INSTRUCTIONAL DESIGN AND ASSESSMENT

Impact of Flipped Classroom Design on Student Performance and Perceptions in a Pharmacotherapy Course

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Objective. To determine whether a flipped classroom design would improve student performance and perceptions of the learning experience compared to traditional lecture course design in a required pharmacotherapy course for second-year pharmacy students.

Design. Students viewed short online videos about the foundational concepts and answered self-assessment questions prior to face-to-face sessions involving patient case discussions.

Assessment. Pretest/posttest and precourse/postcourse surveys evaluated students' short-term knowledge retention and perceptions before and after the redesigned course. The final grades improved after the redesign. Mean scores on the posttest improved from the pretest. Postcourse survey showed 88% of students were satisfied with the redesign. Students reported that they appreciated the flexibility of video viewing and knowledge application during case discussions but some also struggled with time requirements of the course.

Conclusion. The redesigned course improved student test performance and perceptions of the learning experience during the first year of implementation.

Keywords: flipped classroom, active learning, problem-based learning, pharmacotherapy

INTRODUCTION

Standards from the Accreditation Council for Pharmacy Education (ACPE) emphasize the need to prepare graduates to solve problems and think critically by employing teaching methods that actively engage learners.¹ While passive transmission of knowledge using traditional lectures still prevails in pharmacy education, students are accustomed to technology, and they desire to learn by solving problems and collaborating with others.²⁻⁴ The term "flipped classroom" describes a teaching approach that is not new but has become popular.⁵⁻⁷ The flipped classroom model is designed to maximize active learning through interactions during class time while moving content instruction outside of the classroom, commonly with the assistance of technology such as pre-recorded videos.⁶⁻⁹ During class time, instructors focus on identifying and resolving misconceptions, fostering the development of problem-solving skills, and facilitating collaboration among students.^{5,10}

Despite growing interest in the flipped classroom model, a review of the published education literature in

health sciences identifies few studies that detail the flipped classroom designs and report their effect on course outcomes. Four studies in undergraduate and graduate nursing courses evaluated different designs that included lecture capture, readings, case studies, team-based learning and student presentations with an outcome of mixed results in student performance and satisfaction.¹¹⁻¹⁴ In their study in an emergency medicine residency program, Young and colleagues demonstrated medical residents' preference for the flipped classroom format over the traditional lecture format.¹⁵ In another study in a physical therapy program, Boucher and colleagues presented positive student and faculty responses to a flipped classroom design that incorporated recorded lectures, readings, discussion, laboratories, and problem solving.¹⁶ Several studies evaluated the impact of various flipped classroom designs and the use of prerecorded videos in the pharmacy curriculum and found promising results with students' performance and satisfaction with the courses.¹⁷⁻²² No previous studies, however, reported a complete redesign of a required pharmacotherapy course into a flipped classroom model in the doctor of pharmacy (PharmD) curriculum.

At the Texas A&M Health Science Center Rangel College of Pharmacy, Integrated Pharmacotherapy I is the first integrated course on pathophysiology,

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pharmacology, and pharmacotherapy. In previous course evaluations, students indicated that patient cases and the associated audience response questions were most effective for learning; however, many students had difficulty applying the knowledge to the patient cases during lectures where most students first learned the content. Students also felt disengaged and distracted during lectures delivered by distance faculty members via synchronous videoconference technology. Therefore, to engage students in active learning more effectively during class time, we transformed the course into a flipped classroom. We hypothesized that our approach to flipped classroom design would promote short-term knowledge retention measured by student performance during the course and improve perceptions of the learning experience during the first year of implementation of the design.

DESIGN

Integrated Pharmacotherapy I is a required, 2-credit, fall semester course for second-year PharmD students. This course covers renal diseases, fluids and electrolytes, acid-base disorders, and nutrition. Before the redesign, the class met three times each week for 100 minutes during the first five and a half weeks in the fall semester. Our team of instructors consisted of two local faculty and three distance faculty members. All faculty members delivered traditional lectures enriched by active-learning activities such as patient cases and interactive questions using an audience response system. When delivered by distance faculty members, the lectures and activities were transmitted using synchronous videoconference technology.

Beginning in January 2012, the investigators, consisting of four faculty and two staff members from Instructional Design and Support Services, considered the flipped classroom design and the appropriate instructional technologies based on the literature and a course design rubric "Quality Matters."²³ In fall 2012, faculty members transformed the entire course from a traditional lecture model into a flipped classroom with consistent course structure and learning activities. Only a single class session on the pharmacology of diuretics remained unchanged because of the instructor's preference for instructional strategies for that topic. All topics except one were taught by the same faculty members before and after the redesign. Faculty members revised the overall course objectives in 2012 to focus on application of the content and the specific learning objectives for each topic, dividing them between the online and face-to-face learning environments depending on their complexity. Overall course objectives were to: (1) assess the renal function of patients with acute kidney injury and chronic kidney

disease; (2) develop a pharmaceutical care plan for patients with renal diseases, acid-base disorders, and fluid and electrolyte abnormalities; and (3) assess the nutritional status of patients and design total parenteral nutrition regimens for appropriate patients.

In the redesigned course, students completed online components composed of prerecorded videos and self-assessment questions prior to the face-to-face sessions (Table 1). The online components covered foundational concepts, whereas the face-to-face sessions focused on clarifying concepts and applying them to patient cases. Based on other studies, in the redesigned course, the online components replaced 30-60% of the face-to-face class time allocated to a topic.^{19,21} The class met face to face up to twice a week for the remainder of the class time allocated to a topic. Altogether, the online components and the face-to-face class time fulfilled the total class time and credit hours assigned to the course, which remained the same as in previous years. To prepare for the redesigned course, students viewed a short online orientation video that introduced the flipped classroom design and explained the course schedule. Then, on the first day of class, course coordinators provided a detailed face-to-face orientation, explaining the rationale and goals of the redesign, the course structure, learning activities, and students' responsibilities.

The online components were organized into eight learning modules on Blackboard Learn 9.1, Blackboard hereafter, (Blackboard, Washington, DC). Faculty members recorded 59 videos (nine hours of material) using screen capture tool Camtasia, v7.0 (TechSmith, Okemos, MI) to produce narrated lecture slides. The videos were designed based on research on student attention spans and experience from online learning environments such as the Khan Academy and Udacity.²⁴⁻²⁶ Each video was short, with a median duration of nine minutes (range: 3-18 minutes) and focused on one foundational concept essential for the face-to-face patient case discussion. The self-assessment questions, which were either embedded in the videos or were posted along with the videos on Blackboard, engaged students in active learning in the online environment and provided them immediate feedback. Each topic included 4-29 self-assessment questions, including an open-response question seeking students' feedback on concepts that needed clarification. Videos and the self-assessment questions were posted at least two days prior to the associated face-to-face sessions. The course coordinator used tracking tools on Blackboard to identify and contact students who did not complete the online components by the deadlines.

The face-to-face sessions for each new topic began with quizzes to assess students' readiness to discuss cases.

Table 1. Components of the Flipped Classroom Design in 2012

#	Duration	Topics	Format	Formative Assessments
1	21 min	Renal function assessment	Online (3 videos)	Self-assessment questions (5 questions) ^a
	45 min	Renal function assessment	Face-to-face	Quiz (6 questions) Discussion questions (5 questions) ^b
2	37 min	Acute kidney injury	Online (4 videos)	Self-assessment questions (9 questions)
	55 min	Acute kidney injury	Face-to-face	Quiz ^c Discussion questions (6 questions)
3	105 min	Chronic kidney disease	Online (13 videos)	Self-assessment questions (29 questions)
	190 min	Chronic kidney disease	Face-to-face	Quiz (8 questions) Discussion question (21 questions)
4	105 min	Acid-base disorders	Online (10 videos)	Self-assessment questions (24 questions)
	180 min	Acid-base disorders	Face-to-face	Quiz (9 questions) Discussion questions (21 questions)
5	59 min	Fluids and sodium abnormalities	Online (7 videos)	Self-assessment questions (23 questions)
	100 min	Fluids and sodium abnormalities	Face-to-face	Quiz (8 questions) Discussion questions (16 questions)
6	38 min	Other electrolyte abnormalities	Online (4 videos)	Self-assessment questions (14 questions)
	100 min	Other electrolyte abnormalities	Face-to-face	Quiz (7 questions) Discussion questions (18 questions)
7	160 min	Parenteral and enteral nutrition	Online (14 videos)	Self-assessment questions (29 questions)
	100 min	Parenteral and enteral nutrition	Face-to-face	Quiz (7 questions) Discussion questions (8 questions)
8	18 min	Pediatric fluids and electrolytes	Online (4 videos)	Self-assessment questions (4 questions)
	50 min	Pediatric fluids and electrolytes	Face-to-face	Quiz (8 questions) Discussion questions (9 questions)

^aSelf-assessment questions were either embedded in the online videos or were posted on Blackboard

^bDiscussion questions in face-to-face sessions were mostly case-based; however, a few stand-alone questions were added in some sessions to emphasize selected foundational concepts

^cThe face-to-face sessions on renal function assessment and acute kidney injury were taught on the same day and only single 6-question quiz was administered for both topics

Quizzes consisted of 6-9 multiple-choice questions administered over 10-15 minutes. Following each quiz, multiple short cases associated with formative assessment questions were presented using slides and an audience response system. Additional questions not associated with the cases were incorporated in some face-to-face sessions to review and emphasize selected foundational concepts. To foster active learning and collaboration, students discussed their individual answers with an informal group of 3-4 adjacent students before submitting their answers. Students were then called on to elaborate their answers during the large group discussion. When needed, faculty members provided further clarification on the content and the problem-solving process based on students' responses. About 30% of the face-to-face sessions were taught by distance faculty members using synchronous videoconference technology. These sessions consisted of the same learning activities as the other face-to-face sessions.

Examinations accounted for 85% of the final grade with the remainder determined by the quizzes (10%) and

formative assessment questions (5%) during the face-to-face sessions. Examination questions consisted of multiple-choice and open-ended questions assessing the content knowledge as well as application of the content to patient cases. The examinations were redesigned to include more open-ended questions in 2012.

To assess student performance, final grades, mean examination scores, and class performances on 27 repeated, multiple-choice questions from examinations in 2011 before the redesign, and in 2012 after the redesign, were compared. The repeated questions were dispersed throughout five examinations, and the course policy did not allow students to retain a copy of the questions. In 2012, students also completed a 20-question pretest on the first day and an identical posttest on the last day of class. The pretest and posttest questions were constructed according to the course and lecture learning objectives. The pretest and posttest questions assessed the various levels of Bloom's Taxonomy of learning, including eight questions assessing knowledge and comprehension and 12 questions assessing application, analysis, and

evaluation.²⁷ The number of questions allocated to each topic was proportional to the total class time allotment.

Precourse and postcourse surveys and the course evaluations provided the quantitative and qualitative data on student perceptions of the course redesign. The pre-course and postcourse surveys on student attitudes toward the flipped classroom design were conducted on the first and last day of the course in 2012, respectively. The survey questions were adapted from a validated survey instrument of student attitudes toward televised courses.²⁸ Student perceptions of the course before and after the redesign were compared using 5-point Likert items from the course evaluation in 2011 and 2012.

Chi-square test was used to compare the final grade distribution and the class performances on the repeated examination questions. The mean examination scores were compared using independent *t* test. The pretest and posttest scores were compared using paired *t* test. Responses on individual Likert items of the course evaluation from 2011 and 2012 were compared using Mann-Whitney U test. The level of significance was defined as an alpha <0.05. All statistical analyses were performed using SPSS, v21.0 (SPSS, Chicago, IL).

The open-ended comments in the postcourse survey were analyzed by two investigators to identify the emerging themes and categories. Using Lincoln and Guba's content analysis technique, each investigator independently unitized the comments, formed groups of similar units, determined emerging themes from the units, then identified overarching categories from the themes.²⁹ In qualitative research, unitizing is the process of identifying the smallest piece of standalone information within the body of textual data and assigning a descriptive code to the unit.^{29,30} For trustworthiness, the investigators compared units, themes, and categories they arrived at separately to ascertain the quality and reliability of the findings.^{29,31,32} The Texas A&M University Institutional Review Board approved this study.

EVALUATION AND ASSESSMENT

The course enrolled 90 and 89 students in 2011 and 2012, respectively. One student dropped the course after the first examination in 2011, leaving 89 students completing the course in both groups. Student demographic data upon admission to the college are listed in Table 2. The precourse survey in 2012 revealed that 74% of students had taken an online course before, and 29% of students had taken a course that blended the online and face-to-face learning environments.

The overall class performance improved in 2012 compared to 2011 ($p=0.005$; Table 3). The final grades were excellent (A) or good (B) for 88% of students in

Table 2. Admission Demographics of Students Enrolled in the Fall 2011 and 2012 Classes

	(N=89) %	
	2011	2012
Gender		
Male	45	41
Female	55	59
Age, mean (range)	23 (18-36)	23 (19-36)
Degree		
No prior degree	40	45
Baccalaureate	59	53
Postgraduate	1	2
Ethnicity		
Asian	43	29
Black	1	3
Hispanic	17	31
White	38	36
Other	1	1
GPA ^a	3.26	3.38
PCAT ^a	71	69

^aThe GPA (grade point average) and PCAT (Pharmacy College Admission Test) are mean values in each corresponding class of students upon admission

2012 compared with 67% of students in 2011. The mean examination score increased from 83.4% (SD=7.9%) to 88.2% (7.3%) from 2011 to 2012 ($p<0.001$). Students performed significantly better on 11 of 27 repeated examination questions in 2012 than in 2011 ($p<0.05$), and performance improved in 10 additional questions without reaching significant difference. In contrast, students performed significantly worse on two repeated questions in 2012 ($p<0.05$), and performance worsened in three additional questions without reaching significant difference. Student performance was the same on one repeated question in both years. Eighty-six (97%) students completed both the pretest and posttest in 2012. Out of the 20 questions, the mean score increased significantly

Table 3. Final Grades in 2011 before Course Redesign and in 2012 after Course Redesign

Final Grade ^a	(N=89)	
	2011 ^b	2012
A	17	32
B	43	46
C	25	10
D	4	1

^aThe final grade was defined as A=90-100%, B=80-89%, C=70-79%, D=60-69%. D deemed unsatisfactory performance at the college

^b $p=0.005$ for the comparison of the final grade distribution between 2011 and 2012

Table 4. Precourse and Postcourse Surveys on Student Attitudes toward Flipped Classroom Design (N=85)^a

Survey Statement	%			
	Precourse		Postcourse	
	Agree ^b	Disagree ^b	Agree	Disagree
The types of instructional techniques that were used to teach the class (eg, online lecture videos, in-class quizzes, in-class discussions) helped me gain a better understanding of the class topics.	92.9	7.1	88.3	11.7
Viewing the online videos on my own was less distracting than listening to the video-conferenced lectures with possible technology glitches or other students talking with each other, etc.	94.1	5.9	80.8	19.2
I viewed the online videos by the due dates and before coming to class because I wanted to be prepared for the in-class discussions.	90.6	9.4	80.3	19.7
I viewed the online videos by the due dates and before coming to class because of the in-class quizzes.	95.3	4.7	87.2	12.8
I think the interactive patient case discussions encouraged class participation when professors were connected from distance.	89.4	10.6	89.5	10.5
Since the majority of the lectures were available through the online videos, I felt confident that classes would not be temporarily interrupted because of technical problems.	85.9	14.1	81.8	18.2

^aSome students did not participate in both surveys or respond to all items on the surveys. The number of respondents on individual items varied between 84 and 85 in the precourse survey, and between 76 and 78, postcourse survey

^bAgree=strongly agree, moderately agree and slightly agree; disagree=strongly disagree, moderately disagree and slightly disagree

from 6.5 (1.9) on the pretest to 12.2 (3.0) on the posttest ($p<0.001$).

Eighty-five (96%) and 78 (88%) students completed the precourse and the postcourse surveys, respectively. Students reported positive attitudes toward the flipped classroom design including the online videos and the face-to-face case discussion (Table 4). In the postcourse survey, most students rated the course as good (58.4%) or very good (20.8%). The workload was rated as too great, rigorous, and just right by 23.1%, 64.1%, and 10.3% of students, respectively. Compared to other courses, 55.2% of students thought this flipped course was much better or

better, while 12.9% of students thought it was worse or much worse.

The response rate of the course evaluation was 66% in 2011 and 100% in 2012. The increased response rate was a result of a college-led effort to increase the response rates of all course evaluations (Table 5). Most students viewed the course and its various components favorably in both years, but more students strongly agreed with each individual item in 2012 than in 2011. Statistical analyses revealed significant improvements on clarity of the grading system ($p=0.019$), coordination of team teaching ($p=0.006$), and effectiveness of team teaching ($p=0.03$).

Table 5. Course Evaluation in 2011 before Course Redesign and in 2012 after Course Redesign

Evaluation Item	%						
	2011 (n=59) ^a			2012 (n=89)			p^c
	SA/A ^b	n ^b	D/SD ^b	SA/A	n	SD/D	
The stated objectives of this course were consistently pursued.	98.3	1.7	0	95.5	4.5	0	0.088
The grading system was clearly explained.	79.3	8.6	12.1	92.1	7.9	0	0.019
Attendance in this class was essential to good learning.	88.1	3.4	8.5	90.9	6.8	2.3	0.127
Web-based handouts were valuable supplements to this course.	82.1	10.7	7.1	87.6	9.0	3.4	0.147
This course contributed significantly to my professional growth.	98.3	1.7	0	95.5	4.5	0	0.408
The teaching methods used in this course were appropriate.	62.7	23.7	13.6	72.7	13.6	13.6	0.098
Instruction is well-coordinated among the team teachers.	56.9	25.9	17.2	79.8	14.6	5.6	0.006
Team teaching is effectively used in this course.	66.1	22.0	11.9	78.7	16.9	4.5	0.03

^aSome students did not respond to all items on the evaluation. The number of respondents on individual items varied between 53 and 59 in 2011 and between 77 and 89 in 2012

^bSA=strongly agree; A=agree; N=neutral; D=disagree; SD=strongly disagree

^cResponses on individual Likert items in 2011 and 2012 were compared using Mann-Whitney U test

Seventy-four of 78 students who completed the post-course survey provided open-ended comments. Two investigators analyzed the comments. Three overarching categories, construct of flipped teaching, faculty effectiveness, and effect on students, and one to five themes emerged in each category.

Students were clear about how they found the flipped classroom design helpful or unhelpful for their learning and, thus, either supported or opposed the construct of flipped teaching. The positive points included the flexibility and convenience of viewing the recordings. Students could view and review the recordings as many times as they needed prior to the face-to-face class sessions and before the examination associated with that topic. This comment is representative: "I believe the [flipped classroom] was an effective method of teaching that helped me keep up with the material as well as give me a resource (the lecture videos) to review at my convenience and pace to prepare for exams." Another positive point they mentioned was class time being spent applying content introduced in the recordings: "I liked having videos to watch outside of class so that class time would be used to review patient cases and examples. I found it easier to learn the material when I came to class because I already had the background information to use to answer questions in class." In contrast, some students opposed the construct of flipped learning: "I hate that the videos are mandatory. I like getting the slides in advance. I hate watching videos because I never have the time. I can read slides faster than watching vid[eo]s."

This course was taught by a team of four instructors. As in face-to-face courses, students found some instructors more effective than others. The teaching characteristics they found effective included content organization, clear explanations, shorter recordings, and ability to integrate recordings with in-class activities. Here is a representative comment: "Whether or not the online videos are a good learning tool is dependent upon the instructor recording them."

Other themes that emerged involved the effect on students as they learned using the flipped classroom model. Students were vocal about the large amount of time they spent viewing the recordings primarily because they frequently paused to take notes: "I spend most of my time listening to the videos, pausing to write down all the information that the professor is saying. This ends up taking an hour per video." As a result, students perceived that the time requirement of this course was excessive and felt overwhelmed by managing this course with others: "I only had time to study for this class and prevented me from focusing on other classes." Thus, students employed strategies that included cursory

review of the recordings for an upcoming class and foregoing viewing new recordings to review past recordings for an upcoming examination. One student noted "... when I was busy I would put the videos off until Monday evening. This is after the quiz so I would fail but I would watch the videos later." As these negative effects contradict the positive points students noted about the construct of flipped teaching, we further address this finding in the Discussion section.

DISCUSSION

In this study, we assessed student performance and perceptions during the first implementation of a flipped pharmacotherapy course. Our flipped classroom design applied the principles of good teaching practice including active learning through solving patient cases, interactions among students and interactions between faculty members and students during informal small group and large group discussion, and prompt feedback from multiple assessments in the online and face-to-face environments.³³ Before the redesign, few students asked any questions during traditional lectures, and students were hesitant in elaborating on their answers regarding patient cases dispersed throughout the lectures. Student disengagement in the traditional lecture model led to the redesign of this course. After the redesign, most students viewed the teaching methods favorably and felt engaged during class time. Student performance also improved significantly in the redesigned course.

Our findings in performance improvement were consistent with results from several health science education studies that demonstrated improvement in examination scores and final grades associated with the flipped classroom model.^{11,17,18,34,35} In our study, the mean examination scores and the overall grades improved significantly after the redesign. Students performed significantly better on 11 of 27 repeated examination questions but significantly worse on two of them. The concepts tested on the two lower performing questions were either presented briefly during a face-to-face session or were presented as isolated facts in the online videos without integrating with face-to-face case discussion. Thus, effective integration of foundational concepts in the online videos with face-to-face patient case discussion is critical to convey importance of the content to students. The improvement of the posttest scores from the pretest scores also demonstrated student learning associated with the flipped classroom design; yet, students achieved a mean score of only 12.2 (61%) out of the 20 questions. The low posttest scores compared with the examination scores may be associated with a lack of reference information such as normal laboratory values on the posttest

and different student attitudes toward the posttest than toward examinations. It is also possible that students' knowledge retention in our flipped classroom design is still suboptimal.

Overall, students viewed their learning experience positively, based on the results from the postcourse survey and course evaluation. However, we found some conflicting comments regarding our flipped classroom design. Previous studies of flipped classrooms also showed mixed results on student perceptions. Although some studies demonstrated student satisfaction with the teaching methods and student engagement,^{12,17,18} others showed that students viewed the course more negatively after the redesign, reported greater workload, and did not appreciate the value of interactive learning during class time.^{11,34,35}

Our students appreciated the flexibility of the online video viewing and the value of interactive face-to-face case discussions. On the other hand, students were burdened by the amount of time spent on viewing the online videos thoroughly, by quizzes and examination dates in relation to the online video due dates, and by the time commitment of this course and others. Specifically, a common complaint was the longer time required to view the videos than their actual lengths because of note-taking. This experience deserves close consideration as it exemplifies student limitations in self-regulated learning,—(ie, the ability and process of setting learning goals, planning ways to achieve those goals, self-monitoring and evaluating the progress, and modifying the plan when necessary) and perhaps indicate changes they needed to make to their study habits.³⁶⁻³⁹

Without effective self-regulated learning, students do not form new study strategies appropriate for a different learning modality (eg, flipped classroom) and instead carry out the same strategies they have used in a familiar learning environment (eg, face-to-face lectures).³⁸ In a flipped classroom design such as ours, where content is mostly delivered through videos, students need a new strategy for learning from the videos. Otherwise, they will employ the strategies for learning from a book: transcribe the videos to produce a written record and use the transcript as the source of content.⁴⁰ Overall, this approach seems inefficient. An educator's responsibilities include teaching students how to be strategic learners in a particular domain,³⁸ and helping them develop this skill is paramount.⁴¹ The burden they experienced in this new learning modality might explain the overall postcourse decline in student attitudes (Table 4).

To address students' feedback, several aspects of our flipped classroom design have been modified for

subsequent classes. First, the orientation now includes guidance on managing the workload of a flipped course: discussions on note-taking strategies and setting realistic expectations on the time commitment of the course are provided. Moving forward, other approaches for developing self-regulated learning skills will be sought and incorporated. Second, online videos are now posted at least four days prior to the face-to-face sessions to allow adequate study time. Third, the video viewing deadlines have been adjusted from one day prior to the face-to-face sessions to the morning of the sessions. Fourth, students complete all learning activities and the corresponding examination before advancing to another topic in the course.

There are some limitations to this study. First, student perceptions of flipped courses are affected by comfort with and motivation to learn technology skills.⁴² Our students are trained to use instructional technology from enrollment in the program, and 74% of students had taken an online course previously. The results of this study cannot be extrapolated to student populations with less comfort with technology; however, a national survey showed a steady increase in online course enrollment in higher education in the past decade and, therefore, pharmacy students are likely to be experienced with online learning.⁴³ Second, this study was limited to the immediate effect during the first year of implementation of the flipped classroom design. A follow-up study of our research project will evaluate the reproducibility of improvement in student performance and perceptions in subsequent years of implementation, as well as the long-term effect on retention and application of knowledge. Third, different flipped classroom designs have emerged in higher education, and no single model will meet all educational needs.^{5,10}

We used short online videos to deliver the foundational content outside the classroom; however, other flipped classroom designs have used reading assignments, online interactive text, and lecture capture to deliver pre-class content instruction.^{11,18,34,44} No studies have compared different flipped classroom designs, but some might not be as effective as others in a specific setting.⁴⁵ Future studies could evaluate which flipped classroom design is most effective for therapeutic courses in the PharmD curriculum.

SUMMARY

The flipped classroom model requires thoughtful integration of online and face-to-face learning. This study evaluated a course redesign that integrated online videos, face-to-face patient case discussion, and formative assessments in both learning environments in a team-taught,

integrated pharmacotherapy course in the second-year PharmD curriculum. Compared with the traditional lecture model, the redesigned course improved student performance and perceptions of the learning experience. Students found the online videos valuable to their learning. Further studies are needed to evaluate how to optimize course workload and course administration to allow broader implementation of the flipped classroom model into the curriculum.

REFERENCES

1. Accreditation Council for Pharmacy Education. Accreditation standards and key elements for the professional program in pharmacy leading to the doctor of pharmacy degree. <https://www.acpe-accredit.org/pdf/Standards2016FINAL.pdf>. Accessed February 3, 2015.
2. Dipiro JT. Why do we still lecture? *Am J Pharm Educ*. 2009;73(8):Article 137.
3. Blouin RA, Riffie WH, Robinson ET, et al. Roles of innovation in education delivery. *Am J Pharm Educ*. 2009;73(8):Article 154.
4. DiVall MV, Hayney MS, Marsh W, et al. Perceptions of pharmacy students, faculty members, and administrators on the use of technology in the classroom. *Am J Pharm Educ*. 2013;77(4):Article 75.
5. Bergmann J, Sams A. *Flip Your Classroom: Reach Every Student in Every Class Every Day*. Washington, DC: International Society for Technology in Education; 2012.
6. Lage MJ, Platt GJ, Treglia M. Inverting the classroom: a gateway to creating an inclusive learning environment. *J Econ Educ*. 2000;31(1):30-43.
7. Day JA, Foley JD. Evaluating a web lecture intervention in a human-computer interaction course. *IEEE Trans Educ*. 2006;49(4):420-431.
8. Zappe S, Leicht RM, Messner JJ, Litzinger T, Lee HW. "Flipping" the classroom to explore active learning in a large undergraduate course. In American Society for Engineering Education. American Society for Engineering Education, 2009.
9. Herold MJ, Lynch TD, Ramnath R, Ramanathan J. Student and instructor experiences in the inverted classroom. In Frontiers in Education Conference (FIE)IEEE, 2012.
10. Yarbro J, Arfstrom KM, McKnight K, McKnight P. Extension of a review of flipped learning. <http://flippedlearning.org/cms/lib07/VA01923112/Centricity/Domain/41/Extension%20of%20FLipped%20Learning%20LIt%20Review%20June%202014.pdf>. Accessed February 3, 2015.
11. Missildine K, Fountain R, Summers L, Gosselin K. Flipping the classroom to improve student performance and satisfaction. *J Nurs Educ*. 2013;52(10):597-599.
12. Critz CM, Knight D. Using the flipped classroom in graduate nursing education. *Nurse Educ*. 2013;38(5):210-213.
13. Ratta CBD. Flipping the classroom with team-based learning in undergraduate nursing education. *Nurse Educ*. 2015;40(2):71-74.
14. Schlairet MC, Green R, Benton MJ. The flipped classroom: strategies for an undergraduate nursing course. *Nurse Educ*. 2014;39(6):321-325.
15. Young TP, Bailey CJ, Guptill M, Thorp AW, Thomas TL. The flipped classroom: a modality for mixed asynchronous and synchronous learning in a residency program. *West J Emerg Med*. 2014;15(7):938-944.
16. Boucher B, Robertson E, Wainner R, Sanders B. "Flipping" Texas State University's physical therapist musculoskeletal curriculum: implementation of a hybrid learning model. *J Phys Ther Educ*. 2013;27(3):72-77.
17. McLaughlin JE, Roth MT, Glatt DM, et al. The flipped classroom: a course redesign to foster learning and engagement in a health professions school. *Acad Med*. 2014;89(2):236-243.
18. Pierce R, Fox J. Podcasts and active-learning exercises in a "flipped classroom" model of a renal pharmacotherapy module. *Am J Pharm Educ*. 2012;76(10):Article 196.
19. Persky AM, Pollack GM. Transforming a large-class lecture course to a smaller-group interactive course. *Am J Pharm Educ*. 2010;74(9):Article 170.
20. Edginton A, Holbrook J. A blended learning approach to teaching basic pharmacokinetics and the significance of face-to-face interaction. *Am J Pharm Educ*. 2010;74(5):Article 88.
21. Crouch MA. An advanced cardiovascular pharmacotherapy course blending online and face-to-face instruction. *Am J Pharm Educ*. 2009;73(3):Article 51.
22. Sancho P, Corral R, Rivas T, Gonzalez MJ, Chordi A, Tejedor C. A blended learning experience for teaching microbiology. *Am J Pharm Educ*. 2006;70(5):Article 120.
23. Quality MattersTM Rubric Standards 2011-2013 edition. http://www.elo.iastate.edu/files/2014/03/Quality_Matters_Rubric.pdf. Accessed February 11, 2015.
24. Stuart J, Rutherford RJ. Medical student concentration during lectures. *Lancet*. 1978;2(8088):514-516.
25. Khan academy. <https://www.khanacademy.org>. Accessed December 5, 2014.
26. Udacity. <https://www.udacity.com/>. Accessed December 5, 2014.
27. Bloom BS, Engelhart M, Furst EJ, Hill WH, Krathwohl DR. *Taxonomy of educational objectives: Handbook I: Cognitive domain*. New York, NY: David McKay; 1956.
28. Biner PM. The development of an instrument to measure student attitudes toward televised courses. *Am J Dist Educ*. 1993;7(1):62-73.
29. Lincoln YS, Guba EG. *Naturalistic inquiry*. Newbury Park, CA: Sage Publications; 1985.
30. Saldaña J. *The coding manual for qualitative researchers*. 2nd ed. Thousand Oaks, CA: Sage Publications; 2013.
31. Glesne C. *Becoming qualitative researchers: An introduction*. 2nd ed. New York, NY: Addison Wesley Longman; 1999.
32. Merriam SB. *Qualitative research and case study applications in education*. San Francisco, CA: Jossey-Bass; 1998.
33. Chickering AW, Gamson ZF. Seven principles for good practice in undergraduate education. *AAHE Bulletin*. 1987;3:3-7.
34. Ferreri SP, O'Connor SK. Redesign of a large lecture course into a small-group learning course. *Am J Pharm Educ*. 2013;77(1):Article 13.
35. Wong T, Ip EJ, Lopes I, Rajagopalan V. Pharmacy students' performance and perceptions in a flipped teaching pilot on cardiac arrhythmias. *Am J Pharm Educ*. 2014;78(10):Article 185.
36. Bransford JD, Brown AL, Cocking RR. *How People Learn: Brain, Mind, Experience, and School*. Washington, DC: National Academy Press; 1999.
37. Schunk DH. *Learning Theories: An Educational Perspective*. 6th ed. Boston, MA: Pearson Education; 2012.
38. Weinstein C, Acee T, Stano N, Meyer D, Husman J, McKeachie W. Teaching students how to become more strategic and self-regulated learners. In: Svinicki MD, McKeachie WJ, eds. *McKeachie's Teaching Tips: Strategies, Research, and Theory for College and University Teachers*. 14th ed. Belmont, CA: Wadsworth; 2014:291-304.

39. Zimmerman BJ. Self-regulated learning and academic achievement: an overview. *Educ Psychol.* 1990;25(1):3-17.
40. Caspi A, Gorsky P, Privman M. Viewing comprehension: students' learning preferences and strategies when studying from video. *Instr Sci.* 2005;33(1):31-47.
41. Hagemeyer NE, Mason HL. Student pharmacists' perceptions of testing and study strategies. *Am J Pharm Educ.* 2011;75(2):Article 35.
42. Rodriguez MC, Ooms A, Montañez M. Students' perceptions of online-learning quality given comfort, motivation, satisfaction, and experience. *J Interact Online Learn.* 2008;7(2):105-125.
43. Allen IE, Seaman J. Changing course: ten years of tracking online education in the United States. <http://www.onlinelearningsurvey.com/reports/changingcourse.pdf>. Access February 3, 2015.
44. Kellogg S. Developing online materials to facilitate an inverted classroom approach. In Frontiers in Education Conference (FIE) IEEE, 2009.
45. Strayer JF. How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learn Environ Res.* 2012;15(2):171-193.