American Journal of Pharmaceutical Education **2012; 76 (4) Article 67.**

INSTRUCTIONAL DESIGN AND ASSESSMENT

Evaluation of Pharmacotherapy Laboratory Revisions Implemented to Reduce Cost

Casey Gallimore, PharmD, Susanne G. Barnett, PharmD, Andrea L. Porter, PharmD, and Karen J. Kopacek

University of Wisconsin-Madison School of Pharmacy, Madison, WI

Objectives. To revise a pharmacotherapy-laboratory curriculum to decrease course expenditures while maintaining a quality educational experience.

Design. Course mapping identified laboratory activities that achieved the defined learning outcomes. Redundant activities were eliminated, and remaining activities not requiring active in-laboratory participation were converted into prelaboratory assignments and simulations. An online course-management system provided a platform for simulations and automated grading.

Assessment. An evaluation of economic data showed a 64% and 43% decrease in total course expenditures for Pharmacotherapy Laboratory III and IV, respectively. Although a comparison of examination and course grades before and after redesign revealed a small decrease in grades for the Pharmacotherapy III and IV course, the reasons for this decrease were unclear and could not be directly attributed to the redesign. Comparison of students' evaluation scores before and after the redesign showed continued high satisfaction with the course.

Conclusions. Revisions made to the curriculum for a pharmacotherapy laboratory decreased course expenditures while maintaining the quality of education. The successful redesign was related to several key components including course mapping and enhanced use of technology. A similar revision process can be considered by other colleges and schools of pharmacy facing budgetary reductions.

Keywords: pharmacotherapy laboratory, cost reduction, course mapping, curriculum

INTRODUCTION

Many states are facing budgetary shortfalls, requiring funding cuts for higher education.[1] According to the Center for the Study of Education Policy, the national average reduction in state funding for higher education during 2009-2010 was 3% to 4%, with some states reporting reductions greater than 20%.[1] For colleges or schools that receive state funding, these cuts often necessitate curricular changes or reductions in faculty and/or staff members to meet budget constraints.

Institutions of higher education in Wisconsin were not immune to budgetary cuts during this time, with average reductions in state funding above the national average (6.7% vs 3.4%, respectively).[1] Reductions in state funding for the University of Wisconsin System's biennial budget for 2009-2011 was projected to be $174 million.[2] In light of upcoming fiscal restraints, faculty members at the University of Wisconsin-Madison were asked to review current courses for possible ways to reduce expenditures without affecting the quality of student education and training.

The doctor of pharmacy (PharmD) curriculum at the University of Wisconsin-Madison School of Pharmacy is a 4-year program that admits approximately 140 students annually. A required 4-semester pharmacotherapy sequence is scheduled during the second (P2) and third (P3) years of the program. Each semester of pharmacotherapy is assigned 4 credits and includes 4 lectures and 1 laboratory session per week. The laboratory portion of the course is designed to provide students with practical application of lecture material. Each semester of pharmacotherapy laboratory is designed to build upon and enhance the skills and knowledge gained in previous semesters. The laboratory portion of the course is made up of 5 sections of 21 to 28 students, each of which meets daily for 3 hours for 12 to 14 weeks per semester. Instruction is provided by pharmacy practice faculty members (lecturing faculty members and the laboratory coordinator) and residents. Unfortunately, the cost and faculty time associated with a pharmacy laboratory course are significant, particularly with respect to supplies and teaching staff. In response to the reductions in the 2009-2011 biennial budget, the pharmacotherapy laboratory coordinators accepted the challenge of revising the 4-semester

Corresponding Author: Casey Gallimore, PharmD, University of Wisconsin-Madison School of Pharmacy, 777 Highland Avenue, Madison, WI 53705-2222. Tel: 608-890-1916. Fax: 608-265-5421. E-mail: cgallimore@pharmacy.wisc.edu

pharmacotherapy laboratory course to reduce expenditures and improve efficiency.

Other faculty members facing similar challenges with course redesign have used The National Center for Academic Transformation (NCAT) to facilitate necessary changes. Since 1999, NCAT has assisted colleges and universities with redesigning learning environments to reduce expenditures and enhance student learning.[3] Course redesign incorporating instructional technology is the key to achieving these outcomes. Examples of cost-reduction strategies recommended by NCAT include eliminating duplication of faculty efforts, substituting less-expensive instructional staff members when appropriate, and using online tools (eg, tutorials, assessments, and course management systems).[4] We hypothesized that enhancing the instructional technology used in the pharmacotherapy laboratory with new online tools would meet the overall goal of improved efficiency. The online tools selected would also need to support laboratory activities that involve critical thinking and promote self-directed learning in accordance with the Accreditation Council for Pharmacy Education (ACPE) standards and the 2004 Center for the Advancement of Pharmaceutical Education (CAPE) Educational Outcomes.[5,6]

Only 1 article was found in the health-sciences education literature describing the process and results of decreasing course expenditures by incorporating instructional technology.[7] This course was a pediatric-pharmacotherapy elective course taught at remote campuses and did not include a weekly laboratory component. There is a need for information on how laboratory-based courses can reduce cost and maintain quality educational experiences while achieving learning objectives. The objectives of this study were to: (1) describe the key steps taken by faculty members to redesign a 4-semester pharmacotherapy laboratory course to accommodate state budget reductions, (2) evaluate the effect that the course redesign had on student performance, and (3) assess student feedback on the use of online tools for laboratory assignments.

DESIGN

During the summer of 2009, the pharmacotherapy laboratory coordinators initiated a laboratory course redesign to decrease the costs associated with weekly activities without compromising the quality of the educational experience. In order to decrease laboratory expenses, coordinators first identified all high-cost laboratory items and considered why each item was expensive. Items of highest cost included the funding of pharmacy-practice residents, the objective structured clinical examinations (OSCEs), and laboratory supplies. To ensure that the quality of the educational experiences provided in the pharmacotherapy laboratory was retained after the redesign, the coordinators identified and used learning objectives for each semester to map the entire pharmacotherapy-laboratory sequence. The use of mapping to design a new course and assess the achievement of specific curricular outcomes has been previously described.[8] Key learning objectives for laboratory were guided by the ACPE accreditation standards and CAPE outcomes (Table 1).[5,6]

Table 1. Pharmacotherapy Laboratory Course Learning Objectives

Improve application of clinical knowledge to solve health-related problems and promote health improvement, wellness, and disease prevention in cooperation with individual patients.
Gain a working knowledge of the pharmaceutical care process: gathering and evaluating information, formulating and implementing a plan, monitoring and modifying the plan, documenting care, and billing for medication therapy management services provided.
Become familiar with reference books, informatics, and other healthcare system resources to enhance drug information and therapeutic decision-making skills. Demonstrate good judgment in choosing appropriate references to provide medication information and counseling to patients, caregivers, and other healthcare providers.
Learn to prepare and model patient-medication consultations for a variety of therapeutic agents to aid patients in the proper use of their medications, related devices, and supplies. Develop good communication skills through simulated patient consultations. Evaluate personal communication and active-listening skills to enhance patient and other healthcare provider interactions. Acquire the necessary skills and experience to provide patient care as a member of an interdisciplinary team.
Develop an in-depth knowledge of commonly prescribed medications, including the names, strengths, therapeutic indications, and normal dosing regimens of the most widely prescribed commercial drug products.
Acquire strategies for making evidence-based decisions in drug product selection and use based on knowledge acquired through pharmacotherapy lectures and previous courses and instruction in legal standards established for therapeutic equivalence and brand-generic substitution.
Learn about patient medication profile systems and how to use them in performing medication reconciliation and medication-therapy management.
Develop skills and commitment for lifelong learning in order to maintain professional competence.

Existing activities were matched to the identified learning objectives to create the pharmacotherapy-laboratory course map.

Redesign ideas were developed comparing the identified high-cost laboratory items to the course map. The first revision focused on reducing the costs associated with resident teaching. Pharmacy practice residents function as laboratory instructors within the pharmacotherapy laboratory course and are reimbursed by the hour for teaching and grading time. The number of residents per laboratory section ranged from 1 to 4, depending on the number of laboratory activities and amount of grading. Rather than restricting the number of residents allowed to teach in the laboratory, coordinators decided to decrease the total number of teaching hours by reducing the length of each laboratory session from 3 to 2 hours. To shorten the length of the laboratory, coordinators reviewed the course map for each semester and eliminated activities that were a duplication of information presented in lecture or previous laboratory sessions. Coordinators then categorized the remaining activities as exercises that could be completed outside of the laboratory and those that required in-laboratory time for completion. Activities that required in-laboratory time involved pharmacy-practice simulations with real-time student feedback, hands-on product- or physical-assessment training, and patient-case discussions. Preparatory work or activities involving passive learning would be transitioned into pre- or post-laboratory assignments using Moodle (Moodle Trust, Western Australia), an online course-management system. Examples include virtual patient-case discussion questions; online tutorials, quizzes and worksheets; and electronically written subjective, objective, assessment plan (SOAP) notes. Automated or credit/no credit scoring would be used with many online assignments to reduce the amount of resident and coordinator grading time.

Laboratory revisions also focused on reducing the costs associated with OSCEs. A multistation OSCE was administered each semester of the pharmacotherapy sequence. Each examination was completed in a single 8-hour day outside of class and laboratory. The greatest OSCE-related expense was the reimbursement of standardized patients hired through the University of Wisconsin Clinical Teaching and Assessment Center. At least 8 standardized patients were trained to participate in each examination. Coordinators decided to eliminate the fall OSCEs and replace them with a performance-based assessment (laboratory practical examination) that would occur during the normally scheduled laboratory session and use residents in place of costly standardized patients. The laboratory practical assessment would be similar to OSCEs in that the examination would assess various pharmacy-practice skills but require fewer stations. The spring semester OSCEs would be retained and standardized patients hired for the examination.

Decreasing the cost of laboratory supplies was the final area for redesign. Supplies were used for hands-on training and testing of students and included pulmonary drug delivery devices, tobacco-cessation products, blood glucose testing supplies and glucometers, syringes and normal saline for injection training, and lipid testing supplies. Some items are donated by pharmaceutical manufacturers, but the majority must be purchased. Coordinators determined which products were necessary for development of essential practice skills and knowledge, which could be eliminated, and which could be substituted with a cheaper alternative. Hands-on training with devices such as pulmonary drug delivery devices, nonprescription smoking-cessation products, glucose testing supplies, and Cholestech LDX machines (Alere San Diego, CA) for lipid screening were deemed essential to student learning. However, the overall number of individual items purchased could be decreased by having students work in pairs or teams to train with a given product. The use of cheaper alternatives would also be used to simulate more expensive products. For example, a technician-prepared chemotherapy order could be simulated using normal saline and food coloring, then labeled and packaged with supplies donated by a local oncology pharmacy.

EVALUATION AND ASSESSMENT

Implemented laboratory revisions were expected to decrease course expenditures while maintaining quality educational experiences. This hypothesis was tested with outcome measures that included course expenditures, student academic performance, and student course evaluations.

The evaluation process focused on revisions made to the pharmacotherapy Laboratory III and IV, which occur, respectively, during the fall and spring semesters of the P3 year because of the availability of complete data sets from student evaluations and performance for that time period. The study received exemption status from the University of Wisconsin-Madison Educational Institutional Review Board. Data from 2 cohorts of P3 students in the 2007-2008 and 2009-2010 academic years were compared for all outcome measures. These cohorts were selected because 2007-2008 represents the last year prior to implementation of laboratory revisions, and 2009-2010 was the first year in which revisions were fully implemented. Additionally, because P3 students during 2009-2010 had completed pharmacotherapy Laboratory I and II during the year prior to the laboratory redesign, this

cohort of students was exposed to the laboratory experience prior to and following revisions. The academic year of 2008-2009 was not evaluated because revisions were not implemented until the spring semester of that year. Demographics at the time of admission into the PharmD program were similar between the 2 cohorts. The 2007-2008 group was 54.4% female with an average age of 22.5 years and an average grade point average (GPA) of 3.7. The 2009-2010 group had slightly more female students at 60.4%, but the average age of 22.9 years and GPA of 3.7 were comparable.

Economic data for the Pharmacotherapy Laboratory III and IV courses were used to compare course expenditures for the selected years (Table 2). Following laboratory revisions, total course expenditures decreased by $10,138 (64%) for Pharmacotherapy Laboratory III and by $5,601 (43%) for Pharmacotherapy Laboratory IV. Expenses in each semester's budget included duplicating/copying charges, student hourly-worker reimbursement, supplies, and items classified as "other" (resident reimbursement for instruction, standardized patient reimbursement, resource subscriptions, and miscellaneous OSCE/laboratory-practical items).

Student course evaluations, examination scores, and overall course grades from the Pharmacotherapy Laboratory III and IV courses were exported as unidentified aggregate data from the online course-management system. Given the laboratory functions to strengthen and build upon key pharmacotherapeutic principles introduced in lecture, the lecture component of the course did not change. Thus, it was reasonable to evaluate laboratory changes using examination and course grades. To evaluate the impact of revisions on student skills outside of the pharmacotherapy course, student performance on advanced pharmacy practice experiences (APPEs) was compared for the same 2 student cohorts (students in their P4 year during 2008-2009 and 2010-2011). This information was available as unidentified aggregated data in the Annual Report of the Quality Review Committee at UW School of Pharmacy. Differences in pre- and post-revision data were compared using a 2-sample *t* test.

Pharmacotherapy laboratory grades were not included as an outcome measure because changes in the laboratory-grading system were implemented as part of the revision process. This alteration reduces the validity of using laboratory performance as an outcome measure to assess the educational quality associated with revisions. Prior to revisions, the final pharmacotherapy laboratory grade was determined by prelaboratory and in-laboratory assignments graded on a point-based system. After the revisions, laboratory grading changed to a contract grading system with credit/no credit assignments. In this system, students contract for a final laboratory grade of A or B and maintain this grade by achieving a score of "credit" on a specified number of assignments throughout the semester. A score of "credit" is achieved by completing a nongraded assignment on time and receiving no lower than a prespecified score on a graded assignment. All of these expectations are described for students in the grading contract at the beginning of each semester. Although the laboratory practical is also included in the contract grading system for Pharmacotherapy Laboratory IV, the laboratory practical examination for Pharmacotherapy Laboratory III and the spring OSCE are not components of contract grading and are directly factored into the respective final Pharmacotherapy III and IV course grades. Laboratory practical examination and OSCE performances are evaluated using a grading rubric and scores are reported as percentages.

Pharmacotherapy course performance is summarized in Table 3. In the Pharmacotherapy III course, student performance on examinations 1 and 2 was consistent before and after the implementation of laboratory revisions. Scores on examination 3 and the final examination were significantly higher prior to revisions. The final course grade for Pharmacotherapy III was significantly higher following the laboratory redesign. Final grades are a compilation of examination scores, laboratory performance, and OSCE or laboratory practical examination score. In the Pharmacotherapy IV course, performance on examination 1 was significantly higher, while scores on examinations 2 and 3 were significantly lower following

Table 2. Comparison of Costs Associated With Pharmacotherapy Laboratory Courses Prior to and After Revisions

	Pharmacotherapy III Costs, $		Pharmacotherapy IV Costs, $	
Itemized Expenses	**2007-2008**	**2009-2010**	**2007-2008**	**2009-2010**
Duplicating/copying	968.85	980.14	335.50	252.18
Student hourly worker(s)	828.06	317.19	614.83	307.65
Laboratory supplies	1,726.78	501.97	864.51	1,695.20
Other[a]	12,215.76	3,802.25	11,152.01	5,110.51
Total	15,739.45	5,601.55	12,966.85	7,365.53

[a] Other category includes cost of residents' instructional responsibilities standardized patients, resource subscriptions, and miscellaneous OSCE/laboratory practical examination items.

Table 3. Student Performance in Pharmacotherapy III and IV Prior to and After Budget-Reduction Revisions, %

	Pharmacotherapy III Scores, Mean % (SE)		Pharmacotherapy IV Scores, Mean % (SE)	
	2007-2008 (n = 123)	2009-2010 (n = 132)	2007-2008 (n = 122)	2009-2010 (n = 133)
Examination 1	84.3 (0.8)	84.8 (0.7)	84.2 (0.8)	89.8[a] (0.6)
Examination 2	81.3 (0.7)	80.8 (0.7)	85.2 (0.8)	80.5[a] (0.7)
Examination 3	91.1 (0.5)	89.1[a] (0.5)	86.0 (0.9)	82.0[a] (0.8)
Final examination	87.2 (0.7)	80.0[a] (0.7)	–	–
Final course grade	84.5 (0.4)	86.3[a] (0.4)	–	–

[a] Indicates $p < 0.05$ for pre- vs. post-revision comparisons.

laboratory revisions. A pre- and post-comparison for the Pharmacotherapy IV course was not feasible because final course grades for the 2007-2008 year were not accessible.

Student performance on APPEs was evaluated using the NinePoint Tool. Upon completion of an APPE clerkship, the clinical instructor for the site assessed student performance in 9 domains using a Likert scale (1 = does not know, 2 = knows, 3 = knows how, 4 = shows, 5 = does, 6 = not applicable). Average scores for the entire cohort of students participating in APPEs during the academic years 2008-2009 and 2010-2011 (n = 486 to 688, and n = 553 to 743, respectively) are compared in Table 4. For this comparison, scores of 6 (not applicable) were excluded from the analysis. The average score is a compilation of all scores submitted for each domain for all required and elective APPEs. Student performance was similar between 2008-2009 and 2010-2011 years. The only significant difference between the 2 cohorts was in performance of administrative skills. However, the average scores for both cohorts fell between "shows" and "does."

Students completed electronic course and instructor evaluations at the conclusion of the semester (Table 5). Evaluation data from the Pharmacotherapy III and IV courses for the previously stated years were exported as unidentified aggregate data for comparison. Questions providing feedback related to the laboratory portion of the pharmacotherapy courses and/or laboratory revisions were identified and compared between the 2 student cohorts. To assess the general comparability of the 2 student cohorts, the average scores on course-evaluation questions unrelated to the laboratory revisions were also contrasted. The average score on these questions for Pharmacotherapy III was 3.8 for 2007-2008 and 4.0 for 2009-2010, and 3.9 for both the 2007-2008 and 2009-2010 semesters of Pharmacotherapy IV.

DISCUSSION

Revisions made to the Pharmacotherapy Laboratory III and IV courses by laboratory coordinators successfully decreased expenditures while maintaining the quality of student education and training. Student APPE performance

Table 4. Preceptor-Evaluated Student Performance on Advanced Pharmacy Practice Experiences

	Final Average Scores,[a] Mean (SE)	
Student-Performance Domains	**2008 – 2009**	**2010 – 2011**
1a. Communicates with patients	4.8 (0.01)	4.8 (0.01)
1b. Communicates with others	4.8 (0.01)	4.8 (0.01)
2a. Establishes and interprets databases	4.7 (0.02)	4.7 (0.01)
2b. Identifies drug-related problems	4.6 (0.02)	4.6 (0.02)
2c. Recommends appropriate therapeutic plan	4.6 (0.02)	4.6 (0.02
2d. Devises and documents follow-up plan	4.6 (0.02)	4.6 (0.02)
2e. Makes sound pharmaceutical-care decisions	4.7 (0.02)	4.6 (0.02)
3. Technical skills	4.8 (0.01)	4.8 (0.01)
4. Administrative skills	4.7 (0.02)	4.7 (0.02)[b]
5. Information-retrieval skills	4.8 (0.01)	4.8 (0.01)
6. Health promotion and disease prevention	4.8 (0.02)	4.8 (0.02)
7. Professional	4.9 (0.01)	4.9 (0.01)
8. Service and attitude	4.9 (0.01)	4.9 (0.01)
9. Self-directed learning	4.8 (0.01)	4.8 (0.01)

[a] Likert scale: 1 = does not know, 2 = knows, 3 = knows how, 4 = shows, 5 = does.
[b] Indicates $p < 0.05$ for pre- vs post-revision comparisons.

Table 5. Student Evaluation of Pharmacotherapy III and IV, 2007-2008 and 2009-2010

	Pharmacotherapy III Scores, Mean (SE)		Pharmacotherapy IV Scores, Mean (SE)	
Student Evaluation Items	**2007-2008 (n = 110-122)**	**2009-2010 (n = 59-63)**	**2007-2008 (n = 114-119)**	**2009-2010 (n = 55-59)**
I can apply the information/skills I learned in the course.[b]	4.1 (0.1)	4.3 (0.1)	4.2 (0.1)	4.1 (0.1)
The teaching methods used in the course enable me to learn.[b]	3.8 (0.1)	3.9 (0.1)	3.7 (0.1)	3.7 (0.1)
Instructional technology is well-coordinated with course material.[b]	3.9 (0.4)	4.1[a] (0.1)	3.9 (0.1)	4.0 (0.1)
Course activities/assignments help me learn the material.[b]	3.8 (0.1)	4.1[a] (0.1)	3.8 (0.1)	3.8 (0.1)
Lab experiences assist me in learning concepts.[b]	3.6 (0.1)	4.3[a] (0.1)	3.6 (0.1)	3.9 (0.1)
The laboratory sessions are well-organized.[b]	3.4 (0.1)	4.1[a] (0.1)	3.5 (0.1)	3.9[a] (0.1)
What letter grade do you expect to earn in this course?[c]	5.5 (0.1)	5.4 (0.1)	5.2 (0.1)	5.2 (0.1)
If I had to assign a letter grade to this course what would it be?[c]	5.5 (0.1)	5.8 (0.2)	5.4 (0.1)	5.7 (0.2)

[a] Indicates $p < 0.05$ for pre- vs post-revision comparisons.
[b] Likert scale: 1 = not at all, 2 = slightly, 3 = moderately, 4 = very, 5 = extremely.
[c] Grade scale: 1 = F, 2 = D, 3 = C, 4 = BC, 5 = B, 6 = AB, 7 = A.

was similar between 2008-2009 and 2010-2011 years, suggesting that skill development and application on APPEs were not adversely impacted by the pharmacotherapy laboratory redesign. Likewise, student performance remained consistent or improved following course revisions on several Pharmacotherapy examinations and the final course grade. The examinations that noted worsened performance post revisions warrant further discussion.

Although scores on examination 3 and the final examination of Pharmacotherapy III were lower following revisions, the actual percentage difference was small and would not equate to an alteration in assigned letter grade (AB) on examination 3 or a difference of a half-letter grade (B to BC) on the final examination. Scores on examinations 2 and 3 of the Pharmacotherapy IV course were also significantly lower following laboratory revisions. However, between the academic years of 2007-2008 and 2009-2010, there was a change in the lecturing faculty members responsible for delivering course material and administering examinations 2 and 3. The format of the examinations was also changed from case-based to individual multiple-choice questions. Therefore, the difference in performance on examinations 2 and 3 may be related to the aforementioned confounding factors rather than the laboratory revisions. During this time period, the format and lecturing faculty members associated with examination 1 remained consistent and may represent a more valid outcome measure for assessing educational experiences related to laboratory revisions.

Student feedback from the Pharmacotherapy III course suggests that coordination of instructional technology, the ability of course assignments/activities and laboratory experiences to facilitate learning, and the organization of laboratory sessions were improved as a result of the revisions. The ability to apply course information and skills, teaching methods used, expected performance in the course, and course rating remained consistent throughout the revision process. Feedback related to the Pharmacotherapy IV course indicates that the same evaluation points remained consistent following revisions, with the exception of laboratory organization, which appeared to be improved. Similar responses on evaluation questions pertaining to areas of the course that remained relatively unchanged suggest the 2 cohorts (2007-2008 and 2009-2010) had a comparable course experience outside of the laboratory, which reduces the likelihood that outside course factors confounded student responses related to laboratory evaluation questions.

Success of the redesign process was related to the identification of high-cost items, use of course mapping, and expanded application of instructional technology. While quantifying expenses was important for identification of high-cost supplies and activities, course mapping was the crucial first step in directing the laboratory redesign. Course mapping allowed coordinators to confirm key learning objectives for each semester of pharmacotherapy laboratory and match current laboratory activities to each objective. Course mapping allowed for differentiation between activities deemed essential for skill development from those activities that could be altered or eliminated to decrease time spent in laboratory sessions and reduce supply requirements. Creation of the course map also ensured that laboratory course learning objectives were preserved throughout the entire redesign process.

The other important contributor to the pharmacotherapy laboratory course redesign process was the expanded use of instructional technology as a teaching resource. The NCAT has identified the incorporation of technology into courses as an important cost-reduction

strategy.[3,4] The use of the course-management system, Moodle, and its various online tools enhanced the organization of the pharmacotherapy laboratory, improved time efficiency associated with laboratory activities and grading, and decreased overall expenditures. The use of online tutorials allowed for information to be delivered asynchronously, which decreased time spent in laboratory sessions. Online assignments and quizzes with automated grading held students accountable for material covered outside of laboratory while reducing the grading burden on coordinators and pharmacy-practice residents. Moodle also provided a platform to create simulations involving patient-chart reviews, patient and provider communication, prescription verification, and documentation in the form of SOAP notes. Online simulations decreased the number of supplies and residents necessary to facilitate a laboratory session and allowed for student active-learning opportunities outside of the classroom.

A substantial cost reduction was noted within the first year of implementing laboratory revisions. Redesigning Pharmacotherapy Laboratory III and IV through course mapping and use of online tools improved the overall time efficiency of laboratory sessions. These sessions were successfully reduced from 3 to 2 hours by having students complete online assignments, tutorials, and quizzes prior to attending the session. Use of residents as instructors in the laboratory is beneficial to both students and residents; however, the cost associated with teaching and grading was high. Rather than decreasing the total number of residents teaching in the laboratory or eliminating them altogether, coordinators reduced laboratory hours and the number of instructor graded assignments in order to retain this important teaching resource. Another cost-reduction strategy was to reduce the number of OSCEs for P3 students to 1 per year. Hiring standardized patients to hold an 8-hour examination outside of laboratory time was also expensive. By improving laboratory efficiency and reducing expenses, the total costs associated with facilitating Pharmacotherapy Laboratory III and IV were reduced by 64% and 43%, respectively.

Faced with similar budgetary issues, faculty members at the University of Florida College of Pharmacy reported their success with redesigning a pediatric-pharmacotherapy elective course using online tools.[7] The course coordinator initially reduced the number of lectures in order to increase active-learning opportunities in the course, decrease expenses associated with compensating adjunct faculty members, and avoid overlap of topics in other courses. A course-management system was used for prerecorded lectures, patient-case discussions, group presentations, and peer evaluations. In a comparison of course data collected prior to and after the redesign, students who completed the course before revisions scored significantly higher on examinations than did students who took the course after revisions. However, no significant differences were noted in final grades or course evaluations between the 2 groups. Faculty members also noted that the course redesign increased the number of hours students spent on active-learning tasks.

Although the redesign of the 4-semester pharmacotherapy laboratory courses was successful, several barriers were encountered during the process. An initial increase in workload was noted by laboratory coordinators and School of Pharmacy Information and Instructional Technology (IIT) staff members. To ensure the continued coordination of lecture and laboratory material, coordinators met individually with each lecturing faculty member to review proposed laboratory revisions. New online tutorials, assignments, and quizzes had to be created in Moodle from previous laboratory materials and activities. To manage the increased workload, coordinators enlisted fourth-year students enrolled in the Academic APPE clerkship to create or update laboratory activities. Pharmacy practice residents completing a practice experience in the pharmacotherapy laboratory were also assigned a teaching project related to a planned laboratory revision.

The expanded use of technology increased demands on the school's IIT department. Laboratory coordinators required initial training on the new course-management system as well as continued support during the implementation process. Students also required instruction on how to use the new course-management system, which was accomplished by providing practice assignments and "playground" areas where students could gain experience navigating through the system. While the creation and modification of laboratory activities required a substantial amount of work during the first year of implementation, the workload associated with the laboratory has decreased in subsequent years. The online materials and assignments initially created in Moodle are easily updated and maintained from year to year.

SUMMARY

A laboratory course redesign that incorporated course mapping and instructional technology resulted in decreased expenditures in the Pharmacotherapy Laboratory III and IV courses. Student academic performance and course evaluations suggest that the quality of the educational experiences was maintained. The reduction in laboratory costs can be attributed mainly to decreases in resident teaching time, OSCE standardized patient reimbursement, and supplies. The process used to implement revisions and decrease course expenditures

may be useful to other colleges or schools of pharmacy facing budgetary reductions.

ACKNOWLEDGEMENT

The authors wish to thank Jeremy Altschafl, Mara Kieser, Michael Pitterle, and Adam Whitehorse for their contributions to the data collection for this manuscript.

REFERENCES

1. Many States Cut Money for Higher Education. The Chronicle of Higher Education Web site. http://chronicle.com/article/Interactive-Map-Many-States/63567/. Updated January 10, 2010. Accessed February 23, 2012.
2. UW Regents to Discuss Budget Allocations this week. University of Wisconsin System News. http://www.wisconsin.edu/news/2009/r090302.htm. Accessed February 23, 2012.
3. Twigg CA. Improving learning and reducing costs: new models for online learning. *EDUCAUSE Review.* 2003;38(5):28-38.
4. Twigg CA. *Course Redesign Improves Learning and Reduces Cost*. San Jose, CA: The National Center for Public Policy and Higher Education; 2005.
5. 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/S2007Guidelines2.0_ChangesIdentifiedInRed.pdf. Accessed February 23, 2012.
6. American Association of Colleges of Pharmacy, Center for Advancement of Pharmaceutical Education (CAPE) Advisory Panel on Educational Outcomes. Educational Outcomes, revised version 2004. http://www.aacp.org/resources/education/Documents/CAPE2004.pdf. Accessed February 23, 2012.
7. Williams J, Motycka C, St. Onge E. Redesign of a pediatric pharmacotherapy elective course to accommodate budget reductions. *Am J Pharm Educ.* 2011;75(10):Article 206.
8. Hammer DP, Paulsen SM. Strategies and processes to design an integrated, longitudinal professional skills development course sequence. *Am J Pharm Educ.* 2001;65(1):77-85.