RESEARCH ARTICLE

Impact of practice quizzes on student perceptions and assessment outcomes of a third-year pharmacotherapy course

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Abstract

Background: Practice quizzes have been associated with student learning, comprehension, and retention. This study aims to assess the impact of practice quiz utilisation for an infectious disease (ID) pharmacotherapy course. **Methods:** Student performance data for practice quizzes and assessments were collected. A survey was administered regarding student perception information of the practice quizzes. **Results:** Most students (95%) completed at least one quiz. For most of the quizzes (15/20), the number of quiz attempts among students who met the 80% competency bar was statistically higher than that of those who did not meet competency on course tests. Most students agreed/strongly agreed the quizzes impacted examination study behaviours (86%), performance (89%), and confidence (90%). Students supported additional course implementation of quizzes (97%), planned to utilise available practice quizzes in the future (96%), and would recommend them to other students (91%). **Conclusion:** ID practice quizzes were well received by students and may be a valuable learning tool.

Introduction

Pharmacists are essential in preventing bacterial resistance and promoting the optimal use of antibiotics (ASHP, 2010; Parente & Morton, 2018). Clinical roles in infectious diseases (ID) continue to expand, with pharmacists now providing antimicrobial stewardship in a variety of clinical settings (Blanchette *et al.,* 2003; ASHP, 2010; Gubbins *et al*., 2014; Klepser *et al.,* 2017). Student pharmacists must graduate with sufficient knowledge of ID to be prepared for practice (Gallagher *et al.,* 2018). The Accreditation Council for Pharmacy Education requires ID content to be taught within the Doctor of Pharmacy (PharmD) curriculum, but specifics regarding how much time, content, and specific topics for inclusion are at the discretion of individual institutions (Accreditation Council for Pharmacy Education, 2016). The Infectious Disease Society of America (IDSA) emphasises active learning in ID content, and the American College of Clinical Pharmacy provides recommendations for topics to include (Southwick *et al*., 2010; Schwinghammer *et al*., 2016).

In 2019, a survey found that PharmD programmes in the U.S. allotted an average of 60 hours of class time to ID topics, which included a mixture of fundamentals of ID and specific disease topics (Jeffres *et al*., 2019), with the majority of programmes utilising lecture-based rather than the active learning strategies recommended by the IDSA. The faculty in this study reported concerns about the lack of time to cover the topic and the sheer amount of ID-related material to incorporate (Jeffres *et al*., 2019). In general, student pharmacists are tasked with learning an overwhelming amount of information in sufficient depth to readily recall it and apply it in a variety of settings and situations (Zorek, Sprague & Popovich, 2010). Previous efforts have been made to assess and improve student learning of ID topics. For example, one study reported improved student performance after the implementation of ID active learning modules with embedded questions (Hernick, 2015).

One approach to improve learning and retention of ID material that has not been previously explored is the utilisation of quizzes. Quizzes, or test-enhanced learning, are a commonly used educational tool in a wide range of classroom settings and pedagogical types (Gleason *et al.*, 2011). Previous studies have shown that, when designed appropriately, quizzes can be used as both formative tools to enhance learning and summative tools to enhance rigour (Larsen *et al.*, 2008; Peeters, Cor & Maki, 2021). Moreover, adding online quizzes to other instructional activities improved student academic performance by guiding them throughout the learning process (Salas-Morera, Arauzo-Azofra & García-Hernández, 2012). A review of the use of quizzes in medical education showed that quizzes could enhance the active participation of students by promoting healthy competition and discussion between peers and improving student learning, comprehension, and retention (Dengri *et al*., 2021). Weekly quizzes about maternal and child health yielded a statistically significant improvement in the performance of nursing students on the midterm and final examinations as compared with students who did not have access to quizzes (Delaram, Shams & Gandomani, 2017).

This study aimed to describe the implementation of quizzes in an ID pharmacotherapy course and gather information on student utilisation of the available quizzes, the performance of students who utilised quizzes on course examinations, and student opinions of the value of the quizzes

Methods

Course description

Pharmacotherapy IV is a required course in the Doctor of Pharmacy programme at Washington State University College of Pharmacy and Pharmaceutical Sciences (WSU-CPPS) offered during the fall of the third professional year, the fifth out of six didactic terms. Content for this 4-credit pharmacotherapy course includes predominately ID alongside liver disease and oncology. WSU-CPPS utilises an active-learning, flipped classroom model, which has been described previously (Bray *et al*., 2017; Remsberg *et al.,* 2017; McKeirnan *et al*., 2020*)*. Briefly, students are expected to engage with pre-class didactic materials, participate in a 2-hour live active learning class session twice weekly, and then re-engage with session materials after class.

Practice quizzes

As an optional part of their post-class re-engagement, practice quizzes were created for corresponding pharmacotherapy session content within the learning management system (LMS). Practice quizzes were objective-based and contained between 3 and 13 questions per quiz. Question types included multiple choice, multiple answer, fill-in-the-blank, true or false, and matching. The questions on practice quizzes were a mix of Bloom's taxonomy knowledge and application levels (Bloom, 1956). Table I presents a map of the practice quizzes with topics and Bloom's taxonomy levels. One of the purposes of the practice quizzes was to introduce concepts through knowledge-level questions and then build skills to application-level questions. Practice quizzes were available with the session content within the LMS. Questions were displayed one at a time, and randomised answers were shown after each attempt. Students were able to discern if they answered correctly or incorrectly, but the rationale for answer choices was not provided to encourage students to re-engage in the course material. Practice quizzes were optional, and students were allowed unlimited attempts to complete each quiz throughout the term. Practice quiz scores did not contribute to the overall course grade.

Although students enrolled in the 2021 cohort of Pharmacotherapy IV were involved in the study, practice quiz questions were previously piloted during the fall 2020 offering of this pharmacotherapy course. Modifications were made to the questions prior to fall 2021 after reviewing student performance and feedback from 2020. Examples of revisions included the addition of more case-based application questions, clarification of question stems and changing the question type.

Course assessments and grading criteria

Pharmacotherapy IV relies on a competency-based assessment model and consists of four tests and two examinations. Tests include questions from content in a specific portion of the course, while examinations are comprehensive. Hence, Examination 1 comprises content from Test 1 and Test 2, while Examination 2 includes content from Test 3 and Test 4. The term assessment will be used in the survey results to describe both tests and examinations for this course. Each test was weighted at 5%, while each examination was weighted at 40% of the overall course grade. This course is divided into two units, each with two tests and one examination. Students are required to meet competency for both units of the course to receive a satisfactory grade. Unit competency is achieved by at least one of the following: (1) ≥80% on the weighted average for the unit or (2) ≥80% on the unit's comprehensive examination and a minimum of 75% on the weighted average for the unit.

Table I: Practice quiz content map organised by Bloom's level

Assessment		Practice quiz content	Practice quiz Bloom's knowledge-level questions (N)	Practice quiz Bloom's application-level questions (N)	Practice quiz total questions (N)
Examination 1	**Test 1**	Antibiotics I	9	4	13
		Antibiotics II	5	3	8
		Antibiotics III	8	2	10
		Central nervous system infections	3	2	5
		Pneumonia	2	2	4
	Test 2	Infective endocarditis/bacteremia	3	5	8
		Intra-abdominal infections	3	6	9
		Urinary tract infections	4	6	10
		Sexually transmitted infections	3	4	7
		Skin infections	4	3	7
		Fungal infections	2	3	5
		Opportunistic infections	2	3	5
Examination 2	**Test 3**	COVID/influenza	5	2	7
		Liver disease	3	2	5
		Hepatitis	4	1	5
		Sepsis	3	0	3
	Test 4	Breast cancer	3	2	5
		Lung cancer	4	1	5
		Acute leukemia	4	4	5
		Cancer supportive care	5	2	7

Survey

A survey was developed to further assess the perceived impact of the practice quizzes on course assessment performance. It was created in Qualtrics (version Qualtrics Core XM, Qualtrics LLC) and included 8 questions asking students to respond with a level of agreement using a 5-point Likert scale. The survey, which was developed by the course instructor in 2020, was reviewed by a student pharmacist and another faculty member. The survey was piloted with students enrolled in Pharmacotherapy IV in fall 2020. Adjustments were made to the survey before implementation in fall 2021. For example, logic was included in the 2021 version of the survey to determine whether students completed any of the practice quizzes. Those who did not complete the practice quizzes were asked to explain why. Students who reported completing at least one practice quiz progressed to the survey questions shown in Table II.

Students were informed that the survey was expected to take approximately 5 minutes, participation was voluntary, and faculty were requesting their participation so that instructors could better understand how the practice quizzes may have impacted the course experience. The first survey was released during the week following the first examination, at the mid-point of the term. The instructor verbally invited students to participate, posted the anonymous survey link on the LMS, and provided students with class time to complete the survey. A reminder email containing the survey link was sent to all students one week later. The survey remained open for the remainder of the term, but no additional reminders were sent.

The second survey included the same questions as the first survey and was released after the second examination at the end of the term. An email from the instructor requesting student participation in the survey was sent through the LMS on the last day of the course. After the winter break, a reminder was sent during the first day of Pharmacotherapy V, the next course in the series, during spring 2022. The anonymous link was posted in the LMS content of Pharmacotherapy V, and students were provided with time during the first day of the course to complete the survey, which remained open for the remainder of the spring term. No additional reminders were sent.

Data collection and assessment

All students enrolled in Pharmacotherapy IV during 2021 were eligible to participate in both the practice quizzes and the survey. The University Institutional Review Board determined this project as not meeting the criteria for human subject research and therefore did not require board review. Assessment data were deidentified and collected from the LMS after the completion of the term. The structured survey tool data were collected from Qualtrics (version Qualtrics Core XM, Qualtrics LLC).

Table 2. Student responses to Likert-scale survey questions

Questions	Survey	Strongly Agree N (%)	Agree N (%)	Neutral N (%)	Disagree N (%)	Strongly Disagree N (%)	p-value
After taking the practice quizzes, I studied differently for the exam.	Mid-point End	35 (38%) 21 (38%)	35 (38%) 27 (48%)	14 (15%) 7 (13%)	7 (8%) 1 (2%)	1 (1%) 0 (0%)	0.227
I feel that the taking practice quizzes enhanced my performance on examinations.	Mid-point End	57 (62%) 36 (64%)	28 (30%) 14 (25%)	5 (5%) 4 (7%)	2 (2%) 1 (2%)	0 (0%) 1 (2%)	0.771
I had more confidence in my ability to take the examination after the practice quizzes.	Mid-point End	51 (55%) 30 (54%)	32 (35%) 20 (36%)	7 (8%) 3 (5%)	1 (1%) 2 (4%)	1 (1%) 1 (2%)	0.641
The practice quizzes accurately reflected materials tested for on the examination.	Mid-point End	29 (32%) 27 (48%)	38 (41%) 16 (29%)	11 (12%) 9 (16%)	10 (11%) 3 (5%)	4 (4%) 1 (2%)	0.081
I would recommend other students take the practice quizzes in the future.	Mid-point End	69 (75%) 40 (71%)	20 (22%) 11 (20%)	3 (3%) 3 (5%)	0 (0%) 1 (2%)	0 (%) 1 (2%)	0.240
If available, I will continue to utilize practice quizzes in the future	Mid-point End	81 (88%) 46 (82%)	9 (10%) 8 (14%)	1 (1%) 2 (4%)	1 (1%) 0 (0%)	0 (0%) 0 (0%)	0.441
I believe more courses should offer practice quizzes	Mid-point End	89 (97%) 49 (88%)	2 (2%) 5 (9%)	1 (1%) 2 (4%)	0 (0%) 0 (0%)	0 (0%) 0 (0%)	0.083
Practices quizzes should continue to be offered in Pharmacotherapy 554	Mid-point End	86 (93%) 46 (82%)	4 (4%) 7 (13%)	2 (2%) 2 (4%)	0 (0%) 1 (2%)	0 (0%) 0 (0%)	0.072

The primary endpoint was to determine whether the number of practice quiz attempts differed between students who met competency versus those who did not meet competency for each assessment. The secondary endpoint was to assess the utility of the practice quizzes on perceived student performance. Students were divided into two groups depending if competency was met for each assessment. Only practice quiz attempts that were completed before each assessment were included. The number of practice quiz attempts for each practice quiz were compared between the two groups for each assessment using the Mann-Whitney U-Test. Survey responses completed at the mid-point of the term were compared to survey responses at the end of the semester using the Mann-Whitney U-Test. P values of ≤0.05 were considered significant, and all tests were two-tailed. All statistical analyses were performed using Excel (version 16.61.1, Microsoft Inc).

Results

Practice quiz results

There were 20 practice quizzes available for the 135 students enrolled during fall 2021. Practice quizzes included a mode of 5 questions per quiz (range 3-13). Nearly all students (94.8%,128/135) completed at least one quiz, and the majority of students (57.8%,78/135) completed all the practice quizzes at least once. The average number of quiz attempts was the highest for Quiz 3 (4.4 attempts/student), while Quiz 1 had the highest number of students (94.8%,128/135) who completed at least one attempt, as shown in Figure 1.

The average number of quiz attempts completed by students who did meet competency was compared with that of students who did not meet competency for tests and examinations, as shown in Figure 2 and Figure 3, respectively. The average number of quiz attempts was significantly higher for students who did meet competency for 4 out of 5 quizzes for Test 1 material, 5 out of 6 quizzes for Test 2 material, 3 out of 4 quizzes for Test 3 material, and 2 out of 4 quizzes for Test 4 material. The average number of quiz attempts was also significantly higher for students who met competency on 4 out of the 12 quizzes on Examination 1 material and only one quiz on Examination 2. Quiz 16 had a higher average number of quiz attempts among students who did not meet competency on Test 3 and Examination 2 vs those who did meet competency.
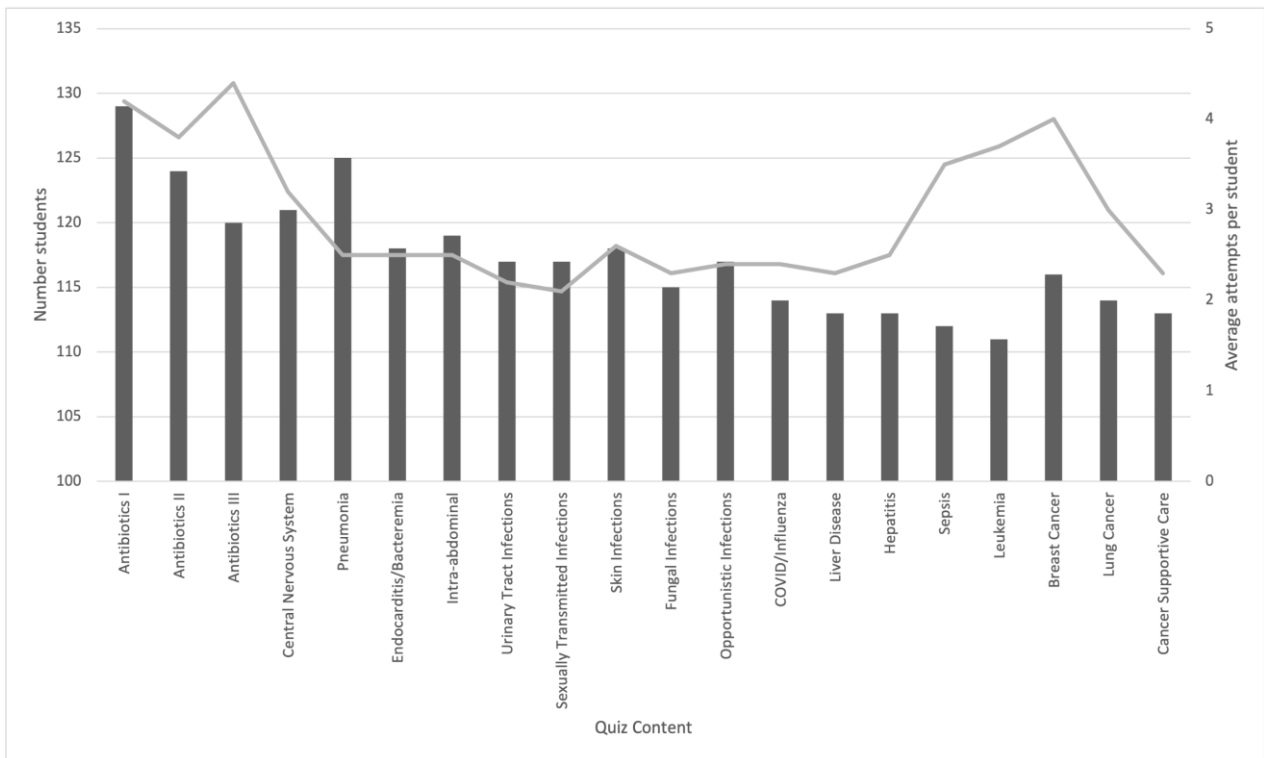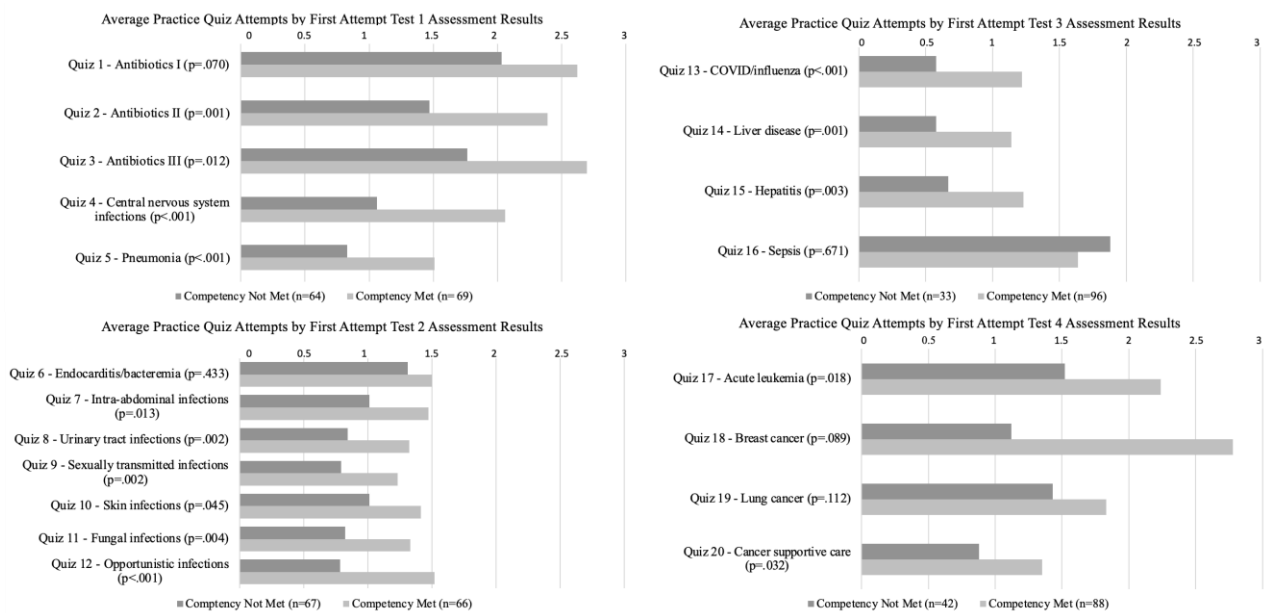
Figure 1: Number of student attempts per quiz and average attempts per student

Competency defined as ≥ 80% on the corresponding assessment

Figure 2: Average number of quiz attempts organized by student competency* on each test
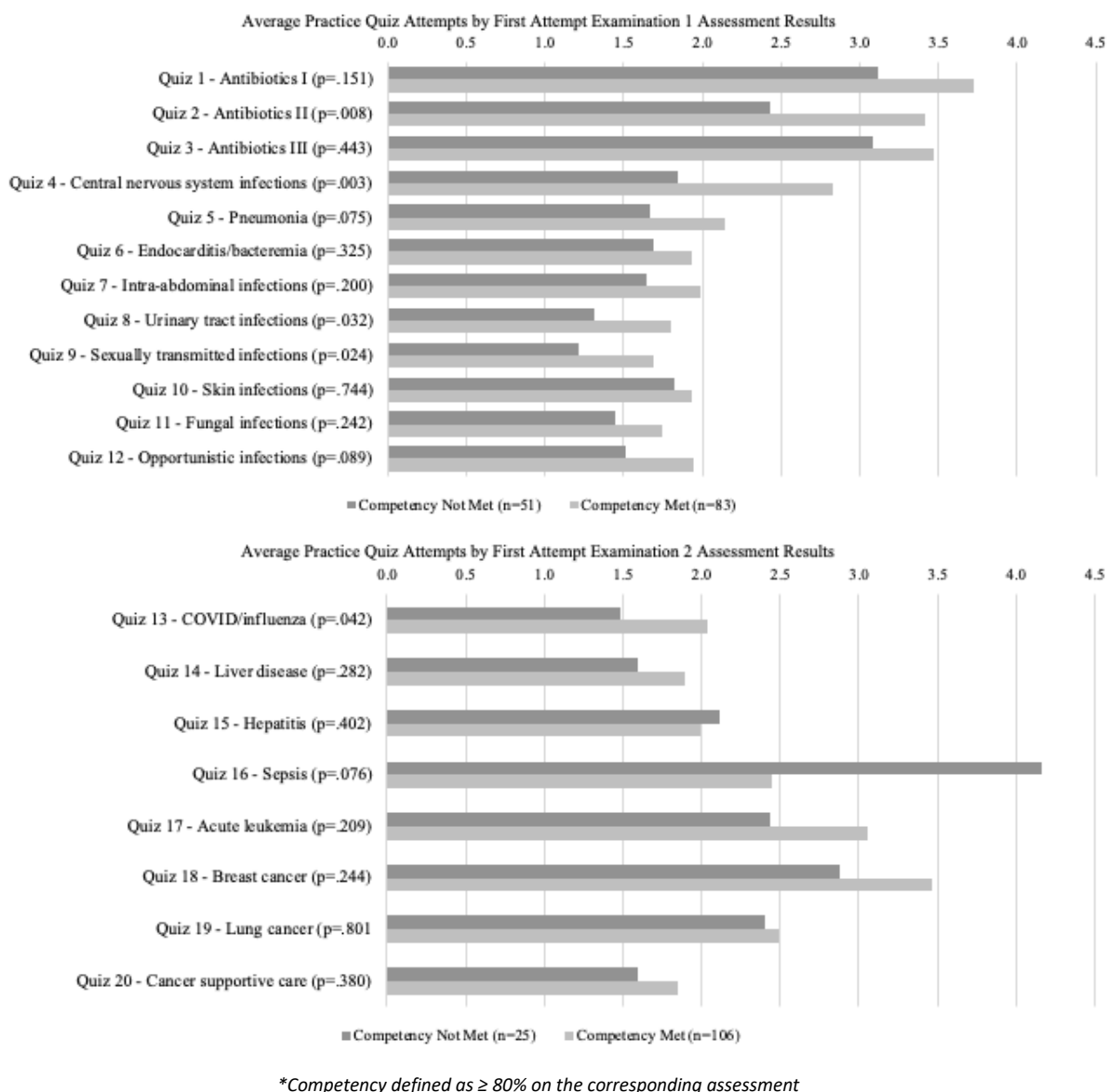
Average Practice Quiz Attempts by First Attempt Examination 1 Assessment Results

Average Practice Quiz Attempts by First Attempt Examination 2 Assessment Results

*Competency defined as ≥ 80% on the corresponding assessment

Figure 3. Average number of quiz attempts organized by student competency* on each examination

Survey results

Table II presents student responses to the survey questions. No statistically significant difference between the mid-point and end-of-semester survey responses was detected. Ninety-two students who completed the practice quizzes completed the mid-point survey (72% response rate, 92/128 students). Most students agreed or strongly agreed that practice quizzes impacted their study habits (76%, 70/92), enhanced assessment performance (92%, 85/92), and improved their confidence (90%, 83/92). The majority of students agreed or strongly agreed they would recommend practice quizzes to other students (97%, 89/92) and will continue to utilise practice quizzes in the future (98%, 90/92).

Fifty-six students who completed the practice quizzes also completed the end of semester survey (44% response rate, 56/128 students). Similar to the mid-point survey, most students agreed or strongly agreed that practice quizzes impacted their study habits (86%, 48/56), enhanced assessment performance (89%, 50/56), and improved their confidence (89%, 50/56). The majority of students would recommend practice quizzes to other students (91%, 51/56) and continue to utilise practice quizzes in the future (96%, 54/56).

Discussion

While various studies have been conducted on test-enhanced learning, very few have examined the effect of testing outside of a laboratory (classroom setting) (Yang *et al.,* 2021). This study is unique because it explored the impact of practice quiz testing in a non-classroom environment. A statistically significant difference in the number of attempts was found for 15 out of the 20 quizzes but only for 5 out of 20 quizzes on the examinations among students who met the 80% competency bar on the tests versus those who did not meet competency. This result is consistent with other literature findings in the classroom setting, showing the increased impact of learning on the number of repetitions of the same materials (Yang *et al.,* 2021). The tests in this course covered a smaller amount of material, while examinations were more comprehensive. The difference in the utilisation of quizzes among students who met competency on tests versus exams may be attributed to the increased difficulty of the larger amount of material. Further research on this topic is needed to identify whether students benefit from the practice quizzes in the short term, as reflected by the test performance, as compared to longitudinal retention. For Quizzes 15 and 16, students who did not meet competency had numerically more practice quiz attempts than average. A partial explanation for this finding is that one student had much higher than average practice quiz attempts (standard deviation>4). The removal of this student did not affect the overall statistical significance.

This study supports that test-enhanced learning benefits can been seen in low-stakes settings. Students were offered practice quizzes that had no impact on their overall course grade but were primarily a self-directed learning tool, which is important because higher-stake quizzes, such as a graded course component, can impede learning through increased anxiety (Tse & Pu, 2012; Khanna, 2015). A recent meta-analysis also concluded that stake level has a minimal impact on learning and demonstrated benefits with low-stakes quizzes (Yang *et al.,* 2021).

Most students attempted at least one practice quiz (95%, 128/135), with the majority completing all of them (58%, 78/135). The number of attempts per student decreased over the term. A previous study identified that student utilisation of practice-recall or completing practice problems decreased over time, similar to the present findings (Persky, 2018). The researchers also hypothesised that the number of attempts may have been higher at the beginning of the term because the early-term material has traditionally been more difficult, and students are not as familiar with the instructor, the difficulty of the course, and the

types of assessment questions. Anecdotally, faculty observed that student pharmacists' comfort level with the course and material increased as the term progressed. Since the retrieval of material and practice testing are considered optimal, study strategies among higher-performing learners, seeing the decline in student practice quiz utilisation is concerning (Brown, 2017; Landoll, Bennion & Maggio, 2021).

The following notion was considered when analysing data and assessing potential confounders: students who score well on a practice quiz may be less likely to need more attempts on the practice quiz. While this may have been true for a few students, the overwhelming number of students with multiple quiz attempts continued to take the practice quizzes regardless of their scores. Additionally, since students were provided with the correct responses, their highest quiz score may not reflect comprehension but memorisation of answers. Therefore, it is hard to correlate quiz scores and assessment scores.

Course faculty are considering adjustments to the quizzes for the next term. Students expressed that they would like more application-based questions on the interpretation of culture and sensitivity, as they find this concept hard to capture. Based on student feedback, practice quizzes will also include a similar knowledge-level to application-level questions as seen on the course assessments. The impact of having similar Bloom's level questions on both practice quizzes and assessments remains unknown. While some data indicate that students can transfer and apply knowledge in different formats, having consistent testing formats have a higher impact on testing effects (Yang *et al.,* 2021). When the practice quizzes were designed, faculty intentionally did not include the detailed rationale for each answer choice to encourage student-directed learning. Previous studies of classroom quizzes have demonstrated conflicting evidence on the benefits of feedback on test-enhanced learning (Rowland, 2014; Adesope, Trevisan & Sundararajan, 2017). Faculty are uncertain whether explaining each question and answer of practice quizzes would increase assessment performance and are considering further research on this topic. Another consideration is the timing of the practice quizzes. Students were allowed to complete practice quizzes at any point throughout the term. Although the data showed that both pre- and post-class quizzes are beneficial, post-class quizzes appear to be more effective (Yang *et al.*, 2021). Faculty are considering offering practice quizzes only after presented in-class. Additionally, this project was not designed to determine whether long-term retention is impacted by completing practice quizzes. Future research on this is also needed.

There were no significant differences between mid-point and end-of-term responses, indicating that students had similar feelings about the quizzes after receiving their grades at the end of the term. Some comments showed that students found the quizzes helpful generally and provided an opportunity for self-assessment to "gauge [their] readiness" for the assessments. Similar to the quantitative survey results, students stated that practice quizzes for this course helped them feel more comfortable with the material. One student wrote that "practice quizzes help[ed] test [their] knowledge and improved areas [they] did not do well in the quiz". By being able to self-assess, students could direct their pre-assessment preparation. There were also more Bloom's knowledge-level questions on the practice quizzes than application-level questions, which may explain why some students commented that practice quizzes were not at the same level of difficulty as the assessments that included more application-level questions.

Strengths and limitations

One strength of this study was the high practice quiz completion rate. Almost the entire cohort of students has completed at least one practice quiz. Another strength is that student confidence increased after completing practice quizzes. While many factors potentially affect test anxiety, self-esteem has been shown to be a significant, strong predictor of test anxiety (von der Embse *et al*., 2017). Hence increased confidence in the material before testing through practice quizzes could reduce test anxiety and improve performance, although additional data are needed to fully support this notion.

The results of this work should be considered within the context of its limitations. This study included a single cohort of students from one institution, so results may not be generalisable to all students and institutions. The mid-point survey had a 72% response rate, partially because the instructions were given during class, where attendance is encouraged but not required. Additionally, while each practice quiz question was based on an objective, questions were not individually mapped to specific objectives in the LMS. Gathering student performance on individually mapped questions may provide more insight into areas needing additional questions.

Conclusion

Practice quizzes in a pharmacotherapy course were well received by students and may be a valuable tool to aid in learning course material. The majority of students agreed that the quizzes helped them learn the course, enhanced their experience, changed how they studied for assessments, and increased their confidence in the coursework. Based on student perception, practice quizzes should be recommended for future students to aid in preparing their pre-assessment. Pharmacy faculty can utilise these results when considering the implementation of similar quizzes for ID or other topics at their own institutions.

Conflict of interest

The authors declare no conflict of interest.

References

Accreditation Council for Pharmacy Education (ACPE). (2016). Accreditation standards and key elements for the professional program in pharmacy leading to the Doctor of Pharmacy degree. Chicago, IL: Accreditation Council for Pharmacy Education. https://www.acpe-accredit.org/pdf/Standards2016FINAL.pdf

Adesope, O.O., Trevisan, D. A., & Sundararajan, N. (2017). Rethinking the Use of Tests: A Meta-Analysis of Practice Testing. *Review of Educational Research,* **87**(3), 659–701. https://doi.org/10.3102/0034654316689306

ASHP. (2010). ASHP Statement on the Pharmacist's Role in Antimicrobial Stewardship and Infection Prevention and Control. *American Journal of Health-Systems Pharmacy,* **67**(7), 575–577. https://doi.org/10.2146/sp100001

Blanchette, L., Gauthier, T., Heil E., Klepser, M., Madaras Kelly, K., Nailor, M., Wei, W., Suda, K. (2018). The essential role of pharmacists in antibiotic stewardship in outpatient care: An official position statement of the Society of Infectious Diseases Pharmacists. *Journal of the American Pharmacists Association,* **58**(5), 481–484. https://doi.org/10.1016/j.japh.2018.05.013

Bloom, B.S. (1956). Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain. New York, NY: McKay

Bray, B.S., Remsberg, C.M., Robinson, J.D., Wright, S.K., Muller, S.J., Garrelts McLean, L., & Pollack, G.M.(2017). Implementation and preliminary evaluation of an honours-satisfactory-fail competency based assessment model in a doctor of pharmacy programme. *Pharmacy Education,* **17**(1),143–153. https://pharmacyeducation.fip.org/pharmacyeducation/article/view/509

Brown, D. (2017). An evidence-based analysis of learning practices: the need for pharmacy students to employ more effective study strategies. *Currents in Pharmacy Teaching and Learning,* **9**(2), 163–170. https://doi.org/10.1016/j.cptl.2016.11.003

Delaram, M., Shams, S., & Gandomani, S.H. (2017). The Effect of Quizzes on Test Scores of Nursing Students for Learning Maternal and Child Health. *Journal of Medical Education,* **16**(2), e105578. https://doi.org/10.22037/jme.v16i2.13582

Dengri, C., Gill, A., Chopra, J., Dengri, C., Koritala, T., Khedr, A., Korsapati, A. R., Adhikari, R., Jain, S., Zec, S., Chand, M., Kashyap, R., Pattan, V., Khan, S. A., & Jain, N. K. (2021). A Review of the Quiz, as a New Dimension in Medical Education. *Cureus*, **13**(10), e18854. https://doi.org/10.7759/cureus.18854

Gallagher, J.C., Justo, J.A., Chahine, E.B., Bookstaver, P.B., Scheetz, M., Suda, K., Fehrenbacher, L., Klinker, K.P., MacDougall, C.(2018). Preventing the post-antibiotic era by training future pharmacists as antimicrobial stewards. *American journal of pharmaceutical education,* **82**(6), 6770. https://doi.org/10.5688/ajpe6770

Gleason, B.L., Peeters, M.J., Resman-Targoff, B.H., Karr, S., McBane, S., Kelley, K., Thomas, T., & Denetclaw, T.H. (2011). An active-learning strategies primer for achieving ability-based educational outcomes. *American journal of pharmaceutical education*, **75**(9), 186. https://doi.org/10.5688/ajpe759186

Gubbins, P.O., Klepser, M.E., Dering-Anderson, A.M., Bauer, K.A., Darin, K.M., Klepser, S., Matthias, K.R., Scarsi, K.(2014) Point-of-care testing for infectious diseases: opportunities, barriers, and considerations in community pharmacy. *Journal of the American Pharmacists Association,* **54**(2),163-171. https://doi.org/10.1331/JAPhA.2014.13167

Hernick, M. (2015). Test-Enhanced Learning in an Immunology and Infectious Disease Medicinal Chemistry/Pharmacology Course. *American journal of pharmaceutical education*, **79**(7), 97. https://doi.org/10.5688/ajpe79797

Jeffres, M.N., Kufel, W.D., Biehle, L.R., Cho, J.C., Narayanan, N, Gruenber, K., Garcia, J., & MacDougall, C. (2019). A Comprehensive Survey of Infectious Diseases Curriculum Among US Pharmacy Schools. *American journal of pharmaceutical education*, **83**(9), 7168. https://doi.org/10.5688/ajpe7168

Khanna, M.M. (2015). Ungraded Pop Quizzes: Test-Enhanced Learning Without All the Anxiety. *Teaching of Psychology,* **42**(2), 174–178. https://doi.org/10.1177/0098628315573144

Klepser, M.E., Dobson, E.L., Pogue, J.M., Labreche, J., Adams, A.J., Gauthier, T.P., Turner, R.B., Su, C.P., Jacobs, D.M., Suda, K. (2017). A call to action for out patient antibiotic stewardship. *Journal of the American Pharmacists Association,* **57**(4), 457–463. https://doi.org/10.1016/j.japh.2017.03.013

Landoll, R. R., Bennion, L. D., & Maggio, L. A. (2021). Understanding Excellence: a Qualitative Analysis of High-Performing Learner Study Strategies. *Medical science educator*, **31**(3), 1101–1108. https://doi.org/10.1007/s40670-021-01279-x

Larsen, D. P., Butler, A. C., & Roediger, H. L., 3rd (2008). Test-enhanced learning in medical education. *Medical education*, **42**(10), 959–966. https://doi.org/10.1111/j.1365-2923.2008.03124.x

McKeirnan, K. C., Colorafi, K., Kim, A. P., Stewart, A. S., Remsberg, C. M., Vu, M., & Bray, B. S. (2020). Study Behaviors Associated with Student Pharmacists' Academic Success in an Active Classroom Pharmacy Curriculum. *American journal of pharmaceutical education*, **84**(7), ajpe7695. https://doi.org/10.5688/ajpe7695

Parente, D.M., Morton, J. (2018). Role of the Pharmacist in Antimicrobial Stewardship. *The Medical Clinics of North America,* **102**(5), 929–936. https://doi.org/10.1016/j.mcna.2018.05.009

Peeters, M. J., Cor, M. K., & Maki, E. D. (2021). Providing Validation Evidence for a Clinical-Science Module: Improving Testing Reliability with Quizzes. *Innovations in pharmacy*, **12**(1), 10.24926/iip.v12i1.2235. https://doi.org/10.24926/iip.v12i1.2235

Persky, A.M. (2018) A four year longitudinal study of student learning strategies. *Currents in Pharmacy Teaching and Learning,* **10**(11), 1496–1500. https://doi.org/10.1016/j.cptl.2018.08.012

Remsberg, C. M., Bray, B. S., Wright, S. K., Ashmore, J., Kabasenche, W., Wang, S., Lazarus, P., & Daoud, S. S. (2017). Design, Implementation, and Assessment Approaches Within a Pharmacogenomics Course. *American journal of pharmaceutical education*, **81**(1), 11. https://doi.org/10.5688/ajpe81111

Rowland, C.A. (2014). The effect of testing versus restudy on retention: A meta-analytic review of the testing effect. *Psychological Bulletin,* **140**(6), 1432–1463. https://doi.org/10.1037/a0037559

Salas-Morera, L., Arauzo-Azofra, A., & García-Hernández, L. (2012). Analysis of online quizzes as a teaching and assessment tool. *Journal of Technology and Science Education (JOTSE),* **2**(1), 39-45. http://www.dx.doi.org/10.3926/jotse.30

Schwinghammer, T. L., Crannage, A. J., Boyce, E. G., Bradley, B., Christensen, A., Dunnenberger, H. M., Fravel, M., Gurgle, H., Hammond, D. A., Kwon, J., Slain, D., & Wargo, K. A. (2016). The 2016 ACCP Pharmacotherapy Didactic Curriculum Toolkit. *Pharmacotherapy*, **36**(11), e189–e194. https://doi.org/10.1002/phar.1846

Southwick, F., Katona, P., Kauffman, C., Monroe, S., Pirofski, L. A., del Rio, C., Gallis, H., Dismukes, W., & Infectious Diseases Society of America Preclinical Curriculum Committee (2010). Commentary: IDSA guidelines for improving the teaching of preclinical medical microbiology and infectious diseases. *Academic medicine*, **85**(1), 19–22. https://doi.org/10.1097/ACM.0b013e3181c485c5

Tse, C. S., & Pu, X. (2012). The effectiveness of test-enhanced learning depends on trait test anxiety and working-memory capacity. *Journal of experimental psychology. Applied*, **18**(3), 253–264. https://doi.org/10.1037/a0029190

von der Embse, N., Jester, D., Roy, D., & Post, J. (2018). Test anxiety effects, predictors, and correlates: A 30-year meta-analytic review. *Journal of Affective Disorders,* **227**, 483–493. https://doi.org/10.1016/j.jad.2017.11.048

Yang, C. Luo, L., Vadillo, M.A., Yu, R., Shanks, D.R. (2021) Testing (quizzing) boosts classroom learning: A systematic and meta-analytic review. *Psychological bulletin*, **147**(4), 399–435. https://doi.org/10.1037/bul0000309

Zorek, J. A., Sprague, J. E., & Popovich, N. G. (2010). Bulimic learning. *American journal of pharmaceutical education*, **74**(8), 157. https://doi.org/10.5688/aj7408157