American Journal of Pharmaceutical Education 87 (2023) 100090

Contents lists available at ScienceDirect

American Journal of Pharmaceutical Education

journal homepage: www.elsevier.com/locate/ajpe

Brief Report

Peer Instruction as an Alternative Active Learning Pedagogy Across the Pharmacy Curriculum

Andrew M. Straw*, Justin W. Cole, Kalista McGuire

Cedarville University School of Pharmacy, Cedarville, OH, USA

ARTICLE INFO

Keywords:
Active learning
Peer instruction
Peer learning
Pharmacy
Teaching

ABSTRACT

Objective: The objective of this study was to determine if peer instruction (PI) is a useful active learning pedagogy to increase correct responses to pharmacotherapy concepts throughout didactic education in a Doctor of Pharmacy curriculum.

Methods: Peer instruction was implemented into 3 pharmacy practice courses spanning 3 years of didactic pharmacy education at Cedarville University: Introduction to Self-Care (PHAR 6112) in the first professional year, Respiratory Module (PHAR 6261) in the second professional year, and Special Populations Module (PHAR 7343) in the third professional year. ConcepTests, which are multiple-choice questions written to help students apply previous knowledge to new scenarios, were re-polled based on a PI algorithm after peer discussion. Changes in students paired before and after peer discussion ConcepTest responses were analyzed using a McNemar test and descriptive statistics.

Results: A total of 52 first-year students, 43 second-year students, and 49 third-year students participated in each respective course. Across all courses, an increase in the percentage of correct responses to ConceptTests after peer discussion was observed from the first polling (51.2%) to the second polling (90.4%). This increase in the percentage of correct responses was observed across all years of the curriculum, with greater increases in cohorts with previous participation in PI-based sessions.

Conclusion: The use of PI fostered improvement in the percentage of correct responses to ConcepTests focused on pharmacotherapy concepts throughout the first 3 years of didactic education. This pedagogy may be an effective and useful active learning strategy in pharmacy education that does not require significant classroom infrastructure changes.

1. Introduction

Classroom content has historically been disseminated through lecturing, a cultural development that has been carried through many generations of educators.[1] Despite the popularity of its use, a lecture is a passive method of education and may be inferior for the achievement of learning outcomes, retention of information, and improved capability of self-directed learning.[2–4] For this reason, active learning methods have been employed to improve the achievement of these same areas.[3] Current literature on active learning implementation in pharmacy schools focuses primarily on team-based learning (TBL) and problem-based learning (PBL).[3,4] However, implementation of these learning strategies may require significant changes to instructional spaces such as round tables, moveable furniture, whiteboards, and/or additional technology.[5,6] The costs for an active learning space (ranging from $30,000 to over $250,000 per classroom) can be a concern in a time of budget constraints in pharmacy education.[7] An evaluation of additional pedagogical approaches is imperative, as TBL and PBL pedagogies may not be applicable or feasible in all pharmacy educational settings. Peer instruction (PI) is an active learning pedagogy that may be useful in pharmacy curricula, particularly when limitations exist for the implementation of other active learning pedagogies, such as classroom orientation, time allotment, and flexibility in delivery. The 4 main components of PI include class preparedness, ConcepTests, peer discussion, and explanation.[8] First, materials are given to students in advance to gain a baseline understanding of the topic that will be covered in class. ConcepTests, which are application-focused multiple-choice questions, are then posed to the students during the session. These

* Corresponding author.
E-mail address: astraw@cedarville.edu (A.M. Straw).

https://doi.org/10.1016/j.ajpe.2023.100090
Received 29 July 2022; Received in revised form 23 February 2023; Accepted 3 March 2023
Available online 9 May 2023

Table 1
Representative ConcepTest Example with Prediscussion and Postdiscussion results.

A newly diagnosed asthma patient presents to the clinic. They are experiencing respiratory symptoms most days and 1 night awakening per week. The patient is unable to utilize any inhaler requiring breath coordination. Which of the following would be the most appropriate initial therapy for this patient?		
Answer option	**First polling % (n)**	**Second polling % (n)**
Daily and as-needed low-dose Symbicort	56.1 (23)	4.9 (2)
Daily and as-needed low-dose Dulera	0 (0)	0 (0)
Daily low-dose Breo Ellipta and as-needed ProAir Respiclick	**31.7 (13)**	**95.1 (39)**
Daily low-dose Arnuity Ellipta and as-needed Ventolin HFA	2.4 (1)	0 (0)
Add on QVAR Redihaler to existing rescue inhaler therapy	9.7 (4)	0 (0)

ConcepTests assess students' understanding of the material provided for class preparedness and their ability to apply the acquired information to new scenarios. If the percentage of correct responses to the ConcepTest does not meet a predetermined threshold (eg, 70%) based on the pedagogical algorithm (Fig. A 1), peer discussion begins. During this important component, students discuss the ConcepTest with one another, typically with those in proximity. Students are then given a second opportunity to answer the ConcepTest. Lastly, further explanation may be provided to all students at the discretion of the instructor. This pedagogy differs from think-pair-share, as individual student responses to ConcepTests are recorded and included as graded assessments in each course. This gives the instructor the ability to truly gauge the level of understanding of a given topic not only for the class but also for individual students. A representative example of a ConcepTest and its results can be seen in Table 1.

Integration of PI has been proven effective in medical school education and other disciplines.[9–13] First evaluated in undergraduate physics courses, Crouch and Mazur[13] found that students engaging in courses structured with PI outperformed students in traditional lecture courses on quizzes. Within medical and health profession education courses, PI has been validated to improve student scoring on quizzes and improve student engagement in courses.[10,12] Currently, literature regarding the effectiveness of PI in pharmacy education is limited.

Thus, the goal of the study is to determine the effectiveness of PI in the delivery of pharmacy education materials by assessing improvement in student performance on ConcepTests after peer discussion.

2. Methods

A sampling of required didactic courses within the Cedarville University Doctor of Pharmacy Curriculum was selected to analyze the effectiveness of PI including Introduction to Self-Care (PHAR 6112) in the first professional year, Respiratory Module (PHAR 6261) in the second professional year, and Special Populations Module (PHAR 7343) in the third professional year. These courses were selected to ensure that multiple years of the professional program and multiple instructors were evaluated. Each instructor attended faculty development sessions on the implementation of PI prior to the study. Individual instructors determined what sessions of their course may benefit most from the PI approach and developed ConcepTests focused on the learning objectives of each course session. Consistent with the PI method, instructors had the freedom to determine the total amount of class time and sessions that PI incorporated. Instructors also had the freedom to determine the weight of the PI sessions in their course which varied from 10% to 15% of the course grade. For ConcepTests that did not require peer discussion, students were graded based on their first response. For ConcepTests that required peer discussion, only the second response was graded (Fig. A 1). Instructors randomly called on students after discussion to share their rationale. This study was exempted from review and granted a waiver of consent by the Cedarville University Institutional Review Board.

Turning Technologies software was used to record student responses for all PI sessions in PHAR 6112, PHAR 6261, and PHAR 7343 between August 2018 and August 2019. Data included an identifier for each student along with all student responses to each ConcepTest polling. Data was collected, de-identified, and stored using Microsoft Excel. The primary investigator completed de-identification prior to data analysis. Secured, cloud-based storage requiring dual authentication was utilized for data storage.

2.1. Data Analysis

Statistical analysis was completed using SPSS v25.0 (Armonk, NY). McNemar exact tests were used for each ConcepTest to assess changes in paired student responses before and after peer discussion. Descriptive statistics were also collected during PI class sessions.

3. Results

Data from 9 sessions in PHAR 6112, 6 sessions in PHAR 6261, and 6 sessions in PHAR 7343 were analyzed. ConcepTest responses from 142 students were included in this study, with 52 enrolled in PHAR 6112, 41 enrolled in PHAR 6261, and 49 enrolled in PHAR 7343. A total of 253 ConcepTests were posed to the students, of which 111 (43.9%) required peer discussion based on the PI algorithm (Appendix 1). The percentage of ConcepTests requiring peer discussion by course was 49.2%, 30.9%, and 55.4%, respectively. There was a statistically significant increase in correct responses to ConcepTests following peer discussion across all cohorts, with PHAR 6112 having the lowest post-PI discussion correct response percentage of 86.2% (Table 2). For all ConcepTests requiring peer discussion, correct responses increased from 51.2% before peer discussion to 90.4% following peer discussion ($P < 0.001$). A significant increase in correct responses after peer discussion was observed across each course.

The frequency of possible response changes was calculated for each course (Table 3). Negative change, defined as a correct response to a ConcepTest upon first polling being changed to an incorrect response after peer discussion, was seen in only 2.7% of paired responses. Negative change was most frequently observed in PHAR 6112, which enrolled first-year professional degree students. A negative neutral response, defined as choosing an incorrect answer both before and after peer discussion, was observed in 6.9% of overall responses. As with

Table 2
Frequency of Correct ConcepTest Responses Before and After Peer Discussion.

	Before peer discussion *n* (%)	After peer discussion *n* (%)	Change in correct response (%)	*P* value
PHAR 6112	1578 (50.8)	2678 (86.2)	+35.4	< 0.001
PHAR 6261	373 (53.8)	683 (98.6)	+44.8	< 0.001
PHAR 7343	800 (50.8)	1494 (94.9)	+44.1	< 0.001
All courses	2751 (51.2)	4855 (90.4)	+39.2	< 0.001

Table 3
Frequency of Answer Response Changes Following Peer Discussion by Course.

Response type	Course			
	PHAR 6112% (*n*)	PHAR 6261% (*n*)	PHAR 7343% (*n*)	All courses % (*n*)
Positive response change[a]	39.2 (1219)	44.9 (311)	45.7 (719)	41.9 (2249)
Positive neutral response[b]	47.0 (1459)	53.7 (372)	49.2 (775)	48.5 (2606)
Negative neutral response[c]	9.9 (307)	1.3 (9)	3.6 (56)	6.9 (372)
Negative response change[d]	3.8 (119)	0.1 (1)	1.6 (25)	2.7 (145)

[a] Change from incorrect to correct response after peer discussion.
[b] Correct response chosen before and after discussion.
[c] Incorrect response chosen before and after discussion.
[d] Change from a correct to incorrect response after peer discussion.

negative response change, the highest frequency was observed among first-year students (9.9%).

4. Discussion

This study was intended to gauge changes in the number of correct student responses to ConcepTests after peer discussion. These preliminary data are necessary to establish the internal validity of the pedagogy itself prior to analyzing student achievement of course outcomes and comparing it to other active learning pedagogies. Overall, PI positively impacted the percentage of correct student responses to ConcepTests across all cohorts with an improvement of nearly 40% on average across all cohorts.

Variation among the 3 cohorts was noted in the incidence of post-discussion response scenarios as PHAR 6112 had both the highest incidence of negative neutral responses and the lowest correct response percentage. Clinical reasoning skills, especially in relation to case-based ConcepTests, are being newly developed in first-year professional pharmacy students. With PHAR 6112 being the first clinical course for first-year professional students, the development of clinical reasoning may play a significant role in the outcomes seen in this study. As students develop clinical skills for application to the Pharmacists' Patient Care Process,[14] they would be expected to formulate correct conclusions on ConcepTests more frequently. This was observed in the post-discussion results for the second and third-year professional students. Peer instruction may be a useful tool to help identify the areas in which students are still developing their clinical decision-making skills.

The average increase in correct response by first-year students of 39.2% was comparable to another study using PI in pharmacy education which reported a mean overall improvement in correct responses of 31.5%.[15]

One strength of this study was that PI was utilized by multiple faculty members in both the pharmaceutical sciences and pharmacy practice departments across multiple years of a professional curriculum. This study was limited based on a relatively small sample of students at a single university. Additionally, increases in the mean percentage of correct answers on ConcepTest questions among cohorts may be attributable to other confounding factors such as relationships between peers, differences in ownership of the learning process, and prior experience with and understanding of PI. This study did not assess the long-term retention of information and achievement of learning outcomes related to the PI sessions.

Peer instruction provides some advantages over other active learning pedagogies that could make it useful as an additional option for instructors. Peer instruction is scalable and requires no or minimal alteration to the existing classroom structure. Since students can discuss with anyone, PI can be completed in any class configuration in which students can reasonably converse. Class size and classroom layout do not significantly change the pedagogical approach eliminating the need for costly classroom remodeling or restructuring often recommended for other active learning strategies.[5] Peer instruction also allows a variety of delivery methods that can be tailored to distance or hybrid learning environments by utilizing teleconferencing and web-based polling. Lastly, PI provides immediate feedback, allowing the instructor to gauge student comprehension of content and efficiently manage class time by taking more time to discuss concepts found to be more challenging to students. Faculty members may use as many or as few ConcepTests as desired during a given session providing flexibility. Given the advantages and scalability of this pedagogy, PI is now the most commonly used active learning pedagogy at the author's institution accounting for the delivery of over 20% of the graduate pharmacy curriculum.

Future studies on the use of PI in pharmacy education should focus on the achievement of learning outcomes related to the use of this pedagogy. Specifically, evaluating student performance in PI sessions to performance on summative assessments covering the same content would help to ensure that PI fosters long-term retention and understanding of information. Additional research into the effectiveness of PI for those who are less comfortable and/or effective in discussions would be valuable. Head-to-head comparison studies of PI with other active learning pedagogies such as TBL and PBL are also warranted. Other future studies may include verification of best practices for writing ConcepTests and PI algorithms, application of PI to undergraduate pharmacy education, and use of PI for specific patient populations or content areas.

5. Conclusion

A significant improvement in the percentage of correct ConcepTest answers after peer discussion was observed in all cohorts. The initial percentage of correct responses was similar among all cohorts, and the percentage of correct responses following peer discussion increased in all observed courses. The results of this study demonstrate that PI may be a useful active learning pedagogy in pharmacy education and may be valuable in situations where a classroom presents spatial or technological limitations to other active learning pedagogies.

Funding/Support

This study was supported in part by a Scholarship of Teaching and Learning Grant from the American Association of Colleges of Pharmacy.

Author Contributions

None.

CRediT authorship contribution statement

McGuire Kalista: Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Cole Justin:** Writing – review & editing, Writing – original draft, Investigation.

Declaration of Competing Interests

None declared.

Appendix

See Fig. A1.

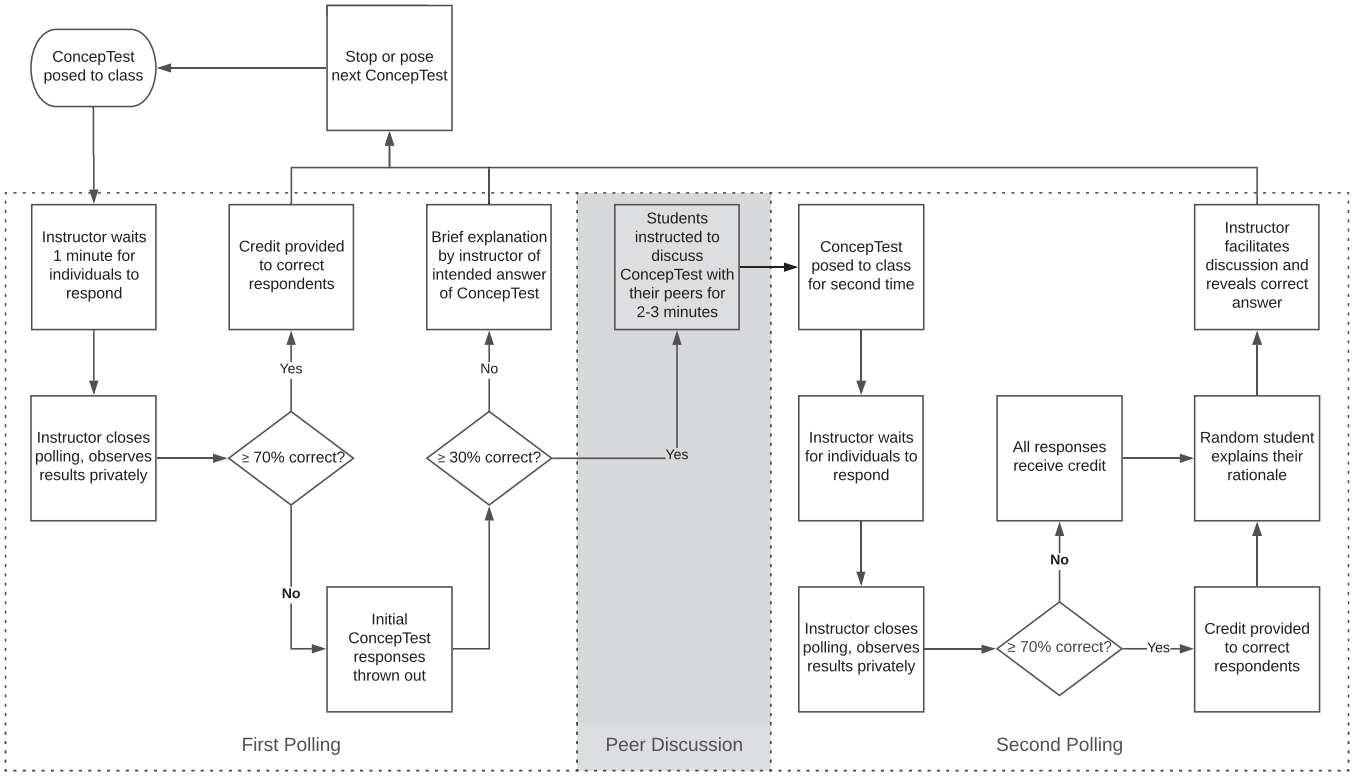

Fig. A 1. Peer Instruction Algorithm.
Adapted from Straw et al.[14].

References

1. Friesen N. The lecture as a transmedial pedagogical form: a historical analysis. *Educ Res.* 2011;40(3):95–102. https://doi.org/10.3102/0013189×11404603
2. Cooper AZ, Richards JB. Lectures for adult learners: breaking old habits in graduate medical education. *Am J Med.* 2017;130(3):376–381. https://doi.org/10.1016/j.amjmed.2016.11.009
3. Bleske BE, Remington TL, Wells TD, et al. A randomized crossover comparison of team-based learning and lecture format on learning outcomes. *Am J Pharm Educ.* 2016;80(7):120. https://doi.org/10.5688/ajpe807120
4. Freeman S, Eddy SL, McDonough M, et al. Active learning increases student performance in science, engineering, and mathematics. *Proc Natl Acad Sci U S A.* 2014;111(23):8410–8415. https://doi.org/10.1073/pnas.1319030111
5. Flaherty C. Spaces matter. *Inside higher education.* Published September 16, 2022. https://www.insidehighered.com/news/2022/09/16/push-more-active-learning-spaces-campus (Accessed Dec 19, 2022).
6. Park EL, Choi BK. Transformation of classroom spaces: traditional versus active learning classroom in colleges. *High Educ.* 2014;68(5):749–771. https://doi.org/10.1007/s10734-014-9742-0
7. Stoltzfus JR, Libarkin J. Does the room matter? Active learning in traditional and enhanced lecture spaces. *CBE Life Sci Educ.* 2016;15(4):ar68. https://doi.org/10.1187/cbe.16-03-0126
8. Mazur E. *Peer Instruction: A User's Manual.* Upper Saddle River, NJ: Prentice Hall; 1997.
9. Schuller MC, DaRosa DA, Crandall ML. Using just-in-time teaching and peer instruction in a residency program's core curriculum: enhancing satisfaction, engagement, and retention. *Acad Med.* 2015;90(3):384–391. https://doi.org/10.1097/ACM.0000000000000578
10. Rao SP, DiCarlo SE. Peer instruction improves performance on quizzes. *Adv Physiol Educ.* 2000;24(1):51–55. https://doi.org/10.1152/advances.2000.24.1.51
11. Zhang N, Henderson CN. Brief, cooperative peer-instruction sessions during lectures enhance student recall and comprehension. *J Chiropr Educ.* 2016;30(2):87–93. https://doi.org/10.7899/JCE-15-9
12. Cortright RN, Collins HL, DiCarlo SE. Peer instruction enhanced meaningful learning: ability to solve novel problems. *Adv Physiol Educ.* 2005;29(2):107–111. https://doi.org/10.1152/advan.00060.2004
13. Crouch CH, Mazur E. Peer Instruction: ten years of experience and results. *Am J Phys.* 2001;69(9):970–977. https://doi.org/10.1119/1.1374249
14. Pharmacists' Patient Care process. Joint Commission of Pharmacy Practitioners; 2014. *https://jcpp.net/wp-content/uploads/2016/03/PatientCareProcess-with-supporting-organizations.pdf* (Accessed July 26, 2022).
15. Straw AM, Wicker E, Harper NG. Effect of peer instruction pedagogy on concept mastery in a first professional year pharmacy self-care course. *Curr Pharm Teach Learn.* 2021;13(3):273–278. https://doi.org/10.1016/j.cptl.2020.10.002