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INSTRUCTIONAL DESIGN AND ASSESSMENT

Vodcasts and Active-Learning Exercises in a "Flipped Classroom" Model of a Renal Pharmacotherapy Module

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Objective. To implement a "flipped classroom" model for a renal pharmacotherapy topic module and assess the impact on pharmacy students' performance and attitudes.

Design. Students viewed *vodcasts* (video podcasts) of lectures prior to the scheduled class and then discussed interactive cases of patients with end-stage renal disease in class. A process-oriented guided inquiry learning (POGIL) activity was developed and implemented that complemented, summarized, and allowed for application of the material contained in the previously viewed lectures.

Assessment. Students' performance on the final examination significantly improved compared to performance of students the previous year who completed the same module in a traditional classroom setting. Students' opinions of the POGIL activity and the flipped classroom instructional model were mostly positive.

Conclusion. Implementing a flipped classroom model to teach a renal pharmacotherapy module resulted in improved student performance and favorable student perceptions about the instructional approach. Some of the factors that may have contributed to students' improved scores included: student mediated contact with the course material prior to classes, benchmark and formative assessments administered during the module, and the interactive class activities.

Keywords: active learning, process-oriented guided inquiry learning, instructional design, pharmacotherapy, renal therapeutics

INTRODUCTON

The challenge for educators in every discipline is for them to transition from being dispensers of facts to being architects of learning activities. Critical in this process is designing experiences that facilitate students developing into active learners rather than passive receptacles of information. While large-group lecture continues to be a staple of medical education, advances in video and audio technology; the exponential growth of available quality online content, such as Coursera and The Kahn Academy; and developments in cognitive science combine to challenge traditional notions of teaching and learning. The "flipped classroom" instructional model was developed by Jonathan Bergmann and Aaron Sams in 2007 to provide instruction to secondary students who were missing class and therefore missing instruction.[1] In the flipped class model, what used to be class work (namely, the instructor-led lecture and student note taking) is done prior to class, while what used to be homework (typically, assigned problems) is done in the scheduled class. The model has transformed teaching practice by changing traditional roles and increasing interaction between the instructor and students during class. In the flipped classroom, the responsibility and ownership of learning is transferred from the teacher to the students through participation in interactive activities.

The empirical support for active learning, generally defined as any instructional method that engages students in the learning process, is extensive.[2] Health professions continue to grapple with the format and the extent to which they should include active learning, despite a growing body of evidence for its efficacy. The Accreditation Council for Pharmacy Education (ACPE) requires the inclusion of active-learning strategies.[3] Gleason and colleagues provided a comprehensive overview of active-learning strategies in pharmacy education and a well-articulated rationale for adopting these strategies.[4] While many programs use technology to electronically capture lectures and thus shift the time and space in which teaching and learning may occur, there is little empirical evidence concerning the use or efficacy of these flipped classroom projects as a tool to improve student performance in pharmacy education. In this project, faculty at

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the Shenandoah University's Bernard J. Dunn School of Pharmacy address the ACPE's requirement for including active-learning practices by integrating instructional approaches that are typically associated with the flipped classroom model. The goal of this project was to assess the impact of the flipped classroom instructional model on pharmacy student performance and perceptions. Flipping the classroom requires a reconsideration of student and faculty interaction because traditional lectures are conducted through videos outside of scheduled classes. In this project, a process-oriented guided inquiry learning (POGIL) activity was used to actively engage students to develop critical thinking and problem solving. The POGIL instructional strategy has been endorsed by the National Science Foundation after 2 decades of showing positive results in undergraduate basic science courses.[5,6] The investigators hypothesized that the flipped classroom instructional model would improve student test performance and student perceptions of the renal module. The research questions included: did the flipped classroom instructional model impact student performance, and did the flipped classroom instructional model impact student perceptions of the renal module?

DESIGN

A *design experiment* was selected as the guiding methodology of this study. The term was introduced in 1992 as a method to conduct formative research and refine educational designs based on principles derived from prior research.[7] Design experiments are set in the messy situations that characterize real-life learning; in order to avoid the distortions of laboratory experiments and therefore constitute a means of addressing the complexity that is a hallmark of educational settings.[8] This investigation examined the impact of active-learning strategies, in a renal pharmacotherapy module within the Integrated Pharmaceutical Care and Science (ICARE) series. The Institutional Review Board of Shenandoah University approved the project in April 2012.

The renal pharmacotherapy module occurred in an 8-week pharmacy integrated therapeutics course that met twice weekly for 2 hours. In 2011 the total contact hours excluding assessments were 23 hours of lecture, a case discussion, and a scheduled 1-hour review period prior to the final examination. Module material was organized into 4 topics which included an introduction to renal and electrolyte disorders, acute kidney injury, chronic kidney disease, and dialysis. The course presented pharmacy students with the pathophysiology of common renal diseases, renal replacement strategies, associated complications, and electrolyte and acid-base disorders. Therapeutic management of patients with renal disease, with specific attention placed on the effects of pharmacodynamic and pharmacokinetic properties of medications, was the focus of the course.

The class of 2012 included 71 pharmacy students of which 30 (42%) were male and 41 (57%) were female. The educational background of participants included students with: 1 to 2 years of undergraduate education (6 [8%]), associates degrees (8 [11%]), 3+ years of undergraduate education (14 [20%]), bachelor's degrees (42 [58%]), and master's degrees (1 [1%]). To assess the development of student knowledge using the flipped classroom instructional model, in 2012, a pretest was administered on the first day of the renal module. The pretest was constructed with an emphasis on the learning outcomes of the module, namely case-based clinical dosing vignettes for patients with end-stage renal disease. The pretest consisted of 17 items, of which 9 (53%) were application-level, case-based multiple-choice questions and 8 (47%) were knowledge-level multiple-choice questions. Eleven (65%) of the 17 multi-choice questions had 4 possible response options and 6 (35%) had 5 possible responses.

Of the 23 hours of course material delivered in 2012, 4 hours of lecture content in the form of vodcasts related to dialysis therapy were provided for the students to review prior to the in-class activity. The vodcasts were assigned on the first day of the module immediately after the pretest. The vodcasts were course lectures that were originally performed live in spring 2011 and made available for viewing on iTunes U platform (Apple Computer, Cupertino, CA). Lectures are recorded in a voiceover slideshow format using Camtasia Relay (Techsmith, Lansing, Michigan). In spring 2012, the same lectures, originally recorded in spring 2011, were assigned, after the pretest, to be viewed prior to the in-class activity. The POGIL activity was conducted during the next scheduled class, which integrated information from the 4 vodcasts.

The POGIL activity consisted of 2 patient cases. The first case was a progressive patient case that required the students to make multiple interventions for a single patient as he transitioned from acute continuous renal replacement therapy to chronic intermittent hemodialysis therapy. The second case involved a patient presenting symptoms of toxic ingestion of alcohol and required the students to determine if renal replacement was necessary or if pharmacological therapy alone was adequate. At the conclusion of these cases, the students spent 90 minutes actively involved in simulated patient care, which included assessment of the patient's renal function, drug dosing in renal replacement therapy, pharmacokinetic calculations, in-depth discussion of the processes and components that affect medication dosing, and discussion of methanol toxicology and the associated therapies.

All of the objectives from the vodcast lectures were covered during the activity through the completion of a series of calculations, or through student-centered discussion of topics. The POGIL activity was conducted at the application level of Bloom's taxonomy of learning domains as students were required to combine patient-specific data and drug information to design a treatment regimen for the patient.[9] The instructor-led activity guided students from one scenario to the next, interjecting salient contextual information that connected lecture content and lesson objectives to the clinical settings. Attendance for the spring module for 2012 was 100%, with 71 students attending all scheduled classes. During the POGIL activity, students were randomly called upon to confirm their answers to the series of clinical questions and calculations. The structure of the activity mirrored the knowledge and skills that were required on the formative assessments, the course final examination, and the national board immediately after the POGIL activity, during the last class prior to the final examination.

Another metric of student progress was a comparison of student performance on the 2011 and 2012 final examination questions that related to the renal module. The same instructor conducted the same lectures in 2011 and 2012 and the identical final examination questions were used in spring 2011 and spring 2012. The final examination included 16 multiple-choice questions from the renal module, of which 8 (50%) questions had 4 possible response options and 8 (50%) questions had 5 possible responses.

EVALUATION AND ASSESSMENT

Student performance on the renal pharmacotherapy module delivered using the flipped classroom model was assessed by a pretest/posttest design and by group comparisons. Assessments were administered electronically using a secure browser in a proctored setting. Questionmark (Perception, Norwalk, CT) was selected for the creation, delivery, and analysis of assessments. Data were further analyzed using SPSS, version 19 (IBM, Armonk, New York).

Descriptive statistics for the formative assessments in 2012 included the pretest (33.5 $\pm$ 11.6 [mean $\pm$ SD], range 0-59) and the posttest (79.2 $\pm$ 10.6, range 53-100). A paired *t* test yielded significant differences for student performance in 2012 between pretest and posttest, $p < 0.001$. No pretest and posttest information was available for 2011. A between-group comparison was conducted for student performance on the 16 renal ICARE final examination questions, between 2011 and 2012. Summed scores were computed and yielded descriptive statistics for the 2011 (77.7 $\pm$ 4.7, range 43-100) and 2012 (81.6 $\pm$ 4.4, range = 43-100) final examinations. A *t* test assuming equal variance conducted to analyze differences in student performance found significant differences between the renal questions on the 2011 and 2012 final examinations, $p = 0.024$.

Student Evaluations

Student's perceptions of the flipped classroom experience also were determined. A 10-question survey instrument was administered using a 5-point Likert scale (strongly disagree, disagree, neutral, agree, strongly agree). The survey instrument investigated 2 domains of student perceptions: attitudes about the POGIL activity and perceptions about the flipped class instructional model. The survey instrument was administered online using Survey Monkey (Palo Alto, CA) and was available for a 13-day period between the posttest and the final examination. The survey response rate was 73.0%. Survey items for agreement (strongly agree and agree) and disagreement (strongly disagree and disagree) were combined for reporting. Students' responses to 5 items addressing student perceptions of the POGIL lecture yielded a Cronbach alpha measure of reliability equal to 0.82. Responses to 5 items addressing perceptions about the flipped classroom instructional model yielded a slightly larger reliability ($\alpha = 0.83$).

Students' perceptions about the POGIL activity (Table 1) were mostly favorable. The majority (96.0%) of the 52 survey respondents agreed or strongly agreed that viewing the prerecorded lectures prior to class was important, and that active student participation was required in the POGIL activity. Most students (76%) also agreed that the extent to which the instructor required student participation in the POGIL activity was important. Ninety percent of the students agreed that the instructor made meaningful connections between the topics in the prerecorded lecture and the class activities. Seventy-six percent agreed that viewing prerecorded lectures was essential to successfully participating in the POGIL activity.

Students' perceptions about the flipped classroom instructional model were also mostly favorable. Eighty percent of students agreed that the model improved their self-efficacy to address the topics on the final examination. Seventy-eight percent of students agreed that being able to view the lectures prior to class was important. Seventy-nine percent also agreed that increased faculty-student interaction was desirable. Seventy-five percent felt the flipped classroom model was dissimilar to the teaching model used in other pharmacy courses (n=39, 75.0%), and 62.0% expressed a desire for more instructors to use the flipped classroom model.

Table 1. Pharmacy Students' Perceptions About the Use of Process Oriented Guided Interactive Lecture and a Flipped Classroom Model to Teach a Renal Pharmacotherapy Module (N = 52)

	Strongly Agree/Agree	Neutral	Disagree/Strongly Disagree
Viewing the lecture before scheduled class prepared me for the class activity.	50 (96)	1 (2)	1 (2)
I did not view the lecture before class although I was supposed to.	2 (4)	0	50 (96)
Viewing the pre-recorded lecture was essential to successfully participating in the class activity.	40 (76)	6 (12)	6 (12)
The instructor made meaningful connections between the topics in the pre-recorded lecture and the class activity.	47 (90)	4 (8)	1 (2)
The flipped classroom model was similar to other classes in the Bernard J. Dunn School of Pharmacy.	3 (6)	10 (19)	39 (75)
I enjoyed being able to view the lecture prior to schedule class as opposed to live class lecture.	41 (78)	5 (10)	6 (12)
The instructor required student participation in the in-class activity.	50 (96)	1 (2)	1 (2)
I am confident about my ability to address these topics on the final examination.	42 (80)	5 (10)	5 (10)
I want more interaction between students and faculty members in class.	41 (79)	8 (15)	3 (6)
I wish more instructors used the "flipped classroom" model.	32 (62)	13 (25)	7 (13)

DISCUSSION

The flipped classroom instructional model for a renal pharmacotherapy module replaced instructor-dominated lectures, during which students traditionally took notes with highly interactive student-instructor activities. The design of this project included repeated exposure to the content at the application level through a series of assessments including a pretest, a class activity, a posttest, and a final examination. Scheduled lecture time was devoted primarily to assessing student knowledge and developing student knowledge through activities. Prerecorded lectures, the primary purpose of which is the transmission of information, were viewed independently by students prior to class. Active learning, through the POGIL activity, increased opportunities for students to apply knowledge to clinical case scenarios in class. Fostering critical thinking and problem solving through formative assessments and participation in the POGIL activity was effective in preparing students for the final examination format and content. Student performance on the 16 final examination questions relating to the renal module significantly improved from 2011 to 2012. While we believe that the improvement in student performance was the result of repeated exposure to the concepts through the pretest, the POGIL activity, and the posttest, further research is needed to discern if the improvement in student scores in 2012 was an anomaly.

Pharmacy students recognized the convenience and pedagogical benefits of the flipped classroom instructional model. Students expressed a consistently high preference for the flipped classroom instructional model relative to the traditional instructor-led lecture model. Future studies may provide additional insight into the impact of the flipped classroom on improved student performance and attitudes as the instructional model becomes more widely adopted in practice and the novelty of the approach abates. This flipped classroom project supports the notion that the quality, not necessarily the quantity, of student-teacher interaction is a compelling force in improving student performance. Additionally, this project supports a growing body of educational research concerning how people learn and developments in modern cognitive science by affirming students' proclivity for active learning, and by demonstrating the efficacy of active learning using the flipped classroom model to improve student outcomes.[10-12]

A limitation of this study was the scope of the intervention. Expanding the intervention to other modules or other courses, where appropriate, may provide additional evidence. Another limitation of the study was the modest although significant improvements in student performance.

SUMMARY

The flipped classroom model is gaining recognition in a wide variety of academic settings as an approach to promote student-centered, active learning. This study detailed how using prerecorded lectures, or vodcasts,

engendered a more active, student-centered lecture style. The implementation of the flipped class in this study accompanied improved student performance and generated positive student attitudes towards the experience. Further research is needed to continue the investigation into the efficacy of the flipped class.

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