TEACHERS' TOPICS

An Introductory Review Module For an Anti-Infectives Therapeutics Course

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Objective. To determine whether an introductory review module using a hybrid-learning approach helped students learn infectious disease management in an anti-infectives therapeutics course.

Design. An introductory module consisting of an online pharmacology review, pre-class assignment, 2 classroom lectures, and 1 case-based lecture was developed and implemented.

Assessment. Among the 110 students who completed pre- and post-tests on the material covered, average scores increased from 71% to 83% ($p < 0.0001$). Performance on knowledge-based question improved for 8 out of 10 questions ($p < 0.05$) and student confidence increased from the first lecture to completion of the module ($p < 0.001$ for all comparisons). Of the 129 students who completed an evaluation of the introductory module, 98% strongly agreed or agreed that the content was essential for course success.

Conclusion. The addition of an introductory module using a hybrid-learning approach to review and solidify concepts of medical microbiology and pharmacology provided the foundation necessary for success in an infectious diseases module.

Keywords: hybrid learning, blended learning, infectious disease, therapeutics

INTRODUCTION

The dearth of new antimicrobial agents being developed and approved for use may lead to a public health crisis. Many pharmaceutical companies have withdrawn from antibiotic development because of low return on investment.¹ This is illustrated by the precipitous drop in antibiotic approvals over the last 30 years from 16 in the 5-year period from 1983 to 1987 to just 4 in the 5-year period from 2003 to 2007.² The decline has continued, with only 2 new antibiotics being approved in the 4-year period from 2008 to 2011. Simultaneously, during this period the rate of antibiotic resistance has significantly increased.¹⁻³ There are 2 main efforts underway to delay this public health disaster: major advocacy campaigns largely driven by the Infectious Diseases Society of America's 10 x '20 initiative (10 new antibiotics by 2020, endorsed by 36 medical societies)⁴ and antimicrobial stewardship programs.⁵

Antimicrobial stewardship programs are an effort to improve and promote the appropriate use of antibiotics through selection of optimal regimens including

agent selection, dosing, duration of administration, and route of administration.⁵ Pharmacists are considered a core member of the multidisciplinary team that implements such programs and frequently are the primary ones responsible for day-to-day stewardship activities.^{5,6} This responsibility has created a need for pharmacists who are highly knowledgeable of the basic principles of antimicrobial therapy such that they are able to implement these stewardship policies effectively in any given clinical scenario.

The Northeastern University School of Pharmacy offers a 6-year doctor of pharmacy (PharmD) program, which the majority of incoming students enter directly out of high school. We identified a need in our students to bolster these basic principles of antimicrobial therapy. Because of the time that elapses between the microbiology course and the pharmacology and medicinal chemistry courses taught in the second preprofessional year and first professional year, respectively, and the therapeutics of infectious diseases course taught in the third year, students have difficulty remembering and applying the foundational material. Feedback from students on course evaluations and exit survey instruments has highlighted the poor sequence of these courses. This paper describes the development and implementation of an introductory review module in the infectious diseases portion of the therapeutics course during the P3 year to bolster students'

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knowledge using a hybrid-learning approach, and an evaluation of the effectiveness of this module on student learning.

DESIGN

The introductory module was designed to enable students to learn and better understand the management of specific infectious diseases taught later in the course, including respiratory infections, endocarditis, meningitis, urinary tract infections, skin/soft tissue/bone infections, and several others. The module maximized class time spent on review and application of previously taught material. An online 1-hour lecture was recorded to review common pathogens, drug classes, drug mechanisms of action, drug spectrum of activity, adverse effects, pharmacokinetic properties of drugs, and drug interactions. Students were asked to listen to the online module between late August and early September, prior to the first class, and to complete a table with pharmacological characteristics of commonly used anti-infectives. For each class of drugs and/or generation, students were asked to describe the mechanism of action, any notable side effects, potential for drug interactions, and route of administration. Once complete, students were asked to upload their charts to the Blackboard course site (Blackboard, Inc., Washington, DC), where course instructors were able to track which students completed this required pre-class assignment.

In addition to the online component, the introductory module included 2 traditional lectures and 1 case-based lecture. The traditional lectures (total of 4 hours and 20 minutes) highlighted the pharmacology of commonly used antibiotics, including antifungal and antiviral drugs. The spectrum of activity of anti-infectives was emphasized. Principles of medical microbiology were also reviewed. How to approach a patient presenting with signs and symptoms of infection were taught, including diagnostics, principles of empiric therapy, antimicrobial stewardship, and organism-specific therapy. Students also were exposed to principles of rational antimicrobial selection, pharmacokinetic and pharmacodynamic considerations, common mechanisms for drug resistance, and clinical approach to managing it. Active-learning opportunities, mostly consisting of audience response clicker questions, were present throughout both lectures to establish baseline knowledge, emphasize important points and concepts, and allow students to apply newly taught material. The last, case-based lecture (130 minutes) was entirely based on patient cases, some of which were submitted by P4 students who had completed general medicine or infectious disease practice experiences. Student participation was captured using an audience response system (Turning

Technologies, Youngstown, OH). Each case and specific question was discussed and the correct and incorrect answers were explained.

ASSESSMENT AND EVALUATION

A pretest was developed to assess students' baseline knowledge of anti-infective pharmacology and a posttest was developed to assess student learning. Four specific objectives were assessed: (1) explain the mechanism of action; (2) identify notable side effects; (3) identify drug interaction potential; and (4) identify the spectrum of activity for each antimicrobial class. The instructor prepared 2 to 3 multiple-choice questions for each of the 4 objectives. Students were asked to rate their confidence in their knowledge of each objective using a Likert scale ranging from strongly agree to strongly disagree. The questions were validated by a course coordinator and 2 education practice experience students to ensure that they addressed the objectives, that distractors were appropriate, and that questions were the same on the pretest and posttest. The pretest was administered in the beginning of the first class and the posttest was administered at the end of the introductory module using an audience response system. Students were instructed to answer questions without assistance from others. Student performance on the pretest and posttest did not count towards their course grade.

In addition, 2 weekly quizzes, as well as the midterm and final examination, included questions that assessed all objectives covered by the introductory module. Questions were developed by the instructor at various levels of Bloom's Taxonomy of Learning and validated and revised for clarity by the course coordinator and education practice experience students. These questions were mapped to lecture objectives and item analyses were performed and reviewed by the instructor and course coordinator. From the 4 objectives assessed on the pretest and posttest, only objective 4 was reassessed on the quizzes and examinations. Pre- and post-test scores were compared using paired *t* test (for the total score) and paired chi-square for individual questions. Likert scale responses on the pre- and post-tests were compared using Related-Samples Wilcoxon Signed Rank Test (IBM SPSS Statistics, Version 19.0, SPSS Inc., Chicago, IL).

Of the 134 students enrolled in the course, over 90% reported that they listened to the online lecture and 92% completed the antimicrobials chart. One hundred ten (82%) students completed both the pretest and posttest. The average score for these students increased from 71% on the pretest to 83% on the posttest ($p < 0.001$). Thirty-five students (31.8%) scored lower than 70% on the pretest. On the posttest, students' scores improved significantly, and only 13 (11.8%) scored lower than

70% ($p < 0.001$). The knowledge-based portion of the pretests and posttests consisted of 10 questions. Student performance increased from pretest to posttest on 8 of 10 questions ($p < 0.05$) (Table 1). In addition to evaluating student knowledge, we also evaluated student confidence based on 4 objectives using a Likert Scale (strongly agree, agree, disagree, strongly disagree). Students' self-reported confidence significantly increased from the pretest to posttest for all 4 objectives ($p < 0.001$) (Table 2).

All 15 lecture objectives for the introductory module were assessed in 2 quizzes, and in the midterm and final examinations. Item analysis demonstrated that students learned the material well and no areas of concerns were identified. Overall, the course was successful with a 100% pass rate, and an average adjusted course grade of 84% (SD=6.3; range 71.1%-100%). Grades were adjusted based on item analyses from all examinations. In addition, to pass the course, students needed to score better than 73% on at least 1 of 2 examinations.

At the end of the course, an anonymous survey was completed by 129 students (96%). Ninety-eight percent of respondents agreed or strongly agreed that completion of the introductory module was essential for success in the course. A majority of the students agreed or strongly agreed that completion of the entire introductory module and each of its components was essential for their subsequent success in the infectious diseases module (Table 3). Ninety-seven percent agreed or strongly agreed that the introductory material helped them prepare for quizzes and examinations.

Over 95% of students disagreed or strongly disagreed with removing the entire introduction module from the course. Thirty percent agreed or strongly agreed that the online lecture component could be removed from the course. When students were asked about time spent reviewing the online material and studying prior to the

start of the infectious diseases module, 4.7% spent 0 hours, 31.7% spent 1 to 2 hours, 31% spent 3 to 4 hours, 18.6% spent 5 to 6 hours, and 3.1% spent over 7 hours.

Students' responses to open-ended survey items were reviewed by the instructor and the course coordinator. General themes identified were that students did not like the pre-class homework assignment and struggled with the spectrum of activity for antibiotics. Many commented on how useful the case-based lecture was to review and apply the material covered by the first 2 lectures.

DISCUSSION

Student performance on the pretests and posttests demonstrated that the review provided by the introductory module was needed and that it positively impacted student learning outcomes in the infectious disease module. These findings were further validated by the results of course assessments and students' perceptions regarding the introductory lectures.

We chose the hybrid approach to teaching to maximize classroom time and to appeal to students with different learning preferences. Other investigations have demonstrated the utility of blended or hybrid learning approaches and their positive impact on student learning.⁷⁻¹⁰ The online component allowed us to incorporate more active-learning opportunities into the classroom lectures and allowed 1 of the lectures to be completely case-based.

Student evaluations revealed that they highly valued all components of the introductory module with the exception of the online lecture component. Over 30% of the class thought that the online lecture was not essential to course success. This finding can be explained by several factors. First, classroom lectures emphasized the material covered in the online lecture and when reflecting on the introductory module, students may have felt that the online lecture did not aid their learning of this material.

Table 1. Third-Year Pharmacy Students Who Correctly Answered Knowledge-Based Questions Before and After Completing an Introductory Module for an Infectious Diseases Therapeutics Module

Objective	Correct, %		<i>P</i> ^a
	Pretest	Posttest	
Explain mechanism of action (3 questions)	63.2	76.5	0.003
	72.0	87.9	<0.001
	97.4	99.1	0.25
Identify side effects (2 questions)	74.8	83.3	0.035
	63.0	56.0	0.118
Identify drug interactions (2 questions)	88.3	99.1	<0.001
	56.8	80.7	<0.001
Identify spectrum of activity of common antimicrobials (3 questions)	42.7	83.5	<0.001
	65.5	80.9	<0.001
	86.7	97.4	<0.001

^a Pre and post-test data were compared using paired chi-square test.

Table 2. Pharmacy Students' Self-Reported Confidence on Content Covered in an Introductory Module to an Infectious Diseases Therapeutics Module, N = 120^a

I am confident in my knowledge of. . .		Strongly Agree, No. (%)	Agree, No. (%)	Disagree, No. (%)	Strongly Disagree, No. (%)	P ^b
mechanism of action of antibiotics	Pretest	4 (3.3)	36 (30)	67 (55.8)	13 (10.8)	<0.001
	Posttest	22 (19.5)	61 (54.0)	30 (26.6)	0 (0)	
side effects of antibiotics	Pretest	1 (0.8)	42 (35.9)	65 (55.6)	9 (7.7)	<0.001
	Posttest	17 (12.2)	65 (56.5)	34 (29.6)	2 (1.7)	
drug interaction potential of antibiotics	Pretest	1 (0.8)	11 (9.2)	75 (63.0)	32 (26.8)	<0.001
	Posttest	4 (3.6)	55 (49.6)	50 (45.1)	2 (1.8)	
antibiotic spectrum of activity	Pretest	0 (0)	16 (13.3)	43 (35.8)	61 (50.8)	<0.001
	Posttest	7 (6.0)	68 (58.6)	38 (32.8)	3 (2.6)	

^a Because not all 120 students answered all questions, the number of responses to individual questions varied between 117 and 120 on the pretest; 118 students completed the posttest and the number of responses to individual questions varied between 111 and 118.

^b Pre and post-test data were compared using Related-Samples Wilcoxon Signed Rank Test.

Second, the instructors asked students to watch the online lecture before the class began, and students may have had difficulty finding time to listen to the lecture. Finally, our students are used to traditional classroom education and we have found that their attitudes towards hybrid learning are generally negative. Lancaster and colleagues used a hybrid approach in a self-care therapeutics course at our school of pharmacy several years ago.¹¹ While this study was able to demonstrate improved learning, over half of the students did not find the hybrid approach valuable to their learning.

We were pleasantly surprised at the high numbers of students who completed the pre-course activities, including the online lecture and the anti-infectives chart, as well as the pre- and post-test assessments, considering that these activities only affected the participation portion of their course grade. We believe they may have been motivated by the reputation of the infectious diseases module as one of the most difficult in the therapeutics series. There were 2 questions for which no significant changes in responses were seen between the pretest and posttest (Table 1). Lack of change in responses to the first question on evaluating the mechanism of action

of drugs was likely due to the extremely high rate of correct answers given on the pretest (>97% pre and >99% post), suggesting that the students had already mastered this content before starting the course. For the second question, the small decline in the number of correct answers may have been the result of confusion over the wording of content presented in the introductory module; specifically, some students may have concluded incorrectly that the lecture statement "beta lactams can rarely cause interstitial nephritis" meant that beta lactams should be classified as a nephrotoxin.

This evaluation had several limitations. The pretests and posttests had a relatively small number of questions designed to evaluate only material covered in previous courses and pre-course homework. While we asked students to answer the questions without discussing them with their classmates, because of the nature of audience response systems, cheating may have occurred. The scores on the pretest and posttest did not count towards the course grade; therefore, students may not have been strongly motivated to put forth their best effort. Additionally, because the pretest was administered after many of students had watched the online portion of the module,

Table 3. Student Evaluation of an Introductory Module to an Infectious Diseases Therapeutics Module (N=129)

	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly Disagree (%)	Unable to Comment (%)
The entire introduction module was essential for my success in the rest of the module	75.9	22.4	0.77	0	0
Online pharmacology lecture/ prep was essential for my success in this module	3.9	61.2	27.9	4.7	1.6
2 didactic lectures were essential for my success in this module	63.5	31	2.3	0	2.3
Case-based lecture was essential for my success in this module	55.8	38.7	3.9	0	0.8
This material helped me prepare for quizzes and examinations	75.9	20.9	1.6	0.8	0

the knowledge gains identified on the posttest can only be attributed to the classroom portion of the introductory module. Course quizzes and examinations were more accurate measures of student achievement of learning objectives, however, we chose not to re-test students' knowledge of the pharmacology of anti-infectives and focused instead on assessing students' knowledge of the antimicrobial spectrum of action, rational selection of antimicrobial therapy, and pharmacodynamic implications.

Based on student feedback regarding the online lecture, it will be revised to focus more heavily on pharmacology and less on material that is emphasized in the classroom portion of the module. Beyond this change, we plan to continue the new introductory module largely unchanged.

SUMMARY

The addition of a hybrid-learning model introductory module was successful in improving student knowledge of infectious diseases management. The methodology we used took advantage of currently available technology and met the needs of various learning preferences among the students in the class. While the problem of poor course sequencing within our curriculum must be addressed with curricular revision, this review module was a feasible short-term solution that was within the control of the instructors and ensured student success.

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