RESEARCH

A Peer-Teaching Model to Reinforce Pharmacy Students' Clinical Knowledge of Commonly Prescribed Medications

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Objective. To implement and assess the effectiveness of a peer teaching series to increase third year Doctor of Pharmacy (PharmD) students' knowledge of and confidence regarding commonly prescribed medications.

Methods. All third-year pharmacy students (n=98) at a college of pharmacy were encouraged to participate in the RxReady peer teaching series prior to beginning their advanced pharmacy practice experiences. Each student in the class was assigned a drug to learn in-depth. Twenty-four of the students were randomly selected to provide peer teaching regarding a single medication. These students were required to meet with a faculty member to prepare for their presentation. Assessment methods included completion of pre- and post-intervention quizzes and anonymous surveys regarding the peer-teaching modality. Students also provided qualitative feedback on the series as part of a course survey.

Results. Among the 96 students who completed the pre- and post-intervention quizzes, there was a mean increase of 15% (SD=11%) on the post-intervention quiz score compared to the pre-intervention quiz score. Ninety-two (96%) students achieved a higher score on the post-intervention quiz. There was no difference in mean percent change in scores between the pre-and post-intervention quiz for students who presented in class compared with students who did not present (17% [SD=10%] vs 15% [SD=11%], respectively). Student-reported confidence significantly improved across all drug knowledge categories. In each category, the median confidence score increased from 2 (somewhat confident) to 3 (moderately confident). The students' qualitative feedback was generally positive, and they provided suggestions to improve the content and design of the RxReady peer teaching series.

Conclusion. A peer teaching approach to reviewing drug information can assist in targeting gaps in PharmD students' drug knowledge and help to build their confidence in their readiness to begin APPEs.

Keywords: peer teaching, top 200 drugs, drug knowledge, student confidence

INTRODUCTION

In 2016, the Accreditation Council for Pharmacy Education (ACPE) updated Doctor of Pharmacy (PharmD) degree standards to require colleges of pharmacy to assess readiness to enter advanced pharmacy practice experiences (APPEs), which is commonly referred to as "pre-APPE readiness."[1] Although ACPE provides example performance competencies that students should meet for each core domain, this directive did not specify how to assess student preparedness. Each school and college of pharmacy is given the flexibility to design assessments compatible with their curricula and practice experiences. During a major curriculum redesign, the Oregon State University College of Pharmacy significantly altered the program's final didactic quarter before students began their APPEs to address this directive. This redesign resulted in splitting the spring quarter of the third professional (P3) year into the Pre-APPE Readiness (PAR) Block and creating an additional required APPE.

The mission of the PAR Block is to ensure students' confidence, competence, and readiness to integrate into collaborative health care settings and serve diverse

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patient populations during the APPE curriculum year. During the PAR Block, multiple assessments were administered to assess students' knowledge, attitudes, and values of the profession. One of these assessments is the Prescription Readiness Assessment Test (RxRAT), a 100-item multiple-choice examination that evaluates students' knowledge of the core domain of medication information, including brand and generic drug names, mechanisms of action, and drug interactions. After the inaugural launch of the PAR Block in spring 2017, the college noticed that 34% of the students received a score of less than 70% on the RxRAT and needed to retake the examination. The high retake rate suggested that the students had difficulty retaining drug information learned during their first professional (P1) and second professional (P2) years of the PharmD program.

Few published studies have evaluated methods for teaching and assessing top 200 drug knowledge.[2-6] Typically, top 200 drugs are introduced during the P1 year, and students' drug knowledge fades unless reinforced in subsequent courses. Educational research in multiple disciplines has demonstrated that repeated opportunities to recall and apply new knowledge is crucial to knowledge retention.[7,8] Deficiencies in students' retention of drug information have been reported as an area of concern in other pharmacy programs. Valdez and colleagues observed significant reductions (decreases from 70.4% to 60.9%) in knowledge retention and clinical confidence in second-year pharmacy students over four months. They postulated that the decline in knowledge retention was attributable to the lack of integration of core concepts throughout the curriculum.[9] Various strategies, such as space learning and gaming, have been described in the literature as ways to address students' retention of knowledge about the top 200 drugs.[10,11]

To address the observed drug knowledge deficit in P3 students at our college, a series called "RxReady" was created in the P3 Pharmacy Practice course. During the series, students engaged in in-depth learning of one specific drug and then a subset of those students were selected to peer teach an assigned drug. The objective of this study was to describe the design and incorporation of this peer teaching series and its impact on student confidence and performance on a comprehensive, knowledge-based assessment for commonly used medications.

METHODS

The Oregon State University College of Pharmacy is a dual-campus, four-year program that includes three quarters every year for the first three years and experiential clerkship or APPEs during the last year of the curriculum. Approximately 90 students are enrolled each

year. The Oregon State University Institutional Review Board reviewed this project and deemed it exempt.

The RxReady series was implemented in 2018 for third-year pharmacy students and consisted of six one-hour, in-person, peer teaching sessions. These series were a part of the P3 Pharmacy Practice laboratory course, and students received up to five additional points based on their level of participation. Students learned about Top 200 drugs during their P1 and P2 years, including the mechanisms of actions, adverse reactions, and black box warnings. Our intention was to expand on students' basic understanding of these drugs and improve their clinical reasoning process by applying their knowledge to patient-specific situations. A list of the top 200 drugs was generated based on volume of prescriptions. Before starting the term, a unique drug was randomly assigned to each P3 student based on a therapeutic area (eg, cardiovascular, endocrine, central nervous system, pain, neurology). Only one drug was selected from each therapeutic class included in the top 200 list to expose the students to different classes of drugs. All students were expected to complete a drug card for their respective drug using a drug template (Figure 1). All completed drug cards were shared on a university-supported learning management system, Canvas LMS (Instructure), to ensure all students had access.

Four drugs were selected for presentation each week. Given that this series was scheduled for six weeks, a total of 24 students presented during class. The drugs included for presentation were selected based on the likelihood of the drug being encountered during the students' APPEs. Furthermore, the drugs were paired based on potential drug interactions (eg, nitroglycerin and sildenafil), similar indications with different mechanism of actions (eg, omeprazole and ranitidine), or commonly used together because of comorbidities (eg, amiodarone and levothyroxine). The intent of pairing was to help students remember drugs by their relationship to other drugs. Additionally, to encourage students to develop an in-depth understanding of each drug, five to six targeted questions associated with each drug were distributed to the entire class before the sessions so that all students had the opportunity to prepare and participate (Table 1). These targeted questions addressed clinical conundrums associated with each drug to further develop students' critical thinking skills and encourage them to reference primary literature to answer the questions.

To ensure the accuracy and thoroughness of presentations, individuals chosen to present were scheduled for mandatory one-on-one meetings with course facilitators prior to class. Each student presenter had an average of two one-hour meetings with the faculty or resident prior to presenting. The students who served as peer

Generic (Brand): Color of cell: Salmon = cardiovascular, Blue = respiratory, Orange = endocrinology, Green = antimicrobial, Yellow = neurologic, Light grey = analgesics, No color = miscellaneous	Boxed Warning: REMS:	Dosage forms/strengths:
Class: MOA: *May display image or written description here*	Common initial ± max/target doses:	Adjustments: Renal/Hepatic:
	Common SE	
	Serious SE/ Contraindications	
	Efficacy monitoring parameters	
	Safety monitoring parameters	
	Major drug-interactions	

Figure 1. Peer-Teaching Drug Card Template for Each Assigned Drug

teachers provided a 10-minute presentation to the class in which they discussed the drug card and responded to targeted questions. At the end of the presentations, the course facilitators provided a summary of the important concepts covered and answered student questions generated during the activity. Each session concluded with all students completing a five-item quiz based on the targeted questions discussed during the class. This quiz provided students with immediate feedback on their knowledge gaps as well as assessed their short-term retention. The correct answers to the questions on the quiz were discussed shortly after the session if time permitted or at the start of the next session. Additionally, students completed two homework exercises during the RxReady series. One focused on commonly used antimicrobials, and the other was a 30-item multiple-choice formative assessment pertaining to drugs included in the Top 200 drugs but not covered during regular sessions.

To assess changes in drug knowledge, students completed a 30-item quiz on the first and last week of the course (pre- and post-quiz, respectively). Questions were identical in the pre- and post-intervention quizzes and assessed the following drug knowledge categories: drug indications, mechanism of action, pharmacokinetics/

Table 1. Examples of Targeted Questions to Reinforce Their Clinical Knowledge of Commonly Prescribed Medications

Types of Questions	Questions
Recalling dosing and formulations:	What is the starting dose of levothyroxine in elderly patients and patients with coronary artery disease? What is the difference between isosorbide dinitrate and mononitrate? How would you discontinue pramipexole?
Determining common and significant side effects:	Why does paroxetine have the highest risk of withdrawal symptoms? What are the safety concerns with long-term use of proton pump inhibitors? Explain the cardiovascular risk of ibuprofen including risk of heart failure hospitalization. What is mechanism of pedal edema with calcium channel blockers?
Explaining the pharmacokinetics and pharmacodynamics:	Name at least two major drug-drug interactions with amiodarone and explain how to manage these interactions. In a healthy person, when should phenytoin levels be drawn? Why is it important to monitor tacrolimus concentrations and when should a level be drawn?
Providing key counseling points to a patient:	Can lamotrigine be used in pregnancy? What is the evidence when compared to other antiepileptics? How would you counsel a patient on empagliflozin? How would you counsel a patient starting olanzapine therapy?

pharmacodynamics, dosing, side effects, counseling, and drug-drug interactions.

A post-series survey was sent to all students after the completion of the RxReady sessions using Qualtrics XM (Qualtrics), a web-based survey platform. This survey used a retrospective pretest-posttest design and included questions using a four-point Likert scale (1=not at all confident; 2=somewhat confident; 3=moderately confident; 4=very confident) to assess confidence in fundamental pharmacotherapy knowledge relating to the drug knowledge categories described above.[12] Students also provided qualitative feedback on the sessions at the end of the survey. Additionally, as part of the PAR Block, students' first attempt pass rates on the RxRAT were also evaluated.

Data management and analysis were performed using Excel and SAS, version 9.4. Changes in students' drug knowledge were assessed as the difference in score (expressed as a percentage) between the baseline score and end of course quiz and evaluated using the Student t test with a null hypothesis of no change in score. Individual drug knowledge categories were analyzed using a one-sample t test of the mean difference between pre- and post-intervention quiz scores.

Mean change in scores on the RxReady pre- and post-intervention quizzes for students who passed their initial RxRAT attempt were compared to those who did not pass using an independent two-sample t test. Differences in scores were also compared between the 24 presenters versus the rest of the class using an independent two-sample t test. The results of the survey questions were analyzed using the Wilcoxon signed rank test. We used thematic content analysis to review students' responses to the open-ended questions from the survey.

RESULTS

Ninety-eight students participated in the RxReady series. Two students were excluded from the analysis because they did not complete the pre- and post-quiz. Of the 96 students who completed both the pre- and post-intervention quizzes, 92 (96%) showed knowledge improvement, with a mean percentage increase in score of 15% (SD=11%; $p<.001$). The difference in the mean change in performance between the pre- and post-quiz was higher among students who passed the RxRAT on their first attempt compared to those who had to retake the test (16% [SD=10%] vs 9% [SD=9%], $p<.05$). There was no difference in mean change in quiz scores for students who presented in class (n=24) compared to students who did not present (n=72) (17% [SD=10%] vs 15% [SD=11%], $p=.33$). Students' scores on all the drug knowledge categories ($p<.05$) except pharmacokinetics/pharmacodynamics improved significantly.

Forty-nine (50%) students responded to the post-series survey. The students' level of confidence pre- and post-survey improved as shown in Figure 2. The survey also showed that student-reported confidence significantly improved across all drug knowledge categories, with a median rank change of 1 point on the 4-point scale for each category (IQR [(0-0.5) – 1]; $p<.05$). In each individual category, the median confidence score increased from 2 (somewhat confident) to 3 (moderately confident).

Among the students who participated in the survey, 88% (n=43) and 90% (n=44) reported that both the homework assignments and the targeted questions respectively were helpful in enhancing their overall knowledge of medications. Majority of the students (n=48, 98%) also indicated that the supplemental materials presented by the facilitators were helpful or somewhat helpful in solidifying drug knowledge concepts. Fourteen of the 24 students assigned to present in class responded to additional survey questions to determine whether the personalized preparatory session(s) with course facilitators were helpful. Among these students, 11
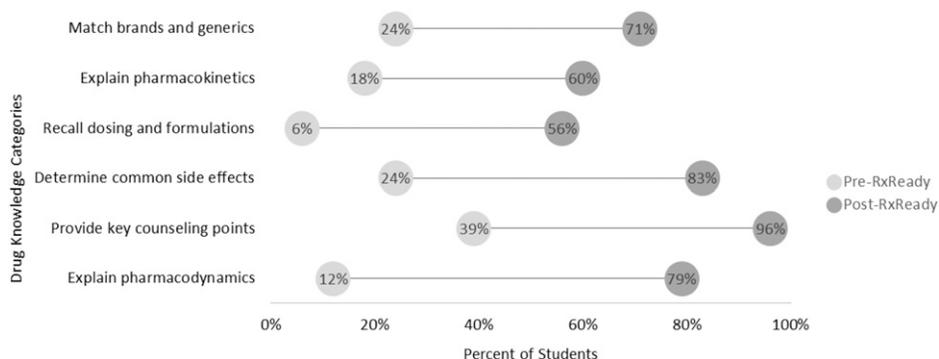

Figure 2. Percentage of Students Indicating Moderate or Very High Confidence in the Post-intervention Survey in Each Drug Knowledge Category

(79%) agreed that the one-on-one sessions were helpful or somewhat helpful in increasing their knowledge and confidence in presenting their drug card in class.

The students' qualitative feedback about how the RxReady series helped them revealed three common themes: reinforcement and enhancement of drug knowledge, development of communication skills, and APPE readiness and beyond. Student quotes exemplifying these themes are summarized in Table 2. Students suggested initiating the RxReady series earlier in their curriculum, ie, during the P1 and P2 years. Additionally, students recommended some changes to the experience for future students, which included increasing the length and frequency of the sessions to cover more drugs in depth.

DISCUSSION

Mastery of fundamental knowledge of medications is essential to PharmD students developing advanced practice skills. With the steady increase in the number of prescription and nonprescription medications, it is challenging for pharmacy schools to develop a comprehensive knowledge base and create mechanisms for students to have repeated exposure to the content. The peer teaching series was implemented to address these issues and prepare students for Pre-APPE Readiness. Student drug knowledge improved as reflected by an increase in scores between the pre- and post-intervention quizzes, and learner-reported confidence also improved based on the survey.

Evidence suggests the positive effects of active-learning strategies and peer teaching in improving the drug knowledge of pharmacy students.[13] A review by Aburahma and colleagues identified six educational research studies that incorporated various methods for peer teaching.[14] These studies highlight that peer teaching promotes a culture of intrinsic motivation and perhaps helps to develop a skill set necessary for lifelong learning. However, this evidence did not show that the examination scores of students who participated in peer teaching improved. Our approach to implementing peer teaching differed from that previously reported in the literature as we recruited peer teachers from the same curricular year rather than a utilizing a hierarchical approach where senior students mentor junior students.[14] For this activity, peer teachers were selected at random from within the cohort rather than asking for students to volunteer. Our intention for this approach was to include students who were generally less inclined to participate.

Drug cards and targeted questions were used to encourage students to identify reputable and pertinent drug information resources, improve their critical thinking skills, and take ownership of their learning experiences. Students stated that the brief drug summaries provided by

Table 2. Student Feedback on Strengths of RxReady Series

Strengths	Exemplar Comments
Reinforcement and enhancement of drug knowledge	"This course provided additional and relevant information about drugs that we were not familiar with." "We were able to go over drugs that previously were not taught in such detail. Some of the information appeared in other areas such as the PCOA exam. Overall, it helped to solidify more information." "Fun and creative way to learn Top 200 drugs." "It helped to reinforce the utilization of primary resources to answer drug information questions. It touched on concepts that have not been discussed since P2 year, which are vitally important to students."
Development of communication skills	"I think that having presentations is a great way to prepare students for future rotations, residencies, and jobs." "This course provided the skills to find [drug information resources] and communicate the important information about medications."
APPE readiness and beyond	"Preparing for PAR block and future career." "This information will be especially helpful when I start my community and ambulatory rotations in May/June." "I have applied this knowledge at work and discussed targeted questions with my preceptors." "I believe the knowledge...will definitely help me in my future practice such as at work, rotations and other practices, and with patients or family and friends."

PCOA=pharmacy curriculum outcomes assessment, P2=second professional year, APPE=advanced pharmacy practice experiences, PAR=pre-APPE readiness

the facilitators and discussions relating to targeted questions were strengths of the course series. Some students later reported that they had applied the knowledge and skills gained from this series in their internships and introductory pharmacy practice experiences.

One of the challenges of peer teaching is to ensure that the material delivered is accurate and relevant. Our process of requiring the peer teachers to attend sessions with facilitators allowed the peer teachers to become well versed with the content before giving their presentation to the class. Students who completed the survey expressed that their individualized sessions with the facilitators were helpful in developing their presentation skills and confidence levels.

Since the implementation of RxReady, we observed a steady decrease in student retake rates on the RxRAT examination from 34% to 11% over the last three years. Even though these findings are encouraging, the results cannot be solely attributed to the RxReady series as other changes were instituted to prepare students to be successful in Pre-APPE Readiness assessments. These included providing students with sample examination items and general curriculum refinement after the first wave of the new curriculum was delivered. These concomitant changes were mostly logistical and not directly associated with curricular content; therefore, the improvement in RxRAT retake rates is likely attributable to students' participation in the RxReady series. Nevertheless, students were able to identify their gaps in knowledge through this activity and develop strategies to improve their drug knowledge skills.

Key limitations in this study should be considered. Only 24 students served as peer teachers. Although the majority of the students did not have an opportunity to serve as peer teachers, observing their peers hopefully helped them to reflect on and improve their own drug knowledge skills. Furthermore, students who presented did not have a greater improvement in scores compared to students who did not get the opportunity to present. The college's long-term goal is to implement RxReady over the pharmacy practice laboratory series so that all students have the opportunity to peer teach and develop their presentation and communication skills. On the post-series survey, the majority of students responded positively to the RxReady series, even if they had not presented. Covering four drugs in detail in an hour was challenging. Students indicated that sometimes it was difficult to grasp the concepts during presentations as the student presenters were rushed to cover the content and to teach all the relevant information in the allocated time. However, the summary provided by the facilitators at the end of each session helped to clarify the main points.

CONCLUSION

The RxReady peer teaching series engaged pharmacy students in clinically meaningful activities that prompted them to recall previous drug knowledge while also challenging them to gain new knowledge. The series was an effective active-learning pedagogy that was used to target gaps in pharmacy students' pharmacotherapy knowledge and enhance their preparedness before beginning their APPEs. Future curricular revisions should be designed to improve long-term retention of drug knowledge.

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Appendix 1. Student-reported Confidence Level Pre- and Post-RxReady Using a 4-point Likert Scale Upon Completion of the Series

Matching Brand and Generics (n=49)[a]

	Pre-RxReady			
	Not Confident (n=14)	Somewhat Confident (n=23)	Moderately Confident (n=12)	Very Confident (n=0)
Post-RxReady Not Confident, No (%)	3 (21)	0	0	0
Somewhat Confident, No. (%)	7 (50)	5 (22)	0	0
Moderately Confident, No. (%)	4 (29)	17 (74)	10 (83)	0
Very Confident, No. (%)	0	1 (4)	2 (17)	0

Recalling Dosing and Formulation (n=48)[a]

	Pre-RxReady			
	Not Confident (n=23)	Somewhat Confident (n=22)	Moderately Confident (n=3)	Very Confident (n=0)
Post-RxReady Not Confident, No (%)	6 (26)	0	0	0
Somewhat Confident, No. (%)	11 (48)	5 (23)	0	0
Moderately Confident, No. (%)	6 (26)	17 (77)	3 (100)	0
Very Confident, No. (%)	0	0	0	0

Determining Common Side Effects (n=49)[a]

	Pre-RxReady			
	Not Confident (n=7)	Somewhat Confident (n=30)	Moderately Confident (n=11)	Very Confident (n=1)
Post-RxReady Not Confident, No (%)	0	0	0	0
Somewhat Confident, No. (%)	5 (71)	4 (13)	0	0
Moderately Confident, No. (%)	2 (29)	24 (80)	8 (73)	0
Very Confident, No. (%)	0	2 (7)	3 (27)	1 (100)

Explaining Pharmacokinetics (n=49)[a]

	Pre-RxReady			
	Not Confident (n=14)	Somewhat Confident (n=26)	Moderately Confident (n=9)	Very Confident (n=0)
Post-RxReady Not Confident, No (%)	5 (36)	0	0	0
Somewhat Confident, No. (%)	7 (50)	7 (27)	0	0
Moderately Confident, No. (%)	2 (14)	19 (73)	8 (89)	0
Very Confident, No. (%)	0	0	1 (11)	0

Appendix 1. (*Continued*)

Explaining Pharmacodynamics (n=49)[a]

	Pre-RxReady			
	Not Confident (n=12)	Somewhat Confident (n=31)	Moderately Confident (n=6)	Very Confident (n=0)
Post-RxReady				
Not Confident, No (%)	2 (17)	0	0	0
Somewhat Confident, No. (%)	5 (42)	4 (13)	0	0
Moderately Confident, No. (%)	4 (33)	25 (81)	5 (83)	0
Very Confident, No. (%)	1 (8)	2 (6)	1 (17)	0

Providing Key Counseling Points (n=49)[a]

	Pre-RxReady			
	Not Confident (n=5)	Somewhat Confident (n=25)	Moderately Confident (n=17)	Very Confident (n=2)
Post-RxReady				
Not Confident, No (%)	0	0	0	0
Somewhat Confident, No. (%)	2 (40)	0	0	0
Moderately Confident, No. (%)	2 (40)	22 (88)	11 (65)	0
Very Confident, No. (%)	1 (20)	3 (12)	6 (35)	2 (100)

[a] Number of students who completed the question on the survey