-2 patient cases (essay format) for one or more of the disease states focused on in this study.

Near the end of the course, the students completed a SIM lab exercise using a DecisionSIMTM case written by the Cardiology pharmacology faculty. The SIM lab exercise was developed to engage the students in all 5 disease states and intentionally walk them through a real-life patient scenario. Students were blindly paired according to course grades prior to the activity, with the strongest students intentionally paired with the weakest students to provide additional teaching and learning opportunities. The SIM lab exercise leads the students through a case in both free answer and multiple choice format, allowing the students to “guide” the treatment path for the patient. Student answers are recorded for the case to allow the faculty to see what was known, learned and enriched during the activity. These questions were matched in content to corresponding final exam content to evaluate how the SIM lab activity influenced final exam grades. For both simulation exercises, pre- and post-simulation grades between the quizzes or SIM lab and exams were compared to determine if there was improvement in student performance.

The students’ information was de-identified and then data was collected from the learning management system, ExamSoft and Decision SIMTM software. The rights and welfare of participants were protected by safeguarding all information under one link on a password protected Excel spreadsheet on a password protected computer. The data included quiz scores and test results from the P1 class of 2025, P2 class of 2024 and P3 class of 2023. The P3 class was the control group; data included quiz grades as well as final exam grades.

Statistical Analysis

To determine the percentage correct of exam questions, an Excel spreadsheet was created for each practice quiz. The spreadsheet was filtered to show the first quiz attempt and quiz questions that were matched with exam questions. Corresponding quiz and exam questions were paired by student ID and then coded as correct or incorrect. Students who answered the exam question correctly were coded as a yes (y) or maintain (m), depending on what answer they gave for the corresponding quiz question. These were then combined to give the percentage correct of exam answers. Students that answered incorrectly were coded no (n) and not included in the percentage. This process was repeated for each quiz and exam for the 3 years of data.

A similar process was used for the SIM lab to final exam question comparison. An Excel spreadsheet was created for the final exam questions, which was filtered to only the questions that were matched to a SIM lab question. The corresponding SIM lab answers were paired by student and coded as correct or incorrect. Students who answered the final exam question correctly were coded as a yes (y) or maintain (m) as above. These were then combined to give the percentage correct of final exam answers. Students that answered incorrectly were coded no (n) and not included in the percentage. This process was repeated for each SIM lab and final exam for the 2 years of available data.

Descriptive statistics were used to describe the continuous variables with normal distributions that were presented as mean. Additionally, an overall mean for percentage correct across all 5 cardiovascular topics was calculated for each class year to assess for overall trends. No other statistical analysis was performed due to the small sample size. Data was then analyzed by topic and year to determine whether practice quizzes or the SIM lab case had the largest effect on exam performance.

Results

The 3 classes involved in the study were all assessed for improvement on exam questions using practice quizzes. This information is shown in Table 1. The percentage correct of exam questions were similar between classes, with a mean of about 72% correct exam question answers. Consistent improvement with similar outcomes for each class helps validate the use of practice quizzes as an active learning activity.

Table 1. Percent Correct on Exam Questions by Linked Content to Practice Quizzes

	HTN	DLD	IHD	HF	A Fib	Mean % correct
Class of 2023	65.6	61.8	71.2	80.4	74.7	70.7
Class of 2024	70.0	77.1	65.3	80.0	63.6	71.2
Class of 2025	70	N/A	69.4	81.5	73.4	73.5

HTN: hypertension; DLD: dyslipidemia; IHD: ischemic heart disease; HF: heart failure; A Fib: atrial fibrillation; N/A: not available

SIM lab exercise answers were compared to matching content on final exam questions and produced the data found in Table 2.

Table 2. Percent Correct on Final Exam Questions by linked content to SIM Lab case*

	HTN	DLD	IHD	HF	A Fib	Mean % correct
Class of 2024	88.5	41.4	66.7	92.3	92.8	76.3
Class of 2025	47.1	33.3	36.4	76.8	71.0	52.9

*Class of 2023 data unavailable

HTN: hypertension; DLD: dyslipidemia; IHD: ischemic heart disease; HF: heart failure; A Fib: atrial fibrillation

These results were surprising, as they were not similar or linear as compared to the practice quizzes. The class of 2024 improved in 4 of the 5 content areas on the final exam after the SIM lab case, with only the dyslipidemia content not showing improvement. Additionally, mean percent correct answers on the 5 studied disease states in final exam questions was 76.3%. However, the class of 2025 clearly did not have the same results from the SIM

lab activity with a mean percent correct of 52.9%. All of the disease states performed worse on the final exam than the practice quizzes, indicating the SIM lab case was not as helpful to this cohort. Unfortunately, the class of 2023 (the control group for the quizzes) was not able to be used as a cohort for the SIM lab exercise due to non-recording of case answers.

Types of questions answered incorrectly on the exams were reviewed as well to look for trends in the data. These results revealed that students consistently missed questions on pathophysiology, pharmacology, major parts of treatment plans and monitoring. Additionally, students did poorly on the calculation of the CHA₂DS₂-VASc score for patients with atrial fibrillation. Upon reviewing quizzes and SIM lab responses, these question types were also missed in those content areas.

Discussion

This study showed the impact of two different types of active learning on final exam grades. Both practice quizzes and the SIM lab case impacted exam questions in a positive manner. With the mixed results of this study, it can not be concluded that one approach is better than the other to improve exam question performance and may be learner specific which is beyond the scope of this study. It appears that some types of active learning work better for some students than others, suggesting different learning styles, so offering multiple types of engagement, including LFS over the semester should be used to engage all students. The disease states chosen for this study are the most common disease states seen in clinical practice and chosen for this reason. The students will encounter these disease states frequently on their future experiential rotations in their 3rd and 4th years of Wingate's PharmD program.

This study has several limitations. First, it was performed during the modernization of the curriculum at the pharmacy school, where the Cardiovascular Pharmacotherapy course was changed from a 10 week therapeutics focused course in the Fall of the second professional year to a 15 week integrated course of anatomy/physiology, pharmacology and therapeutics in the Spring of the first professional year. The class also increased credit hours from 3 to 6 with the curricular integration. This could be argued as a benefit by some, as the class is now integrated and all cardiology material is taught at one time in one integrated course. This change has caused the faculty members to focus on essential material because of the time all of the integrated material takes to cover. However, this information can be overwhelming to a struggling first year professional student, as this is the first class of this type in the modernized curriculum, so it does take some time for students to adjust to the volume and speed of the course.

Additionally, the study habits of students in the first vs. second professional year of pharmacy school are generally very different, which could have a large impact on the mixed results of the study. Another limitation of the study is guideline changes are constant in cardiology, so questions could not be consistent for the 3 years of the study, as almost all guidelines of the 5 disease states have had at least some minor updates and/or major overhauls to the guideline directed medication therapy. Therefore, not all practice quiz questions and SIM lab case answers had a corresponding match on exam questions.

Another limitation was the lack of providing dyslipidemia practice quiz questions for the class of 2025. This was an oversight on both the professor teaching the material and the course coordinator during the semester. Thus, there was no practice quiz improvement calculation for this class provided in Table 1.

Timing may also be a limitation for this study, as the SIM lab case was an in-class opportunity near the end of a long and tiring semester in order to integrate all of the disease states. The students completed the case in matched pairs or groups, with the students unaware of how the groups were composed. This gives an advantage of “group brain thinking” to SIM lab case answers that were recorded for the study. Additionally, students were aware the case was not graded for accuracy at that time. This may have led some students to perform at a lower level as the evaluation was only for completion. The students could repeat the activity on their own after class, but there was less than a week to practice with the SIM lab case prior to the final exam.

The practice quizzes were available on an unlimited time frame after the topic was covered in class. The students could repeat the quizzes as many times as they wanted and continue to get feedback on their answers with each quiz question answered. This may help explain why quizzes had more effect on exam outcomes than the SIM lab, especially in the first professional year students (class of 2025) results. Additionally, the course was spread to 15 weeks instead of the 10 weeks with the first two groups, giving the students 5 additional weeks of time to forget material or have to remember it longer with all the other additional information that is being taught at the same time. This time factor may help explain why hypertension and dyslipidemia performed so poorly on the final exam, as they were the first therapeutic topics covered in the course.

Review of questions types missed gives valuable information to faculty teaching in the course. Although it is not helpful in this research, the information obtained will be used by all professors in the course to continue to emphasize this material in lecture, practice with more active learning cases, and other techniques such as simulation both in and out of the classroom. For example, students struggled with the concept of preload and the Frank Starling mechanism in patients with systolic heart failure. To improve comprehension of this concept during the upcoming course, rubber bands of different caliber (representing heart stretching fibers and amount of heart failure present) will be shot at a target by student volunteers. All students will easily be able to see the “stretchy” rubber bands will travel a further distance; therefore, they have more capacity to move additional blood volume through the heart.

LFS may be viewed as a limitation in active learning techniques, as it is not as popular as HFS. Nevertheless, LFS is certainly a much more affordable option for smaller schools that do not have the budget or manpower to use HFS efficiently or effectively. The students involved in this study viewed the LFS simulation as very positive with comments given such as “great review and way to make us think critically” and “loved choosing the therapy path for the patient, able to put my clinical knowledge to work”. The LFS case used for this study mirrored a real life clinical situation and was specifically crafted to challenge students with exam level questions and concepts. Not only should this experience improve final exam performance, it should also help prepare students for situations they may see on experiential rotations and in real life as a pharmacist.

Conclusions

Simulation, in any form, adds to the available active learning techniques to enhance didactic learning in the classroom. HFS and LFS are often used to practice in the didactic setting before clinical rotations. In this study the LFS case and the practice quizzes were well received by the study participants and both have been requested to be used even more in the future. There is a paucity of literature published to date in the health sciences literature on the use of LFS; therefore, this study adds to the body of evidence to support learning via simulation.

The vast use of simulation in professional schools is an untapped area of study. Massoth and colleagues found that simulation was not correlated to outcomes in medical students on rotations. (Massoth, 2019) There is no evidence of this same investigation in PharmD students using any kind of simulation. Therefore, additional studies need to be completed over a longer time span to determine if the LFS made an impact on either Introductory Practice Pharmacy Experiences (IPPE) in the third year or Advanced Practice Pharmacy Experiences (APPE) in the fourth year of the PharmD program. Additionally, within the modernized curriculum, HFS should be explored. With more opportunities for learners to engage in real-life situations prior to experiencing them, simulation labs are becoming more popular for providing these learning opportunities.

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