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Research Paper

Pharmacy resident teaching and learning curriculum program outcomes: Student performance and quality assessment

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ABSTRACT

Introduction: The purpose of this study was to assess: (1) student performance on topics taught by first and second year postgraduate pharmacy residents and (2) the quality of learning objectives and multiple choice questions prepared by pharmacy residents.

Methods: Using a retrospective cohort design, residents and students who taught or were enrolled, respectively, in the Medication Therapy Management course in years 2010 to 2012 were participants in this study. Student performance was assessed using scores earned on the individual readiness assurance tests (iRATs), team readiness assurance tests (tRATs), and course examinations. To assess the quality of the learning objectives and multiple choice questions written by pharmacy residents, criteria were established by the authors. Each learning objective and multiple choice question was then evaluated independently by two authors to determine if these criteria were met.

Results: Statistical differences were observed in student performance across all content areas among the three years for iRAT, tRAT, and course examination scores, with the exception of the heart failure course examination ($p = 0.05$; all other p -values < 0.05). A total of 20 (42%) learning objectives met all quality review criteria, while 73 (79%) of the multiple-choice questions met all quality review criteria.

Discussion and conclusions: Student performance varied significantly depending on the content, but the overall impact of resident instructors on student course performance was not educationally significant. Teaching and learning curriculum programs should focus on teaching residents to create quality learning objectives that help students focus on learning the most important course content.

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Introduction

In 2006, the American College of Clinical Pharmacy (ACCP) published a position statement regarding the completion of postgraduate residency training for pharmacists who intended to enter direct patient care practice.¹ The position statement recommended resident instruction in teaching methods as an essential component of postgraduate training.¹ The first report regarding the incorporation of a formal teaching and learning curriculum program into pharmacist residency training was published in 2001.² Since that time, many institutions have implemented teaching and learning curriculum programs for pharmacy residents in postgraduate years one and two. In 2013, the ACCP published a white paper and provided guidelines for resident teaching experiences.³ This white paper specified recommendations to include content related to basic teaching experiences such as writing learning objectives and evaluating student performance. Identifying learning objectives prior to teaching has distinct advantages for both instructors and students. They provide a clear picture of the intended outcome as a result of teaching-learning interactions. Learning objectives communicate the target behavior that the instructor wants students to show as a measure of successful attainment of behavioral change, hence acquisition of new knowledge, skill attainment, values orientation, or professional attributes. Similarly, learning objectives help focus student attention on what they need to study and master promoting their concentration on what is essential. When measured along a continuum, learning objectives indicate the degree of success students have attained and additional behavioral changes, new learning, skill attainment, or attitude formation still needed. When used wisely, learning objectives can be used to develop corresponding measures of assessment to test the sustainability of behavioral changes, skill development, or performance actions over time. Learning objectives provide a means for faculty to communicate with one another across courses, programs, or institutions. In addition, they give purpose and focus to teaching in ways that can ensure alignment between the selection and organization of content, learning activities, assessments, and outcomes. Determining learning objectives prior to instruction can assist instructors with selecting the material that is likely to be of greatest value to students.⁴

In 2014, the American Association of Colleges of Pharmacy (AACP), Pharmacy Practice Section's Task Force on Student Engagement and Involvement collaborated with the American Society of Health-System Pharmacy (ASHP) to establish a framework for teaching and learning curriculum programs.⁵

After their review of published teaching and learning curriculum programs for pharmacy educators, Strang et al⁶ recommended further study of program quality outcomes related to teaching behaviors and faculty development. The review identified 20 papers on residency training teaching and learning curriculum programs. They discovered that the outcomes of these programs relied heavily on the use of participant surveys and changes in self-efficacy following program completion. In addition, the framework created by Wright et al.⁵ recommended a process for programmatic assessment. However, this framework focuses heavily on participant surveys and self-efficacy of the participants and does not recommend routine assessment of the quality of instructional materials created by residents in the program. To date, there has been one published report of a program that assessed the impact of resident instruction in an elective course on student performance.⁷ However, the quality of the instructional materials prepared by residents has not yet been evaluated. The purpose of this study was to assess: (1) student performance on topics taught by first and second year postgraduate pharmacy residents in a required course and (2) the quality of learning objectives and multiple choice questions prepared by pharmacy residents.

Methods

This proposal was reviewed and deemed exempt by the University of Tennessee Graduate School of Medicine and University of Florida Institutional Review Boards. In 2009, faculty at the University of Tennessee Health Science Center College of Pharmacy implemented a teaching and learning curriculum program for pharmacy residents in programs throughout the state. First and second postgraduate year pharmacy residents at the University of Tennessee Medical Center participated in this program. The program components met the criteria for a resident teaching certificate program described by the ACCP white paper on resident teaching experiences.³ These components included: (1) developing a teaching philosophy, (2) receiving guidance from a mentor, (3) attending a seminar and workshop series focused on educational pedagogy, and (4) acquiring experiences in delivering didactic lectures, facilitating small-group active learning, and precepting students on advanced pharmacy practice experiences (APPEs). The program elements are summarized in [Table 1](#). Of note, the teaching and learning curriculum program provided instruction on writing learning objectives, multiple choice questions, and active learning strategies including team-based learning (TBL). Residents who participated in the program were also instructors in a required Medication Therapy Management (MTM) course that was offered in the spring semester of the second professional year in the doctor of pharmacy degree program. As the instructors, residents created materials for one topic that was delivered as a one-hour didactic lecture and a two-hour TBL session. The residents wrote multiple choice questions for the readiness assurance tests (RATs) for the TBL sessions and course examinations. Each resident was paired with a faculty mentor who provided guidance in developing course materials. After mentor approval, the course director reviewed the materials. Residents teaching in this course also received additional training in creating TBL modules and specific classroom procedures used in the course.

Using a retrospective cohort design, residents and students who taught or were enrolled, respectively, in the MTM course in 2010 (year 1), 2011 (year 2), and 2012 (year 3) were participants in this study. The analysis included course topics that residents taught across all three years of the study period, including hypertension, heart failure, dyslipidemia, and gastroesophageal reflux disease (GERD). Prior to enrollment in the MTM course, all students completed a therapeutics course that first introduced pathophysiology and management of these disease states. The disease content was taught by a different instructor in the therapeutics course series. For the MTM course, each year a different resident taught each topic with the exception of the heart failure content, which was taught by

Table 1

University of Tennessee Health Science Center College of Pharmacy teaching and learning curriculum program elements.

Program element	Description	Time of year
Resident symposium	7–8 h symposium; topics varied slightly each year, but commonly included: -Creating a syllabus -Learning objectives -Exam questions -Introduction to teaching methodologies -Evaluating student achievement	August
Seminar series	Attend 80% of the 2 h presentations on topics including: -Educational philosophy and assembling a teaching portfolio -Preparing class materials -Lecture presentation skills -Using technology in education	One seminar in each of the following months: September, October, November, February
Workshop series	Attend all workshops on topics including: -Writing learning objectives -Exam questions and item analysis -Teachers panel discussion	One workshop in each of the following months: October, January, March
Active learning facilitator	Facilitate at least 8 h of active learning sessions and be evaluated by students and mentor	Spring semester (January–March)
Large group instruction	Present at least one 50-min lecture to students which includes learning objectives, presentation slides, and exam questions	Spring semester (January–March)
Experiential teaching	Serve as primary preceptor for at least one student on an advanced pharmacy practice experience Create a syllabus for a fictional advanced pharmacy practice experience	Precept during the final 6 months of the residency experience
Teaching portfolio	Teaching philosophy Fictional Advanced Pharmacy Practice Experience syllabus Summary of teaching experiences Examples of teaching work (learning objectives, presentation handout, assessment questions) Documentation of teaching effectiveness (student, peer, and faculty/mentor feedback) Current Curriculum Vitae	Submitted in December (formative assessment) and May (summative assessment)

the same resident in years 1 and 2.

Student performance

Student performance was assessed using scores earned on the individual RATs (iRATs), team RATs (tRATs), and course examinations for the content areas that were developed by pharmacy residents. The number of multiple choice items for the iRAT and tRAT within each TBL session was standardized at five questions and the same questions were used for both the iRAT and tRAT. The number of items on the course examinations was variable, so they were adjusted to a score of 10 possible points for comparison. In instances where the same student was enrolled in the course during more than one of the study years, only data from the first year of course enrollment was used for the analysis. Data for students with excused absences from a class session were treated as missing data for the iRAT and tRAT. There were no missing data for course examinations.

Quality review

To review the quality of the learning objectives and multiple choice questions, criteria were established by the authors as shown in [Appendices A](#) and [B](#). The criteria were developed based on best practices for writing learning objectives and multiple choice questions that were developed by the University of Wisconsin-Madison Continuing Studies, the Vanderbilt University Center for Teaching.^{8,9} The learning objectives and multiple choice questions were then evaluated independently by two authors to determine if these criteria were met. One of these authors did not have any prior interaction with the course design, content, or residents included in the study. The other author served as a course director for the years of the study. Results of the independent quality review were compared when discrepancies occurred. The authors engaged in a face-to-face discussion to reach consensus on discrepant ratings.

Statistical analysis

Kolmogorov–Smirnov tests were conducted to test the normality of data distribution. Since the scores of all dependent variables were non-normally distributed ($p < 0.001$), Kruskal–Wallis tests followed by the Dunn–Bonferroni approach to post hoc pairwise

Table 2

Student performance on individual readiness assurance tests (iRAT).

	Year 1 N = 170 Mean ± SD	Year 2 N = 143 Mean ± SD	Year 3 N = 129 Mean ± SD	All years N = 442 Mean ± SD	p value
Hypertension ^a	4.5 ± 0.66	3.63 ± 1.03	3.97 ± 0.99	4.06 ± 0.97	<0.001
Heart failure ^{a,b}	4.48 ± 0.86	3.97 ± 0.87	4.19 ± 0.89	4.23 ± 0.9	<0.001
Dyslipidemia ^a	3.81 ± 0.92	3.38 ± 1.19	3.66 ± 1	3.63 ± 1.05	0.01
GERD ^a	4.80 ± 0.58	4.03 ± 1.28	3.8 ± 1	4.26 ± 1.07	<0.001
Total iRAT ^c	17.61 ± 1.58	15.01 ± 2.53	15.67 ± 2.39	16.18 ± 2.45	<0.001

SD = Standard Deviation; GERD = gastroesophageal reflux disease; iRAT = individual readiness assurance test.

^a Students could earn up to five possible points.^b Topic was taught by the same resident in year 1 and year 2.^c Students could earn up to 20 possible points.

multiple comparisons were used to compare students' iRAT, tRAT, and course examination scores among study years. Quality review of learning objectives and multiple choice questions was summarized using descriptive statistics.

Results

A total of 442 students were enrolled in the course during the study period (year 1, $n = 170$; year 2, $n = 143$; year 3, $n = 129$). There were 11 unique pharmacy residents who were responsible for content development (year 1, $n = 4$; year 2, $n = 3$; year 3, $n = 4$).

Student performance

Tables 2–4 identify the differences in student performance across the study period for iRATs, tRATs, and course examinations, respectively. Student performance was higher on tRATs than iRATs. Of note, statistical differences were observed in student performance across all content areas among the three years for iRATs, tRATs, and course examination scores, with the exception of the heart failure course examination ($p = 0.05$; all other values $p < 0.05$). When data were summarized to include all content areas, statistical differences were observed for the iRAT, tRAT, and course examinations across all years of the study period ($p < 0.001$).

Quality review

The results of the quality review of learning objectives and multiple choice questions are listed in Tables 5 and 6, respectively. The review included 48 unique learning objectives (year 1, $n = 15$; year 2, $n = 14$; year 3, $n = 21$) and 92 unique multiple choice questions (year 1, $n = 29$; year 2, $n = 36$; year 3, $n = 36$). Two objectives and nine multiple choice questions from year 1 were repeated for use in year 2 and only counted once in the quality analysis. Author ratings for the quality analysis were congruent without need for consensus development for 35 (73%) of the learning objectives and 75 (82%) of the multiple choice questions. A total of 20 (42%) learning objectives met all quality review criteria, with a median of one flaw observed in each learning objective. The most common reason why a learning objective did not meet the quality criteria was that it did not clearly specify the change in student behavior that was sought during instruction. A total of 73 (79%) of the multiple choice questions met all quality review criteria, with a median of zero flaws observed in each multiple choice question. The most common reason why a multiple choice question did not meet the quality criteria was that the answer choices were not similar in length.

Table 3

Student performance on team readiness assurance tests (tRAT).

	Year 1 N = 170 Mean ± SD	Year 2 N = 143 Mean ± SD	Year 3 N = 129 Mean ± SD	All years N = 442 Mean ± SD	p value
Hypertension ^a	4.83 ± 0.38	4.1 ± 0.97	4.88 ± 0.52	4.61 ± 0.75	<0.001
Heart failure ^{a,b}	4.92 ± 0.56	4.72 ± 0.59	4.85 ± 0.53	4.83 ± 0.57	<0.001
Dyslipidemia ^a	4.66 ± 0.65	4.32 ± 0.81	4.41 ± 0.65	4.48 ± 0.72	<0.001
GERD ^a	4.97 ± 0.39	4.76 ± 1.02	4.91 ± 0.294	4.88 ± 0.65	0.002
Total tRAT ^c	19.37 ± 0.986	17.90 ± 2.22	19.07 ± 1.22	18.80 ± 1.68	<0.001

SD = Standard Deviation; GERD = gastroesophageal reflux disease; tRAT = individual readiness assurance test.

^a Students could earn up to five possible points.^b Topic was taught by the same resident in year 1 and year 2.^c Students could earn up to 20 possible points.

Table 4

Student performance on course examination content.

	Year 1 N = 170 Mean \pm SD	Year 2 N = 143 Mean \pm SD	Year 3 N = 129 Mean \pm SD	All years N = 442 Mean \pm SD	p value
Hypertension ^a	7.82 \pm 2.3	8.9 \pm 1.7	7.66 \pm 2.4	8.12 \pm 2.2	<0.001
Heart failure ^{a,b}	8.98 \pm 1.62	8.8 \pm 1.3	8.62 \pm 1.6	8.81 \pm 1.52	0.05
Dyslipidemia ^a	8.0 \pm 2.39	5.59 \pm 3.39	8.45 \pm 1.69	7.35 \pm 2.87	<0.001
GERD ^a	9.56 \pm 0.99	9.06 \pm 1.45	8.14 \pm 2.42	8.98 \pm 1.76	<0.001
Total examination ^c	34.36 \pm 4.32	32.35 \pm 4.80	32.86 \pm 4.82	33.28 \pm 4.70	<0.001

SD = Standard Deviation; GERD = gastroesophageal reflux disease.

^a Students could earn up to 10 possible points.^b Topic was taught by the same resident in year 1 and year 2.^c Students could earn up to 40 possible points.**Table 5**

Quality review for learning objectives.

	Year 1 N = 15 %	Year 2 N = 14 %	Year 3 N = 21 %	All years ^a N = 48 %
The objective met all of the quality criteria	53	50	29	42
The objective was distinct	60	79	76	73
The objective highlights what learning should result by the end of the class session	67	57	71	65
The objective uses only one active verb	100	86	76	85
The active verb can be measured with the type of assessment used in the course	87	100	62	79
The objective presents a clear picture of the intended learning outcome	47	43	48	46
The objective communicates to the student the type of behavior or change the instructor seeks	67	64	32	65

^a Two objectives from year 1 were repeated for use in year 2 and only counted once in the quality analysis.**Table 6**

Quality review for multiple choice questions.

	Year 1 N = 29 %	Year 2 N = 36 %	Year 3 N = 36 %	All years ^a N = 92 %
The multiple choice question met all of the quality criteria	83	86	72	79
The question stem is stated using positive terminology	93	94	97	95
The stem is a complete sentence	93	97	67	95
Language used in the stem did not contain excessive or irrelevant information	100	97	97	98
No technical flaws were identified (e.g., use of abbreviations or terminology unfamiliar to the student)	100	100	94	98
The question stem focuses on one concept	100	100	100	100
The question stem states only one question	100	100	100	100
All answer choices are plausible	100	100	100	100
All answer choices are presented in a logical manner	100	100	100	100
All answer choices are similar in length	93	94	86	90
All answer choices have a consistent theme or focus	93	97	97	97

^a Nine multiple choice questions from year 1 were repeated for use in year 2 and only counted once in the quality analysis.

Discussion

Fluctuations in student performance have potential to be a primary concern for faculty when introducing pharmacy residents as instructors into a course. Our results indicate that there is a statistically significant difference in student performance from year to year when different pharmacy resident instructors develop and deliver the content. However, the difference in performance did not result in an educationally significant difference, defined as a lack of practical differences in student performance across course years. Except in the case of the dyslipidemia content, student performance on course examinations (the summative evaluation used in the course) varied only slightly when comparing letter grades earned for the content. This is evidenced by the data on the total course examination where each student cohort earned mean scores of 86% in 2010, 81% in 2011, and 82% in 2012. Based on the grading scale used in the course, the letter grades earned for each year would have been B in 2010, B- in 2011, and B- in 2012. It is not possible to determine if differences this small in course grades were the result of overall learning of the students. The variations of student performance could also be influenced by a multitude of external factors such as instructors in prior coursework and academic performance history of the students in each year.

These results contrast to prior work published by Howard et al.,⁷ where pharmacy residents became the primary instructors for an

elective course that was previously taught by faculty. Student performance, as assessed by final course grades, did not differ significantly between faculty instruction and pharmacy resident instruction. However, this was an elective course with high performance reported (faculty-taught course grade mean 94.1% vs. pharmacy resident-taught course grade mean 94.2%). The average student performance in required courses is not expected to be at this same level.

This is also the first study to assess the quality of learning objectives and multiple choice questions prepared by pharmacy residents. Even following mentor and course director review of the residents' work, learning objectives were poorly written as determined by the criteria we created. Only 42% of objectives met all of the quality criteria established by the authors. This finding suggests that there is a need to improve the teaching and learning curriculum program offered at this institution and to modify the learning methods used to teach writing learning objectives. One opportunity to improve the program is to encourage faculty mentors and course directors to regularly participate in workshops on writing learning objectives to become more skilled at providing feedback to resident instructors.

More than three quarters of the multiple choice questions met all of the quality criteria we established. Thus, it can be concluded that overall the pharmacy residents developed multiple choice questions that met best practice criteria for both the formative (iRAT and tRAT) and summative (course examinations) assessments in the course. It was uncommon to observe more than one flaw in the multiple choice questions. However, our quality criteria focused solely on the structure of the question and did not consider the performance of the item using statistical analysis as others have previously discussed.¹⁰ Caldwell et al.¹⁰ examined the impact of a multiple choice item peer review process by comparing the performance of the items by classifying them into levels based on difficulty and point biserial correlation. Following a peer review process, they identified improvement in the number of items that were classified in the ideal level, however the difference was not statistically significant.

There are additional limitations to the quality review performed in this study. The quality criteria did not assess the level of difficulty of the multiple choice question according to the cognitive domain of Bloom's Taxonomy.¹¹ Future research should include an analysis of item difficulty as an additional quality assessment indicator. Though the tools developed for quality review were based on best practices, they contain limitations. The tools incorporate a checklist approach to identifying quality learning objectives and multiple choice question based on structure. Scores were not assigned to the tools, as we did not intend for scores to be calculated to delineate "good" or "bad" learning objectives or multiple choice questions. Instead the tools can be used to self-assess if the items written follow best practices. The tools were not designed to assess alignment of the multiple choice questions with the learning objectives. Sound instruction and evaluation should ensure that there is an alignment between what instructors tell students to learn (learning objectives) and the degree that formative and summative assessments measure if they learned the content. Additionally, the quality review assessed the final product of each pharmacy resident following influence from a faculty mentor and course director. This editorial process was developed to improve the quality of the learning objectives and multiple choice questions; however, the effectiveness of this process has not yet been assessed. We did not have access to workshop attendance records for each of the residents enrolled in the teaching and learning curriculum program. Attendance and participation in key workshops could have influenced the residents' ability to write high quality learning objectives and multiple choice questions. Subsequently, the program now requires residents to attend all workshops either live or by watching the recording of the workshop online in the event that patient care responsibilities conflicted with the scheduled workshop.

At this time, comparative data that assesses the variations in student performance, quality of learning objectives and multiple choice questions are not available for similar teaching and learning curriculum programs, nor is comparative data available for content created by faculty in colleges and schools of pharmacy. It is unclear if the quality of the materials developed by the pharmacy residents included in this study were better than, worse than, or similar to the materials created by pharmacy residents in other teaching and learning curriculum programs or faculty.

Conclusion

This is the first report to describe student performance in a required course on topics taught by first- and second-year postgraduate pharmacy residents, and assess the quality of resident-developed learning objectives and multiple choice questions. Student performance varied significantly depending on the content, but the overall impact of resident instructors on course performance did not result in educationally significant variations in the course. Teaching and learning curriculum programs should focus on teaching residents to create high quality learning objectives that help students focus their learning of the content. Future research should focus on evaluating the difference between resident instructors and faculty instructors with regard to student performance and the quality of the instructional materials they create.

Conflicts of interest

None.

Financial disclosures

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Appendix A. Criteria used to evaluate the quality of learning objectives

Category	Item
Specificity	The objective is distinct
	The objective highlights what learning should result by the end of the class session
Measurability	The objective uses only one active verb
	The active verb can be measured with the type of assessment used in the course
Clarity	The objective presents a clear picture of the intended learning outcome
	The objective communicates to the student the type of behavior or change the instructor seeks

Appendix B. Criteria used to evaluate the quality of multiple choice questions

Category	Item
Stem writing mechanics	The question stem is stated using positive terminology
	The question stem is a complete sentence
	Language used in the stem did not contain excessive or irrelevant information
	No technical flaws were identified (e.g., use of abbreviations or terminology unfamiliar to the student)
Stem content	The question stem focuses on one concept
	The question stem states only one question
Answer choices	All answer choices are plausible
	All answer choices are presented in a logical manner
	All answer choices are similar in length
	All answer choices have a consistent theme or focus

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.cptl.2018.03.015](https://doi.org/10.1016/j.cptl.2018.03.015).

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