TEACHERS' TOPICS

Active-Learning Assignments to Integrate Basic Science and Clinical Course Material

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Objective. To develop, implement, and evaluate active-learning exercises requiring the integration and application of pathophysiology, medicinal chemistry, pharmacology, and therapeutics knowledge of osteoarthritis and rheumatoid arthritis to formulate therapeutic recommendations for patients with musculoskeletal disorders.

Design. Two team-based case study exercises, one evaluating a patient with osteoarthritis and the second, a patient with rheumatoid arthritis, were developed, incorporating material and questions from pathophysiology, medicinal chemistry, pharmacology, and therapeutics. The learning assignments were implemented in a required pharmacotherapy module.

Assessment. Student learning was evaluated using performance on the team-based case study exercises and on 2 examinations. A standard student course evaluation was used to assess students' impressions of the learning activity. The mean student grades for the osteoarthritis and rheumatoid arthritis activities were 9.1 and 8.9, respectively, on a 10-point scale. The majority of students indicated that the learning exercises were more than adequate to excellent in helping students learn.

Conclusion. The addition of active-learning activities was successful in teaching pharmacy students the knowledge needed to formulate therapeutic recommendations for patients with musculoskeletal disorders.

Keywords: team-based learning, case-based learning, active learning, osteoarthritis, rheumatoid arthritis, integrated courses

INTRODUCTION

The Commission to Implement Change in Pharmaceutical Education (CAPE) outcomes and the Accreditation Council for Pharmacy Education (ACPE) Accreditation Standards and Guidelines emphasize the need for educational procedures that require students to use critical-thinking and problem-solving skills in formulating therapeutic recommendations for patients, their families, and other health-care professionals.^{1,2} To do so, students must use their knowledge base to analyze and evaluate numerous patient care situations, while incorporating the tenants of patient care. Professors and preceptors model these abilities in the classroom and practice settings, and traditionally students developed competence in formulating therapeutic recommendation primarily in the practice setting. Increasingly, students are being asked to formulate therapeutic recommendations during individual and group active and prob-

lem-based learning activities in required and elective courses. This fosters independent versus dependent learning in the classroom setting to increase student preparedness' for practice experiences and independent practice as a pharmacist.³⁻⁵

Pharmacy students born from 1976 to 1988 should be uniquely suited for a successful transition from dependent to independent learning as they are part of the Millennial generation or Generation Next (individuals born between 1976 and 1994).⁶⁻⁸ In general, the Millennials are comfortable with a team-based approach to learning and do not require a lot of supervision, but do expect prompt feedback. They often become impatient with outdated educational methods and prefer real-life application and active learning.^{9,10} They enjoy collaboration with peers and forming connections with classmates, either in class or through technology.⁷ However, Millennials are goal oriented and if not given assignments that support preparation for examinations, they may become disengaged from the learning process.^{7,9-11}

At Mercer University College of Pharmacy and Health Sciences, the curriculum committee requested that 25% or

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more of the contact hours in required pharmacotherapy modules be devoted to active-learning strategies. One team-taught required pharmacotherapy module, Disorders of the Musculoskeletal Systems and Pain Management, is taught by faculty members from the pharmaceutical sciences and pharmacy practice departments, and is coordinated by a faculty member from pharmacy practice. Traditionally, course faculty used active-learning strategies, including formative quizzes, empty outlines, lecture summaries, and mini-patient case analysis that focused on material presented by individual faculty members and did not require integration with other course material.

In a precourse planning meeting in 2009, course faculty members agreed to incorporate several activities that would require integration of material presented by the pharmaceutical sciences and pharmacy practice faculty members. The goal of this project was to develop, implement, and assess team-based active-learning assignments that would require integration, synthesis, and application of knowledge from individual lectures in pathophysiology, medicinal chemistry, pharmacology, and therapeutics of osteoarthritis and rheumatoid arthritis, 2 of the major disorders of this module. Specific learning objectives for the lectures and associated active-learning assignments in osteoarthritis and rheumatoid arthritis were developing proficiency or demonstrating competencies in:

- Understanding structure-activity relationships and applying this knowledge to medication selection and use in patients.
- Explaining mechanisms of drug action and applying this knowledge to medication selection and use in patients.
- Recommending appropriate and recognizing inappropriate medication use in patients.
- Identifying cautions/contraindications for use and needed monitoring for medications in patients.
- Screening and avoiding adverse drug reactions in patients.
- Formulating therapeutic recommendations for patients and their health care professionals.
- Providing counseling information for patients and their health care professionals in the areas of osteoarthritis and rheumatoid arthritis.

This article provides a description of the active-learning assignments developed, reports student mastery of learning objectives in the areas of osteoarthritis and rheumatoid arthritis via performance on the 2 active-learning assignments and on examination questions, and describes student perceptions of the course as determined by standardized evaluations.

DESIGN

Disorders of Musculoskeletal Systems and Pain Management is a required third-year pharmacy (P3) module taught over 4 weeks in a block format in which the class meets 18 hours each week. In a pre-course meeting, 2 graded case-based active-learning assignments which would include questions from pathophysiology, medicinal chemistry, pharmacology, and therapeutics and require integration and synthesis of this material, were proposed. Each would count 2% of the course grade.

This project was approved by Mercer University's Investigational Review Board (IRB). The 2 cases, case questions, and a grading rubric (Figure 1) were developed. Detailed case answer keys were developed for faculty facilitators to use during the small-group breakout sessions. This project was evaluated using mastery of learning objectives in the areas of osteoarthritis and rheumatoid arthritis on traditional examinations and scores on the case assignments, and standard student course evaluation to determine the students' impression of the activity. The goal of the osteoarthritis and rheumatoid arthritis active-learning assignments was to assess student proficiency in integrating, synthesizing, and applying knowledge from individual faculty lectures in pathophysiology, medicinal chemistry, pharmacology, and therapeutics in evaluating patients to formulate therapeutic recommendations and provide patient counseling.

For student access, the 2 cases were posted to Mercer University's online course access platform 5 days before scheduled break-out case discussion meetings. In this pharmacotherapy module, students attended lectures on anatomy and physiology, the inflammatory process, immunologic reactions, physiology of pain, pathophysiology

Item	Maximum Score	Student Score
1. Quality of written responses.	2	
2. Quality of participation in case discussion group.	2	
3. Understanding of structure-activity relationships and mechanism of action of medications.	2	
4. Appropriateness of therapeutic recommendations considering patient specific parameters, including cautions, contraindications, and potential adverse reactions.	2	
5. Appropriateness of recommended patient monitoring and follow-up, considering patient specific needs.	2	
Total	10	
Active learning activities, maximum score = 10 Grade for each item: 2 = excellent, 1 = adequate, 0 = inadequate		

Figure 1. Grading rubric used for active-learning assignments on osteoarthritis and rheumatoid arthritis.

of osteoarthritis and rheumatoid arthritis, medicinal chemistry and pharmacology of medications used to treat these conditions, and the clinical presentation and therapeutic management of patients with osteoarthritis and rheumatoid arthritis. Students then worked in small groups to analyze and develop answers for the active-learning assignments. To increase participation, each student was required to turn in written answers to each case prior to the scheduled case discussions. The course coordinators divided the 146 students into 6 groups of 24-25 students for the case discussion sessions with 6 faculty facilitators.

The osteoarthritis case discussion occurred at the end of week 2 of the 4-week module, and the rheumatoid arthritis case discussion at the end of week 4. As per the grading rubric, students were graded based on their submitted written answers and participation during the case discussion sessions. In addition to performance on the graded case study exercises, student learning was assessed via performance on examination questions covering pathophysiology, medicinal chemistry, pharmacology, and therapeutics for osteoarthritis and rheumatoid arthritis. Items included on the standard end of course survey instrument were used to evaluate students' perceptions of the active-learning assignments.

EVALUATION AND ASSESSMENT

Student mastery of course learning objectives for osteoarthritis and rheumatoid arthritis was assessed via student performance on the 2 active-learning assignments (Figure 1) and student performance on specific examination questions on pathophysiology, medicinal chemistry, pharmacology, and therapeutics for osteoarthritis and rheumatoid arthritis. For this course, A = 89.5 or higher, B+ = 86.5 – 89.4, B = 79.5 – 86.4, C+ = 76.5–79.4, C = 69.5 – 76.4, and F = 69.4 or less. One hundred forty-nine students completed both the active-learning assignments and the examinations. The osteoarthritis active-learning assignment occurred prior to examination 2, and the rheumatoid arthritis active-learning assignment occurred prior to examination 4. Of the 4 examinations in the course, these 2 contained the questions specific to osteoarthritis and rheumatoid arthritis. The mean student grade for the osteoarthritis active-learning assignment was 9.1 ± 1.5 out of 10 (median 9.5). The mean student grade for the rheumatoid arthritis active-learning assignment was 8.9 ± 1.2 out of 10 (median 9.0). Examinations 2 and 4 contained 175 multiple-choice questions, 103 of which assessed mastery of specific learning objectives for the pathophysiology, medicinal chemistry, pharmacology, and therapeutics of osteoarthritis and rheumatoid arthritis. The mean number of the 103 questions on examinations 2 and 4 that were answered correctly was 82.2 ± 14.6 (median = 85.9).

Examinations 1 and 3 contained 160 questions. Two hundred thirty-two examination questions pertained to material not covered in the active-learning assignments. Mean student performance on these questions was 82.0 ± 13.9 (median = 85.5). When the students' performance on the 103 examination questions on the osteoarthritis and rheumatoid arthritis material were compared using the student *t* test to their performance on the other 232 examination questions, no significant difference in scores was found ($p = 0.91$).

Students' responses on the course evaluation are presented in Table 1 ($n = 110$; response rate = 73.8%). Responses were based on a 5-point scale: 1 = poor, 2 = less than adequate, 3 = adequate, 4 = more than adequate, and 5 = excellent. Means responses on all 8 items ranged from 3.7 to 3.9. Fifty-nine percent to 75% of students responded "more than adequate" to "excellent" on all 8 items. Item 5, "How well the active-learning activities (class exercises, discussion groups, laboratories) helped you learn," received a mean score of 3.7 ± 1.1 ($n = 110$). Sixty (54.5%) respondents ranked this item as "more than adequate" or "excellent." Item 6, "Integration of basic science, clinical, and administrative content," received a mean of 3.9 ± 1.0 ($n = 110$). Seventy-five (68.2%) of course evaluation respondents ranked this item as "more than adequate" or "excellent." The evaluation form included a section for free responses. Among the 39 responses received for this section, there were a few comments about the active-learning assignments, team-based case preparation, and discussion. Six students believed that the active-learning assignment grades should have been available prior to the subsequent examination covering the same material; 4 students made the suggestion that the lecture material needed for the active-learning assignment stop more than 2 days prior to the discussion days; 5 students stated that they enjoyed working with other students to complete the active-learning assignments prior to the discussion; 4 students commented that they learned from peers in the case discussion; 2 students indicated that completing the cases and attending the case discussions helped them prepare for the subsequent examinations; 2 students reported that completing the active-learning assignment infringed upon examination study time; and 1 student did not believe that the grading of participation was fair.

DISCUSSION

The osteoarthritis and rheumatoid arthritis exercises provided an opportunity for student integration of material presented by pharmaceutical sciences and pharmacy practice faculty members. Assessment of student performance on the integrated active-learning assignments was positive, with means of 9.1/10 and 8.9/10, respectively,

on the osteoarthritis and rheumatoid arthritis active-learning assignments (A to B+ performance level). Assessment data from the 103 examination questions indicated that students had a good mastery of the material as well, with a mean of 82.2 ± 14.6 (B level performance) and median grade of 85.9. However, there was no significant difference between student performance on examination questions based on the integrated case activities with lecture versus those based on traditional lecture only. This was not unexpected as in prior years student performance on examination sections on the pathophysiology, medicinal chemistry, pharmacology, and therapeutics of osteoarthritis and rheumatoid arthritis had been lower than examination performance on the other topics covered in the course, ie, gout, lupus, myasthenia gravis, fibromyalgia, muscle sprains and strains, and chronic pain management. The complexity of treatment regimens for rheumatoid arthritis and the need to incorporate material from the prior year's courses (cardiovascular and nervous systems) in formulating treatment plans to choose correct examination answers in the areas of osteoarthritis and rheumatoid arthritis present a challenge. Faculty members selected these topics for development and inclusion of the active-learning assignment to increase student competence in these areas. Student performance on all examinations this year was not compared to student performance from the prior year as course content, learning objectives, and grading had changed.

Student impressions of the course overall (Table 1, item 8) were positive (mean 3.8 ± 0.9), with 64.5% of

respondents indicating that the course overall was more than adequate to excellent. More applicable to this project, however, were the results on item 5 "How well the active-learning activities helped you learn," and item 6, "Integration of basic science, clinical, and administrative content." Sixty (54.5%) respondents ranked item 5 as "more than adequate" or "excellent" and 75 (68.2%) respondents ranked item 6 as "more than adequate" or "excellent." In our experience, active-learning assignments that integrate material from pharmaceutical sciences and pharmacy practice faculty members were beneficial to student learning and fairly well received by our students, who are members of the Millennial generation. Millennial generation students are considered goal oriented and they value team-based activities with real-life applications that support learning and preparation for future assessments.^{7,9,10} The simulation of patient case scenarios required student integration and application of material presented in earlier lectures, and this seemed to appeal to many of our students.

This project had several major limitations. Students were not randomized into an intervention group (lecture and integrated cases) or control group (lecture). We did not compare mastery of learning objectives prior to and after inclusion of osteoarthritis and rheumatoid arthritis integrated cases. However, as previously mentioned, course content, learning objectives, and grading were different in the prior year, which would have made comparison difficult or even unfair. Also, it would have been preferable to include a voluntary student perception survey specific to the osteoarthritis and rheumatoid arthritis active learning

Table 1. Course Evaluation Items and Student Responses, n=110

Survey Item	Response, No. (%)					Mean (SD)
	Poor	Less Than Adequate	Adequate	More Than Adequate	Excellent	
Organization of the course.	0 (0)	10 (9)	28 (25.5)	33 (30)	38 (34.5)	3.9 (1.0)
Coordination of team teaching.	0 (0)	9 (8.2)	38 (34.5)	29 (26.4)	34 (31)	3.8 (1.0)
How well the required materials (textbook, course packs, etc) helped you learn.	1 (0.9)	13 (11.8)	37 (33.6)	28 (25.5)	31 (28.2)	3.7 (1.0)
How well the technology utilized (Blackboard, CD ROM, Online data bases, etc) helped you learn.	1 (0.9)	7 (6.4)	33 (30)	38 (34.5)	27 (24.5)	3.8 (0.93)
How well the active learning activities (class exercises, discussion groups, laboratories) helped you learn.	2 (1.8)	15 (13.6)	31 (28.2)	30 (27.3)	30 (27.3)	3.7 (1.1)
Integration of basic science, clinical, and administrative content.	2 (1.8)	3 (2.7)	30 (27.3)	44 (40)	31 (28.2)	3.9 (0.9)
How well the testing/evaluation methods reflected content covered.	3 (2.7)	3 (2.7)	34 (3.1)	37 (33.6)	33 (30)	3.9 (1.0)
The course overall.	1 (0.9)	4 (3.6)	34 (31)	45 (40.9)	26 (23.6)	3.8 (0.9)

assignments. The high student response rate and positive response on course evaluation items 5 and 6 tempers this limitation.

CONCLUSION

The majority of students indicated that learning exercises in arthritis requiring integration of material from the pharmaceutical sciences and clinical pharmacy faculty were more than adequate to excellent in helping students learn. Grades from examinations and exercises documented that students had a good mastery of course learning objectives in this area.

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