INSTRUCTIONAL DESIGN AND ASSESSMENT

Virtual Patient Case Sharing Across Two Schools of Pharmacy

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Objective. To expand the use of virtual patients at 2 schools of pharmacy through virtual patient case sharing.

Design. Faculty members at two schools of pharmacy collaborated to expand the use of virtual patients. Two simulation programs, vpSim and DecisionSim (Decision Simulation, LLC, Chadsford, PA), were used to create interactive patient cases for a required course and an elective course at the different schools. Each school developed cases for their own use and then shared the cases with the other school.

Assessment. The development, sharing, and subsequent modification of cases were examined using a standardized data collection form completed by both schools. Survey instruments were used to gather data regarding faculty perception and student satisfaction. Pre- and post-tests were administered to assess student learning. Five cases were developed and shared between the institutions. The time spent constructing new cases (22 hours/case) was significantly longer than the time spent modifying the shared cases (1.2 hours/case). Faculty members and students were largely satisfied with case sharing and the use of virtual patient cases, respectively. Virtual patients significantly enhanced student learning of material (mean score: 3.2 vs 3.6 on a 5-point scale).

Conclusions. The sharing of virtual patient cases may allow institutions to overcome barriers to implementation of virtual patient programs, namely faculty resources, while improving student learning and satisfaction.

Keywords: virtual patients, case sharing, simulation

INTRODUCTION

Educational technologies including computer-aided instruction, virtual patients, and mannequin model simulators are supported by pharmacy education accrediting bodies and widely used in pharmacy schools.[1-5] Virtual patients in particular have been used to help students develop the requisite knowledge and skills of the medical profession through independent, practical repetition, while providing educators with a means of granting student access to real patients.[4,6,7] Virtual patient technology is flexible in that it can be used across courses and disciplines and in a variety of teaching strategies. It allows students to emulate healthcare practitioners in a hospital environment without the risk of patient harm, and provides learners with immediate and specific feedback based on their performance.[8,9]

Despite these advantages, several obstacles limit the widespread adoption of virtual patients in pharmacy curricula.[10] Namely, the use of virtual patients can be resource intensive, requiring both monetary investment and faculty time. Licensing fees to access virtual patient software platforms can be as high as $75 per student and $1100 per author per year.[11] Additionally, faculty time invested in case design and development has been reported to be as high as 50 to 100 hours per case.[4,12-14] As a result, it is likely that collaborative development and use of virtual patient cases is necessary for further implementation and integration in pharmacy curricula in order to offset the time and monetary restrictions to single institutions. The sharing of virtual patients using a similar system has been proposed; however, data regarding the implementation of sharing across any health profession does not exist.[15-17] This project details the design, development, implementation, and evaluation of a collaborative effort between two schools of pharmacy to overcome the monetary and time commitment obstacles associated with virtual patient simulations in order to expand virtual patient use by students.

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DESIGN

Faculty members of the Philadelphia College of Pharmacy (PCP) and the University of Pittsburgh School

of Pharmacy collaborated to expand the use of virtual patients in each school's curriculum. The goals of case sharing were to (1) maximize the return on investments of purchasing virtual patient software licenses by expanding each university's case library; (2) maximize faculty time investments in the development of virtual patient cases as 2 cases were gained for every 1 developed through case sharing; (3) to improve the validity and fidelity of the virtual patient cases through a peer-review process of the virtual patient cases and (4) ensure student learning of case material. Objectives developed to realize study goals were to (1) design virtual patient cases to satisfy course needs, (2) share completed virtual patient cases with a second school of pharmacy, (3) edit and modify shared cases to coincide with content and pedagogical needs, (4) integrate cases into the curriculum and provide case feedback to the second school of pharmacy, and (5) assess student learning.

Faculty used virtual patient software (vpSim/DecisionSim, Decision Simulation, LLC, Chadsford PA) to achieve the project goals. Virtual patient cases developed through the vpSim/DecisionSim platform make use of a "branched-narrative" model, in which learners are presented with a challenge and given choices, and then provided with a consequence specific to their choice. Use of this model allows learner input to directly affect the outcomes of the virtual patient, where appropriate recommendations will improve the simulated patient's condition and suboptimal recommendations will worsen it. In this platform, students become healthcare providers, making recommendations in authentic clinical scenarios. A more detailed description of this platform has been published.[18] Public cases and further information also can be found at http://vpsim.pitt.edu/.

Three virtual patient cases were developed at PCP for use in a critical care therapeutics elective course offered to third-year (P3) pharmacy students. The critical care therapeutics elective is a team-taught, 2 credit-hour course offered to 24 P3 students each semester. The aim of the course is to educate students on the pharmacotherapeutic management of critically ill patients through a combination of classroom teaching sessions and patient case applications. All 3 of these cases were shared with the University of Pittsburgh. Faculty members at the University of Pittsburgh had previously built cases that had been used in a P3-required therapeutics course. Advanced Pharmaceutical Care is a team-taught, 3 credit-hour required course offered to P3 students. The course provides students with an understanding and appreciation of the challenges of providing pharmaceutical care to critically ill patients, as well as those with acute and chronic kidney disease. Three cases were shared with PCP. Faculty members at each school then uploaded, reviewed, edited, and modified the shared cases to better fit their pedagogical constructs and content requirements.

Faculty developed virtual patient cases from predefined learning objectives for their course content (Table 1). Each case was then saved in an xml file and shared via email with the other institution. The shared case was then modified to fit the content of the course in which it was to be used. During the modification process, peer-review of the cases was performed and provided to the original authoring institution. The peer-review process was used to help ensure the validity of the cases and was completed by a content expert and virtual patient expert at each institution. Feedback regarding the cases was aimed at content, pedagogical application, and style.

The peer-review process emulated that of manuscript review. The cases were then implemented at each institution separately. Both schools used the cases as supplements to classroom teaching sessions; PCP used the virtual patients in an elective course and the University of Pittsburgh used the cases in a required course. Both institutions obtained institutional review board approval for this project. Descriptive statistics, Mann-Whitney U (to compare median time of case construction and modification), and chi-square tests

Table 1. Examples of Virtual Patient Cases Created by Two Institutions

Case and Predefined Learning Objectives
ICU hyperglycemia case developed by the University of Pittsburgh
Identify patient-specific factors that should be considered before transitioning from intravenous insulin continuous infusion to subcutaneous insulin in a critically ill patient.
Recommend a strategy to transition from intravenous to subcutaneous insulin in a critically ill patient.
Recognize risk factors for hypoglycemia in a critically ill patient.
Sepsis case developed by the University of Pittsburgh
Prioritize fluid resuscitation and appropriate vasopressor use using an "Early Goal Directed Therapy Model" for septic shock.
Explain mechanism of action for select vasopressor agents, as well as mechanisms for adverse events.
Evaluate risk factors for critical illness related corticosteroid insufficiency (CIRCI) given a patient case, then formulate a patient specific treatment regimen for CIRCI.

(to compare pretest and posttest scores) were calculated using SPSS Statistics, version 21 (IBM, Armonk, NY).

EVALUATION AND ASSESSMENT

A survey was developed by investigators to collect information relating to case design, case editing, and faculty satisfaction (Appendix 1). The faculty survey was developed to capture the process of case building, sharing, and modification from beginning to end. It was also designed to encompass faculty satisfaction across the various steps of this process. Faculty members involved with the development and/or modification of virtual patient cases were asked to complete the survey (Table 2). Student satisfaction of the learning experience was also assessed using a survey instrument, which was administered at each institution. The results are reported in aggregate in Table 3. Pre- and postsimulation questions were administered to students at the University of Pittsburgh immediately before and after the virtual patient case on sepsis to ensure student learning, but scores were not included in calculating course grade. Questions were not identical from pre- to posttest, but were similar in content and level of difficulty (questions available upon request). To accomplish this, all pre- and posttest questions were constructed from learning objectives developed for the virtual patient case (Table 1). Face validity of the questions was established by course faculty members who served as content experts. Regarding level of difficulty, consensus was achieved by the content experts based on Bloom's taxonomy learning activity levels.[19]

Case development took approximately 112 hours to complete 6 cases (median 22 hours/case). Each case had 3 to 5 learning objectives (median 4). The structure of the cases was determined to be linear (n=1), branched (n=4), and branched-linear (n=1). The average number of nodes (ie, screens) per case was 72.2. Each case included gamification strategies such as visible point scoring and rules developed within the cases to route the student down the learning path consequential to their decisions. Case editing took approximately 8.8 hours to complete 5 cases (median 1.16 hours/case). Editing and use of 1 of the cases took place after the end of the academic year. The edit types included but were not limited to: style/preferences edits (eg, medications on formulary at hospitals local to each institution), clinical application changes (eg, updates to evidence or different hospital policies), and learning objective alignment (eg, making case more applicable to specific class). Each case allowed for opportunities for student repetition. Case modification took significantly less time to complete than building a new case ($p<0.05$).

Three faculty members involved in the design and integration of the virtual patients were surveyed. All faculty members agreed or strongly agreed that case sharing allowed for the use of more virtual patient cases and a better return on investment, and took minimal time and effort. Faculty members also agreed that case editing allowed for easy customization, that the peer review process was helpful in improving cases, and that they would continue to participate in case sharing moving forward. Two faculty members indicated that the case sharing process does not require significant improvement for future use, case editing required minimal time and effort, and that case sharing allowed for critical and valuable peer review. Faculty reported mixed results for providing the other authors with timely and constructive feedback (one response each for strongly agree, agree, and neutral).

Students at both institutions recorded positive responses to the satisfaction survey (Table 3). The satisfaction survey response rate was approximately 77% (101 to 102 students out of a possible 131). Ninety-one percent to 96% of students agreed or strongly agreed that the cases they completed were effective for clinical application of knowledge. Seventy-six percent of the students who responded to the survey stated they agreed or strongly agreed that virtual patient cases should be used in all clinical required courses. Additionally, students reported that they enjoyed using the cases (97% agreed or strongly agreed), the content was appropriate (93% agreed or strongly agreed), and that their learning was enhanced

Table 2. Faculty Survey Data on the Development, Modification, and Implementation of Virtual Patient Cases

Case Name	Pain, Agitation, Delirium	Sepsis	ICU Prophylaxis	Hemodynamics	ICU Hyperglycemia
Case construction time (hours)	30	16	24	20	22
Case structure	Branched	Branched	Branched	Branched-Linear	Linear
Nodes per case	95	50	130	33	53
Student repetition opportunity	Y	Y	Y	Y	Y
Case Editing					
Editing time (hours)	4.5	1.16	0.83	1.25	1.08
Student repetition	Y	Y	Y	Y	Y

Table 3. Student Perceptions of Virtual Patient Cases

	N	Strongly Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)
The virtual patient cases I used were effective for allowing me to practice clinical applications in:						
Pain, agitation, and delirium	101	0	1	3	41.6	54.5
Sepsis	102	0	1	3.9	26.5	68.6
Advanced hemodynamics	101	1	2	5.9	29.7	61.4
ICU hyperglycemia	102	0	1	4.9	28.4	65.7
ICU prophylaxis	101	1	1	5	30.7	62.4
Virtual patient cases should be used in all clinical required PharmD courses	102	2	4.9	17.6	36.3	39.2
I enjoyed using virtual patient cases in this course to help me learn	102	0	0	2.9	25.5	71.6
Content of the virtual patient cases were appropriate for my level	102	0	0	6.9	40.2	52.9
Virtual patient cases enhanced my learning of material in this course	102	0	0	1	20.6	78.4

by the use of virtual patients (99% agreed or strongly agreed). The average score on the pretest was 3.2 (out of a possible 5) and was completed by 67 out of 109 students (61% response rate). The average score on the posttest was 3.6 ($p<0.05$). Cases were used as lecture supplements, with a majority of students completing the virtual patient cases within 10 to 20 minutes.

DISCUSSION

Through the design, development, and integration of a virtual patient case sharing at 2 schools of pharmacy, we have achieved study objectives. Three cases that were developed to meet the content and pedagogical needs of each institution were developed and integrated into their respective curricula. These cases were developed from predefined learning objectives; included branching, gamification, and student repetition opportunities; and took over 20 hours to create.

These cases were then shared with another school of pharmacy, whose faculty members were able to modify the cases not only to meet their individual course needs, but also to provide meaningful feedback on the shared cases. Because the development of new cases took a significantly greater amount of time than modification of a shared case (22 hours vs 1.2 hours), faculty members were able to maximize the amount of time they invested in virtual patient case development. Also, editing of cases through peer review allowed for improved validity and fidelity of all cases. We were able to critique and enhance cases, thereby improving the student experience.

The use of technology in higher education is expanding; however, significant barriers to implementation remain, especially in the face of rising costs and faculty time constraints.[3,20] We demonstrated the ability to minimize financial and faculty workload barriers, while improving case content, flow, and student usability. One university had significant experience with using virtual patients and wanted to build upon their case library so they would have more virtual patients to use. The other university had little experience with using virtual patients and wanted to demonstrate the utility of adding virtual patients to their curriculum. The use of the shared virtual patient cases was flexible, with each institution integrating the cases in different courses, with different numbers of students, and for different purposes. Students at both schools indicated that the cases were enjoyable, effective, and should be further implemented. Assessment of student learning was completed with one case as to not overburden the students with assessments. As with previously published literature, the use of virtual patients improved student learning.[4,6-8,21]

The financial burden of purchasing virtual patient software licensing was lessened through the implementation of a greater number of cases than would have been possible without the case sharing. Although the costs of virtual patient programs may seem significant, sharing virtual patient cases helps to maximize return on investment, as faculty members gained 2 cases for every 1 developed. Upfront faculty time commitment to the development of a virtual patient case can be significant. We report here that it takes approximately 22 hours of faculty time for the development of a case. When sharing virtual cases, faculty resources are spread among all developers and the modification of cases took significantly less time. Additionally,

because future use of the preexisting cases now only will require updates, the faculty burden will be decreased with each subsequent use of the cases.

The case sharing data presented has limitations that should be noted. First, student learning data were collected only at 1 institution and for 1 case (ie, sepsis) because of course management and student availability issues; however, virtual patient technology has already been shown to improve student learning.[4,6-8,21] Second, the faculty survey data were derived from a small number of faculty members because the sharing strategy is relatively new and in early adopter phase. Future work on case sharing will involve more students, more cases, and more schools. The focus of this project was to highlight the feasibility and acceptability of case sharing. While the educational impact of virtual patients in higher education has been established, impact on learning regarding case sharing will need to be further studied.

The initial phase of sharing virtual patient cases was deemed to be successful at each institution based on the return on investment, faculty derived feedback, and student experience. Further iterations of case sharing should include a case summary describing the case and significant student decision points to help institutions better understand the case prior to sharing. Additionally, a set timeline for development and feedback may be beneficial to institutions looking to implement cases during a certain timeframe.

SUMMARY

The use of virtual patients in pharmacy education is growing rapidly, despite several barriers to implementation. Sharing of cases encourages collaboration among institutions as they work together to improve pharmacy education, minimizes barriers to implementation, allows for a peer-review process, and preserves student satisfaction and learning. Pharmacy educators should consider the use of virtual patient case sharing among institutions to maximize resources and the efficiency of pedagogical design.

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REFERENCES

1. Medina MS, Plaza CM, Stowe CD, et al. Center for the Advancement of Pharmacy Education. Educational Outcomes 2013. *Am J Pharm Educ.* 2013; 77 (8) Article 162.
2. Accreditation Council for Pharmacy Education. Accreditation standards and guidelines for the professional program in pharmacy leading to the doctor of pharmacy degree. http://www.acpe-accredit.org/pdf/ACPE_Revised_PharmD_Standards_Adopted_Jan152006.pdf. Accessed August 2, 2013.
3. AAMC Institute for Improving Medical Education. Effective use of educational technology in medical education. Colloquium on educational technology: recommendations and guidelines for medical educators. March 2007. https://members.aamc.org/eweb/upload/Effective%20Use%20of%20Educational.pdf. Accessed August 12, 2013.
4. Benedict NJ, Schonder K. Patient simulation software to augment an advanced pharmaceutics course. *Am J Pharm Educ.* 2011;75(2): Article 21.
5. Monaghan MS, Cain JJ, Malone PM, et al. Educational technology use among US colleges and schools of pharmacy. *Am J Pharm Educ.* 2011;75(5):Article 87.
6. Orr KK. Integrating virtual patients into a self-care course. *Am J Pharm Educ.* 2007;71(2):Article 30.
7. Triola MM, Feldman H, Kalet AL, et al. A randomized trial of teaching clinical skills using virtual and live standardized patients. *J Gen Intern Med.* 2006;21(5):424-429.
8. Cook DA, Triola MM. Virtual patients: a critical literature review and proposed next steps. *Med Educ.* 2009;43(4):303-311.
9. Tworek J, Coderre S, Wright B, McLaughlin K. Virtual patients: ED-2 Band-Aid or valuable asset in the learning portfolio? *Acad Med.* 2010;85(1):155-158.
10. Greenberg AD. Wainhouse Research whitepaper. Blended learning technology: navigating the challenges of large-scale adoption. Duxbury, MA: Wainhouse Research; 2012
11. Decision Simulation. DecisionSim Institutional License Price List 2014.
12. Benedict NJ, Schonder KS, McGee JB. Promotion of self-directed learning using virtual patient cases. *Am J Pharm Educ.* 2013;77(7):Article 151.
13. Battaglia JN, Kieser MA, Bruskiewitz RH, Pitterle ME, Thorpe JM. An online virtual-patient program to teach pharmacists and pharmacy students how to provide diabetes-specific medication therapy management. *Am J Pharm Educ.* 2012;76(7): Article 131.
14. Al-Dahir S, Bryant K, Kennedy KB, Robinson DS. Online virtual-patient cases versus traditional problem-based learning in advanced pharmacy practice experiences. *Am J Pharm Educ.* 2014;78(4):Article 76.
15. Triola MM, Campion N, McGee JB, et al. An XML standard for virtual patients: exchanging case-based simulations in medical education. *AMIA Annu Symp Proc.* 2007;741-745.
16. Zary N, Johnson G, Boberg J, Fors UGH. Development, implementation and pilot evaluation of a Web-based virtual patient ase Simulation environment – Web-SP. *BMC Med Educ.* 2006;6 (1):10.
17. Smothers V, Greene P, Ellaway R, Detmer DE. Sharing innovation: the case for technology standards in health professions education. *Med Teach.* 2008;30(2):150-154.
18. Benedict N. Virtual patient and problem-based learning in advanced therapeutics. *Am J Pharm Educ.* 2010;74(8):Article 143.
19. Bloom BS. *Taxonomy of Educational Objectives*. Boston, MA: Allyn and Bacon; 1984.
20. Ellaway R, Poulton T, Fors U, McGee JB, Albright S. Building a virtual patient commons. *Med Teach.* 2008;30(2):170-174.
21. Smith MA, Mohammad RA, Benedict NJ. Use of virtual patients in an advanced therapeutics pharmacy course to promote active, patient-centered learning. *Am J Pharm Educ.* 2014;78(6):Article 125.