INSTRUCTIONAL DESIGN AND ASSESSMENT

Active-Learning Implementation in an Advanced Elective Course on Infectious Diseases

Levita Hidayat, PharmD, Shreya Patel PharmD, and Keith Veltri, PharmD

Touro College of Pharmacy, New York, NY

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Objectives. To describe the development, implementation, and assessment of an advanced elective course on infectious diseases using active-learning strategies.

Design. Pedagogy for active learning was incorporated by means of mini-lecture, journal club, and debate with follow-up discussion. Forty-eight students were enrolled in this 4-week elective course, in which 30% of course time was allocated for active-learning exercises. All activities were fundamentally designed as a stepwise approach in complementing each active-learning exercise.

Assessment. Achievement of the course learning objectives was assessed using a 5-point Likert scale survey instrument. Students' awareness of the significance of antimicrobial resistance was improved ($p \leq 0.05$). Students' ability to critically evaluate the infectious-disease literature and its application in informed clinical judgments was also enhanced through these active-learning exercises ($p \leq 0.05$). Students agreed that active learning should be part of the pharmacy curriculum and that active-learning exercises improved their critical-thinking, literature-evaluation, and self-learning skills.

Conclusion. An elective course using active-learning strategies allowed students to combine information gained from the evaluation of infectious-disease literature, critical thinking, and informed clinical judgment. This blended approach ultimately resulted in an increased knowledge and awareness of infectious diseases.

Keywords: active learning, infectious disease, curriculum, elective course, pharmacy education

INTRODUCTION

The World Health Organization has identified antibiotic resistance as 1 of the 3 greatest threats to human health.¹ The rapid increase in resistant pathogens has rendered currently available antibiotics ineffective. Without access to effective antibiotics, clinicians face considerable challenges in treating patients with infectious diseases. Evidence-based practice guidelines assist practitioners with the decision-making process for developing effective treatment strategies for infectious diseases. However, 1 study found that the Infectious Diseases Society of America (IDSA) clinical-practice guideline recommendations are primarily based on low-quality evidence derived from nonrandomized studies and expert opinion.² The study found that there is a deficiency in research-based evidence to assist clinicians in making critical clinical decisions.

Further complicating the effective treatment for infectious diseases is the stagnant antimicrobial development

pipeline, which has come to a standstill because of minimal economic and regulatory incentives. IDSA issued a global initiative in 2010 to develop 10 new antimicrobial agents by the year 2020.¹ The slow development of antimicrobial agents highlights the importance of conserving the effectiveness of currently available antibiotics.

Pharmacists are positioned to play a prominent role in the judicious use of antibiotics for infectious diseases through the principles of antimicrobial stewardship. The antimicrobial stewardship program improves patient outcomes, limits emergence of antimicrobial resistance, and prolongs the effectiveness of available antibiotics in the treatment and prevention of infections.^{3,4} As integral members of multidisciplinary healthcare teams, pharmacists actively engage in identifying patient risk factors for resistant pathogens, designing evidence-based antibiotic regimens and monitoring plans, evaluating patient progress, and redesigning antibiotic regimens as necessary to effectively treat infections.^{3,4}

The importance of educating pharmacy students on the rational and judicious use of antimicrobial agents is highlighted by the rapid increase of resistant pathogens, the remarkable scarcity of high-level evidence in clinical practice guidelines, the stagnant antimicrobial pipeline,

Corresponding Author: Levita Hidayat, PharmD, Touro College of Pharmacy, 2090 Adam Clayton Powell Jr Blvd, Suite 603H, New York, NY 10027. Tel: 626-841-9242. E-mail: Levita.Hidayat@touro.edu

and the emerging role of pharmacists in determining optimal treatment for and preventing infectious diseases. Pharmacy students should receive training in the application of evidence-based medicine to optimize antibiotic selection, dose, route, and duration to maximize therapeutic effect while limiting unintended consequences, such as adverse effects and the development of antimicrobial resistance. Pharmacy students should also be able to gather evidence-based data, evaluate the clinical implications, and apply the information to provide effective patient care.

Traditionally, pharmacotherapy of infectious diseases is taught within a lecture-based course in the third or fourth year of the doctor of pharmacy (PharmD) curriculum. Large, lecture-based courses create a bulimic learning environment, wherein students memorize a vast amount of information with little long-term retention of the knowledge and skills necessary to competently practice pharmacy.⁵ The Accreditation Council for Pharmacy Education (ACPE) and the American Association of Colleges of Pharmacy (AACP) both encourage a PharmD curriculum that directly involves students, facilitates the transition from “dependent to independent learner,” and develops graduates with an ability to integrate and apply learning to both the present practice of pharmacy and the advancement of the profession.^{6,7}

The active-learning approach has been widely implemented in pharmacy education to allow students to actively engage in the learning process and further develop their critical-thinking skills. Various implementations of the active-learning approach have been used to teach pharmacotherapeutic topics.⁸ One study identified and described the use of active learning in an infectious-diseases pharmacotherapy course.⁹ However, the implementation of active-learning exercises in 4-week infectious-diseases course has not been previously described.

We designed an advanced elective course on infectious diseases. Incorporating stepwise active-learning exercises in the course created a dynamic learning environment that allowed students to engage more deeply in the process of learning lecture materials, which promoted critical thinking and self-directed learning. This study describes the implementation of stepwise active-learning exercises, assessment of students’ performance and mastery of learning objectives, and student perceptions of the course.

DESIGN

The PharmD program at Touro College follows a 4-year curriculum. Students attend the classroom component of the program in the first 2 years with introductory practice experiences in the summer, followed by year-round advanced practice experiences for the remaining

2 years. A 4-week, 3-credit advanced elective course on infectious diseases was designed and offered in January of the third-year. The course involved 8 hours of classroom time and 4 hours of online lecture weekly. Thirty percent of the course time was allocated to active-learning exercises. Students enrolled in the course were required to successfully complete the therapeutic modules during their first and second years, which introduced them to the basic principles of infectious diseases, classification of infectious organisms, spectrum of activity, and basic pharmacokinetics/pharmacodynamics of antimicrobial agents. Therefore, the expected learning outcomes in the elective course were designed to integrate the knowledge they had attained in the therapeutics module as well as knowledge they were going to gain from the advanced elective course. The teaching objectives for the elective course were designed so that after completion of the active learning exercises, students would be able:

- (1) To apply principles of infectious diseases through understanding of the pathogen, host, and antimicrobial properties’ relationship in improving positive outcomes in the health-care setting.
- (2) To apply principles and strategies that limit antimicrobial resistance by developing a clinical rationale, selecting optimal agents, and understanding the judicious use of available antimicrobial agents.
- (3) To introduce the principles of antimicrobial stewardship as the pillar of antimicrobial therapy and the clinical pharmacist’s role as part of a multidisciplinary team.
- (4) To strengthen skills in critically evaluating the infectious-diseases literature and its application in informed clinical judgment.
- (5) To increase awareness and understanding of the Centers of Disease Control and Prevention’s (CDC’s) public health campaign to prevent antimicrobial resistance.

To accomplish these objectives and ensure long-term retention of knowledge attained in the classroom, various active-learning strategies were integrated into the course to augment students’ educational experience and motivate them to be critical thinkers and self-learners in a dynamic learning environment.⁹⁻¹¹ The use of active-learning techniques benefits not only students by allowing them the opportunity to practice skills and ask questions but also instructors by offering them an opportunity to assess students’ understanding and remediate important points on a nearly “real time” basis.¹¹ The skills acquired from these activities are critical to the personal,

professional, and intellectual development of healthcare providers.⁹

The 3 types of active-learning exercises were designed as a stepwise approach to complement each type of exercise through a faculty-guided group discussion in 2 stages: the preparatory and final-stage presentations (Figure 1). The preparation-stage presentation was comprised of 2 components, the mini-lecture and journal club, which were presented to the other students in the class and the course faculty members. These activities were designed as peer-teaching tools to promote collaborative learning and served as a foundation for the third active-learning exercise, which consisted of a debate presented before all college faculty members followed by a discussion. This final active-learning exercise served as a forum for the application of previously acquired knowledge and further assessment of the infectious-diseases literature necessary for the formulation of a concise verbal clinical judgment.

On the first day of class, students were provided with a patient case along with learning objectives, expectations, and stepwise instructions for the active-learning components and competencies. The patient case given to the students involved a nursing-home resident who was admitted to the hospital intensive care unit to be treated for healthcare-associated Methicillin-resistant *Staphylococcus aureus* (MRSA) infection complicated by septic

shock. Students were divided into 4 groups to facilitate a better team-learning experience and application of information learned through the various activities (Figure 1). Each group was assigned a different treatment agent chosen because it offered both advantages and disadvantages for use in the given patient case.

Students were required to critically evaluate the patient case in order to formulate an optimal treatment plan. Student groups were then required to perform the necessary literature searches for the topic and assigned treatment agent to successfully complete the active-learning exercises. Following each learning activity, students were required to integrate the information reviewed with the information they had researched to prepare for their final debate. Students were also expected to gather information and assess other treatment options through their peers' preparatory-stage presentations, but to refrain from asking patient/case-related treatment questions or drawing conclusions until the discussion session following the debate. The insights and understanding gained from the preparation-stage presentations were expected to facilitate the design of an informed and effective treatment plan for the patient.

Students were given faculty guidance and a deadline for submission of literatures searches and presentations to ensure time management, preparedness, and active participation in all classroom activities. The course

Figure 1. Active-Learning Procedure Chart

was taught by 3 faculty members: an infectious-diseases pharmacotherapy specialist and 2 internal medicine pharmacotherapy specialists. Course faculty members were expected to provide office hours at least once weekly. One course faculty member was assigned as the primary advisor for each active-learning exercise to avoid conflicting directions. Three mandatory meetings with a course faculty member were to be scheduled by the groups' representatives—1 prior to each active-learning exercise. A minimum of 30-minutes per group was requested to ensure adequate time for appropriate direction and clarification of questions prior to completing the active-learning exercise. The aims of the mandatory meetings were to provide necessary guidance, to review the progress of literature searches, and to discuss teamwork-related issues. Finally, all students were required to participate actively in discussions, and faculty members were asked to facilitate when necessary by asking thought-provoking questions. Each of the active-learning presentations was scheduled for 2 hours. The mini-lecture and journal club presentations were scheduled for week 3 and the debate with follow-up discussion for week 4 (Figure 1).

The mini-lecture was implemented as a peer-teaching tool and part of the preparation-stage presentation. In this activity, students were required to evaluate and depict the highlighted background information of the available treatment options in the patient case through the information they had learned in class and through searches of the infectious-diseases literature. Therefore, students were expected to familiarize themselves with infectious-diseases literature associated with their assigned topics (Table 1). To complete this activity, all 4 groups were required to prepare 15-minute presentations, to be followed by 10-minute question-and-answer sessions. Students were asked to select 2 group members to present the information learned on the assigned topics.

The journal club activity was also designed as a peer-teaching tool and was part of the second preparatory-stage presentation. In this activity, students were required to depict, analyze, and critically evaluate the primary clinical trials, which assessed and reported the efficacy and toxicity of the assigned agent (Table 1). Students were expected to perform literature searches to identify clinical trials that had been conducted on their respective antimicrobial agents. This active-learning exercise was intended to teach students the application of evidence-based medicine in real-life clinical situations. The student groups were also expected to compare and contrast different methodologies, results, and clinical implications of the published clinical trials in 15-minute presentations followed by 10-minute question-and-answer sessions. Students in each group

Table 1. Example of Assigned Topics in Active-Learning Exercises Implemented in the Course

Student Group	Assigned Topics ^a
A	Mini-lecture: Current MRSA infection treatment armamentarium Journal club: Antimicrobial susceptibility testing (focus on discrepancies between testing methodologies in MRSA susceptibility testing)
B	Mini-lecture: Clinical practice guideline on management of healthcare-associated pneumonia (focus on MRSA pneumonia) Journal club: vancomycin vs. linezolid in the treatment of pneumonia
C	Mini-lecture: telavancin drug monograph Journal club: vancomycin vs. telavancin in the treatment of pneumonia
D	Mini-lecture: ceftaroline drug monograph Journal club: vancomycin vs. ceftaroline clinical trials

Abbreviation: MRSA = methicillin-resistant *Staphylococcus aureus*.

^a The focus for mini-lecture and journal club can be adapted according to the patient case created in the course.

selected 2 members to present the information learned on the assigned topics.

The debate with follow-up discussion, which was the concluding active-learning exercise, was intended to mimic a clinical discussion. Students were expected to apply the knowledge they had gained from the preparatory-stage presentations to formulate their informed clinical recommendation. During the debate with follow-up discussion, 2 members from each group summarized the advantages and disadvantages of the antimicrobial agent assigned for the patient case, including but not limited to efficacy, toxicity, the potential for development of resistance, dosing feasibility, and cost. After each presentation, 1 student from the group was allowed up to 10 minutes to present rebuttal points, and then a question-and-answer session was held.

EVALUATION AND ASSESSMENT

Several methods were used to assess student performance on the learning objectives of the elective course. The overall course grade was determined by means of the following parameters: 2 examinations (60% total), quizzes and patient cases (10%), and active-learning exercises (30%). Active-learning exercises included the mini-lecture (7.5%), journal club (7.5%), and debate (15%).

Student performance on the objectives for the active-learning exercises was assessed using a nonstandardized grading rubric developed by the course faculty members.

The grading rubric consisted of 4 elements: knowledge application, self-learning, critical-thinking application, and communication and preparedness skills. Course faculty members were asked to attend the preparatory-stage presentations, which included the mini-lecture and journal club segments. This helped ensure that the student groups focused on the material they needed to include in their final debate and follow-up discussion. All pharmacy faculty members were invited to attend students' final debate with follow-up discussion to ensure grading objectivity and to obtain feedback on the course. To minimize the effect of outliers in the grading process, the highest and lowest scores were removed from the calculated average score for each group.

Students completed 3 survey instruments during the course. The first assessment was conducted at the beginning and end of the course and the other 2 at the end of the course only. The first assessment measured student performance on the course objectives that were to be achieved through completion of the active-learning exercises. The second assessment assessed student perceptions of the usefulness of the active-learning exercises in advancing their skills. The final assessment evaluated the course processes, organization, and achievable outcomes.

The study objectives were analyzed through univariate and bivariate analysis. Mann-Whitney U test was performed to compare pre- and post-course survey results. Significance was set at $p < 0.05$. Statistical analyses were performed using GraphPad Prism v4 (San Diego, CA).

Of the 48 students enrolled in the course, 45 (94%) completed the precourse survey instrument, and 47 (98%) completed the postcourse survey instrument. Students' perceptions regarding improved awareness and skills were measured by means of 4 main outcomes (Table 2): (1) awareness of antimicrobial resistance, (2) understanding

the importance of antimicrobial stewardship, (3) understanding of the CDC campaign to prevent antimicrobial resistance and their ability to critically evaluate the infectious-diseases literature, and (4) application of acquired knowledge in informed clinical judgments. Significant improvements were shown in all measured outcomes (Table 2).

A majority (47; 98%) of students completed the second assessments. Students agreed that active-learning exercises helped advance their skills, including communication, knowledge application, self-learning, literature evaluation, clinical applications, and critical thinking (Table 3).

Similar method and response rates were observed for the final assessment: 98% ($n = 47$) of students completed the survey instrument that served as an anonymous exit evaluation. Students rated the class intensity or difficulty as 4 on a 5-point scale. Students also rated the class organization and achievable outcomes positively: median (25%-75% interquartile range [IQR]), 4.7 and 5 for class organization and achievable outcomes, respectively (Table 4). Finally, students agreed that active-learning methods should be included in the pharmacy curriculum: median (25%-75% IQR), 5 (Table 4).

DISCUSSION

Pharmacists are positioned to play an important role in the critical evaluation of evidence-based literature and its application to patient care. Active-learning techniques have been shown to engage students more deeply in the process of learning course material by encouraging critical thinking and fostering the development of self-directed learning.⁹⁻¹¹ In our study, the 3 stepwise active-learning exercises were designed as peer-teaching activities, concluding with the debate and follow-up discussion, which was intended to mimic a clinical discussion. While there are published studies on active-learning

Table 2. Student's Perceptions in Meeting the Learning Objectives of the Course Through Active-Learning Exercises

Descriptions	Precourse Survey ^a (N = 45)	Postcourse Survey ^a (N = 47)	P
My awareness of the problem in antimicrobial resistance in the era of stagnant anti-infective pipeline	4 (3-4)	5 (4-5)	<0.05
My understanding of antimicrobial stewardship as the pillar of antimicrobial therapy	3 (3-4)	5 (4-5)	<0.05
My awareness and understanding of CDC public health campaign in preventing resistance	3 (3-4)	5 (4-5)	<0.05
My ability to critically evaluate the wide array of infectious disease literature and its application in informed clinical judgments	3 (3-4)	4 (4-5)	<0.05

Abbreviation: CDC = Centers for Disease Control and Prevention

^a Numbers denote median (25%-75% interquartile range), based on 5-point Likert scale on which 5 = excellent; 4 = good; 3 = average; 2 = below average; 1 = poor

Table 3. Students' Perceptions of the Effectiveness of the Active-Learning Method in Advancing Their Skills

Acquired Skills	Results ^a (N = 47)
Communication and preparedness	4.0 (4-5)
Knowledge application	4.7 (4-5)
Self learning	5.0 (4-5)
Literature evaluation	4.0 (4-5)
Clinical application and implications	4.2 (4-5)
Critical thinking	4.2 (4-5)

^a Numbers denote median (25% -75% interquartile range) based on 5-point Likert scale on which 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree

techniques, to the best of our knowledge, this is the first study that describes the implementation of innovative active-learning exercises in a 4-week advanced elective course on infectious diseases.^{5,9,12,13}

Through the stepwise active-learning exercises, student groups were assigned a complex patient case and expected to apply the specific learning objectives they gained in the course to their work on the patient case. In addition, through the thought-provoking questions and discussion during the active-learning exercises, students were introduced to the clinical pharmacists' role as part of the interdisciplinary team and the principles of antimicrobial stewardship as the pillar of antimicrobial therapy. During the discussion, students were also asked to think from different perspectives, such as that of a physician, pharmacist, or clinical microbiologist. Finally, students were introduced to the unique public-health role of the pharmacist in the CDC public health campaign to prevent antimicrobial resistance.

Table 4. Students' Evaluation of the Course Process and Outcomes (N = 47)

Course Process Elements	Results, Median (IQR) ^a
Difficulty/ intensity of the class	4.0 (4-5) ^b
Class organization	4.7 (4-5) ^c
Outcomes and expectations are achievable	5.0 (4-5) ^d
Active-learning methods should be implemented as part of pharmacy curriculum	5.0 (4-5) ^d

^a IQR = interquartile range (25% -75% interquartile range).

^b Based on 5-point Likert scale on which 5 = very difficult, 4 = difficult, 3 = neutral, 2 = easy, 1 = very easy.

^c Based on 5-point Likert scale on which 5 = very organized, 4 = organized, 3 = neutral, 2 = disorganized, 1 = very disorganized.

^d Based on 5-point Likert scale on which 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree.

Students' performance in and perceptions of the course were assessed to evaluate the feasibility of this course in a 4-week time span. Overall, students performed well on the examinations, quizzes, and graded active-learning exercises. Course faculty members attended the preparatory-stage active-learning exercises and judged the students' performance to be excellent using the grading rubric evaluation. Of the 12 faculty members who attended the final debate with follow-up discussion, evaluations of students' performance were also consistent. Three types of evaluations were given to assess students' perceptions of the course. Students rated these evaluations positively and agreed that active-learning methods are useful and should be implemented as part of the pharmacy curriculum.

We believe our stepwise active-learning method is innovative and transferrable to other PharmD programs and disciplines. Implementing the active-learning techniques used in this course elsewhere in the pharmacy curriculum also should be considered. For example, in the therapeutic course, a complicated case involving a patient with multiple comorbidities can be created with different treatment options. The active-learning approach will then allow students to apply their constructed knowledge and skills through evidence-based medicine. There are a few critical elements in implementing the stepwise active-learning activities, including the expertise of faculty members involved, stepwise instructions, mandatory team meetings, and the development of the patient case aligned with the topical assignment of mini-lecture, journal club, and debate with follow-up discussion. Because students are expected to base their treatment decisions for the patient on evidence-based medicine, faculty members should be current with evidence-based practice.

Three faculty members developed and taught the elective course. One coordinated all the activities while the other 2 each served as advisor for 1 type of active-learning exercise. Students commented that the different areas of expertise provided by each faculty member enriched the breadth and depth of the course. Further comments addressed the usefulness of the 3 mandatory meetings prior to the presentations. Frequent reinforcements and course organization are also critical elements of successful implementation of the active-learning exercises. Students felt that they were well prepared and guided for their presentations. They also appeared to be enthusiastic about communicating their clinical thoughts throughout all the active-learning exercises, and they enjoyed critically analyzing the patient case study through the various activities.

Of the implemented active-learning exercises, students stated that they enjoyed the debate with follow-up

discussion the most. Students also felt that they were able to gather and learn information from their peers through the mini-lecture and journal club activities. The skill acquired by students through all the exercises was evidenced by the deep engagement and informed discussion regarding the optimal antimicrobial regimen for the patient during the question-and-answer sessions.

We identified a few barriers to implementing active-learning exercises in the course. These included an increase in commitment of faculty time for meeting students, creating the patient case aligned with the different active-learning exercises, and developing the activities' quantitative assessments. Faculty members were expected to provide necessary guidance and address students' initial confusion on the exercises and teamwork issues. They were also expected to increase their office hours to meet students' needs in the course and to allocate an adequate amount of time developing a patient case with higher complexity and ensuring that the case aligned with the different exercises. We also faced challenges in assessing how much work each student contributed to the various assignments. A standardized grading rubric would be helpful in grading the completion of the activities quantitatively. We are not aware of any published standardized grading rubric that measures critical thinking or quantifies performance for these types of activities. The future goals of this course are to address the identified barriers. We plan to further develop the grading rubric used for the activities, increase the number of cases, and form smaller student groups, which we hope will enable us to equalize the workload among the students. Future work should also include an evaluation to determine whether these active-learning methods enhance student skills during APPEs.

A rewarding aspect of this study was observing students' enthusiasm for scientific analysis, their deep engagement with each other, and their appreciation for the evolution the infectious-diseases literature, its application to patient care, and their need to stay abreast of the most-recent developments. The positive feedback and comments generated by this course have resulted in high course enrollments compared with other electives offered at the college. The course was regarded as invaluable by both students and the college and thus has become a prerequisite for taking the infectious-diseases advanced practice experience elective.

SUMMARY

Through the addition of active-learning exercises in an advanced elective course on infectious diseases, students were able to integrate critical evaluation of the infectious-diseases literature, critical thinking, and

informed clinical judgment to develop a therapeutic plan. Based on students' self-assessment, the active-learning exercises increased their awareness of the antimicrobial resistance problem, the principle of antimicrobial stewardship, and the CDC's public health campaign, and improved their ability to critically evaluate the infectious-diseases literature. Students commented on the positive teaching and learning experiences they had in the course, and course faculty members received positive feedback about the course from students and other faculty members.

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