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SHORT REPORT

A small-group activity to enhance learning of cardiovascular drugs for health science students

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Abstract

This small-group activity provides two cases in cardiovascular pharmacology to engage students in a medical or other health professions curriculum. The goal of this activity is to apply students' basic knowledge of physiology and pharmacology to clinical case scenarios. Students were provided with the cases 1 week in advance and were encouraged to use their lecture notes and/or other references of their choosing to answer as many of the questions as possible and prepare to discuss the answers with their classmates at the session. Facilitators were provided with detailed notes and a video that explain the answers and provide suggestions for engaging and challenging the students. For the 2021 academic year, 201 students (139 first-year medical students and 62 second-year pharmacy students) at UC San Diego participated in the small-group activity. Eighteen facilitators were recruited to lead this 110-min session. Students' performance was assessed on the final exam of their integrated cardiovascular physiology-pharmacology course. Students achieved 84% (SD 17.54) on questions related to the small-group session compared to 78% (SD 15.60) on other cardiovascular pharmacology questions not related to the activity. Student perceptions of the facilitators leading the small-group activity were very positive (average of 4.7 on a 5-point Likert Scale). Using this approach, we demonstrate that a small-group activity with clinical scenarios helps students master the pharmacology content related to cardiovascular drugs. The small-group activity included constructed response questions to foster conceptual understanding.

KEYWORDS
small group teaching, pharmacology education, cardiovascular system

1 | INTRODUCTION

Cardiovascular disease (CVD) is one of the leading causes of death in the United States, and approximately 48% of adults (>20 years of age) have one or more forms of cardiovascular disease.[1] Hypertension is a major risk factor for CVD, and successful management is critical for the prevention of death, myocardial infarction, and stroke.[2] Health care providers need a strong background on medications to treat CVD, including the ability to integrate the knowledge of the mechanism of action of these drugs with cardiovascular physiology.

Many health professions schools have changed their pharmacology curriculum in the past decade.[3] Most changes involve the

Abbreviations: CS I, Cardiovascular System I; CVD, Cardiovascular disease; SOM, School of Medicine.

implementation of active-teaching strategies to shift content delivery from a teacher-centered to a learner-centered approach.[4] These developments include the use of small-groups, team-based learning,[5] and problem-based learning[6] as well as several other strategies involving the increased use of clinical scenarios.[4] Small-group learning has been increasingly used to better model the team-based approach to healthcare.[7] In addition, small-group learning has been shown to be associated with higher retention of the material and increased students' engagement.[8,9] A previous study also demonstrated the effectiveness of small groups in learning certain Pharmacology subjects.[10]

Another recent change in pharmacology education is an increased appreciation for the value of pharmacology as an integrative science.[11] The meaningful study of pharmacology involves an application of important physiological principles, and many medical school curricula integrate pharmacology with physiology in the pre-clerkship years.[11] In addition, pharmacology connects the basic sciences to the clinical sciences, providing fundamental concepts for clinical problem-solving and ensuring a scientific basis for making therapeutic decisions. Studies have shown that medical students learn better in their pre-clerkship years when basic sciences such as pharmacology are taught in a clinical context.[12–14] In this activity, we use small-group teaching and clinically relevant cases to foster an understanding of the antihypertensive drugs and the drugs used to treat angina pectoris.

The target audience for this small-group activity is preclinical health professions students. Our audience was first-year medical students and second-year pharmacy students enrolled in their shared course on the cardiovascular system. The preceding didactic sessions introduced students to cardiovascular physiology, the physiology and pharmacology of the autonomic nervous system, the renin-angiotensin system, and most classes of cardiovascular drugs. This small-group activity was designed to help students apply the knowledge that they gained from the preceding didactic sessions to the treatment of hypertension and angina pectoris by discussing two clinical scenarios. The activity was scheduled for the last week of the cardiovascular course.

2 | MATERIALS AND METHODS

At the UC San Diego School of Medicine (SOM) there is a long history of interprofessional education. Most importantly, first-year medical students and second-year pharmacy students are enrolled in a common curriculum for most of their courses. Specifically, their shared curriculum includes courses in molecular cell biology and genetics; the cardiovascular, respiratory, gastrointestinal, renal, and reproductive systems; endocrinology and metabolism; immunology; hematology; and microbiology. In these courses, medical and pharmacy students participate together in lectures, team-based learning, and small-group activities, which helps prepare them for the teamwork and collaboration that will be important during their clinical rotations and future careers. Note that pharmacology is integrated into all courses in the shared curriculum. The students are introduced to virtually all the major classes of drugs, with emphasis on the therapeutic uses and adverse effects that are predictable from the mechanism of action of the drug. This small-group activity was implemented in a course called Cardiovascular System I (CS I) at the UC San Diego SOM. This four-week course, which is the first organ system course in both Year 1 of the SOM curriculum and Year 2 of the curriculum of the Skaggs School of Pharmacy and Pharmaceutical Sciences at UC San Diego, includes didactic lectures, team-based learning, small-group sessions, and labs. The CS I course emphasizes the normal function of the cardiovascular system, focusing on cardiovascular physiology, pharmacology, anatomy, and histology. The small-group activity involves the discussion of two cases that focus on the treatment of cardiovascular disease (Appendix S1). The CS I course contains two assessments, one formative (Midterm Exam, 2 weeks after the start of the course) and one summative (Final Exam, 4 weeks after the start of the course). The small-group activity was scheduled 4 days before the summative assessment.

Students were taught all relevant pharmacology background in didactic lectures preceding this small-group activity. Students required basic knowledge of pharmacologic and pharmacotherapeutic principles of the diseases presented in these cases: hypertension, angina pectoris, coronary disease, and peripheral vascular disease. For this activity, we recruited 18 facilitators from the Department of Pharmacology and the School of Pharmacy. The facilitators received detailed notes (Appendix S2) and a video in which one of the authors went over the cases and questions (Appendix S3). In addition, the facilitators were provided with an optional two-hour Zoom session, in which one of the authors went over the cases. The content and delivery of the Zoom session were very similar to the recorded video. However, facilitators were able to ask question and clarify any difficulties that may come up. Approximately 50% of the facilitators participated in this Zoom meeting which took place 2 days before the small-group activity. The cases were posted on the students' course website 1 week in advance of the session, and students were assigned to groups (average group size 12 students, with both medical and pharmacy students in each group). An e-mail was sent to students 1 week before the activity, reminding them to work on the cases and questions before the session in order to benefit maximally from the activity and participate in the discussion of the cases. The small-group session was a mandatory activity and students were required to e-mail their facilitator and the course's administrative coordinator if they were unable to participate (e.g., due to illness). There were no grades associated with this activity.

We encouraged facilitators to use a "small-groups within a small-group" approach:

1. At the beginning of the session, the facilitator divides students into three sub-groups of three to four students each.
2. Each sub-group discusses Case 1, and the facilitator encourages students to focus on the questions that they had trouble answering. The facilitator wanders around and helps any sub-group that "gets stuck" or has questions. In general, the students, working together, are able to answer correctly the questions in the case. Most students had studied the cases in advance, and by working together, they help each other answer any questions.

3. After a "reasonable" amount of time (and keeping in mind that the session must finish in 110 min), the facilitator asks one of the sub-groups to present their answers to the questions.
4. If the students make a mistake during their presentation, the facilitator stops them right away and uses "Socratic-type" questioning (and/or input from other students, e.g., the facilitator might say, "I think that I need a second opinion on that statement") to help the students correct their error. If the students omit a key part of the answer, the facilitator uses "Socratic-type" questioning (and/or input from other students) to guide the students toward a complete answer. Most facilitators concisely write the key points on the board as the students present their answer. Some facilitators also use an iPad or tablet and project their screen (Appendix S4). For facilitators who prefer to use slides when leading a small-group session, we provide a PowerPoint slide deck that shows all questions and answers (Appendix S5).
5. After the students finish presenting their answer, the facilitator asks if other sub-groups have anything to add or if any of the students have questions. If a student or sub-group has a question, the facilitator encourages other students or other sub-groups to answer it.
6. The facilitator repeats Steps 2–5 for Case 2.

At the conclusion of the activity, we post detailed explanations of the cases on the students' course website (Appendix S6).

2.1 | Statistics

Statistical analysis was conducted using GraphPad PRISM (version 9). Students' performance on pharmacology questions was compared using a paired *t*-test. $p < .05$ was considered significant.

3 | RESULTS

3.1 | Exam results

All 201 students participated in the cardiovascular pharmacology small-group activity; 139 were first-year medical students, 62 were second-year pharmacy students. We assessed students on the CS I final exam. The exam contained 54 questions, including 19 that were related to pharmacology. Of the 19 pharmacology questions, we identified five that tested the content covered in this small-group activity. Although the CS I exam questions are part of a secure question bank and therefore cannot be shared, questions from practice quizzes posted on the students' course website that test relevant content are shown in Appendix S7.

Overall, students' ($n = 201$) performance on 14 cardiovascular pharmacology questions that were not related to the activity was 78% (SD 15.60). Students averaged an 84% (SD 17.54) correct response rate on the five pharmacology questions that tested content covered in the small-group activity. Our results show that the understanding of pharmacology related to the small-group activity was significantly better than the understanding of cardiovascular concepts that were not supported by a small-group activity (paired Student's *t*-test, $p < .0001$) (Figure 1).

3.2 | Faculty evaluations

A total of 192 students submitted evaluations of the facilitators for the small-group activity (96% response rate). Facilitators were evaluated by students with three questions using a 5-point Likert scale (strongly disagree = 1 to strongly agree = 5). Student perceptions of the facilitators leading the small-group activity were very positive (Table 1).

Students also had the opportunity to answer the following open-ended question: "Please give specific examples of something the instructor did particularly well or provide constructive feedback." The following are examples of the responses:

> I enjoyed the whiteboard learning and the fact that the class got to more actively participate when we recreated important figures/diagrams on the whiteboard.

> ...Gave us ample time to participate and very open to answering questions. Appreciate that she walked among the students while we worked through the cases so that we could get more specific questions answered. Explanations were very clear and logical.

> Super organized, patient, understanding, and knowledgeable!

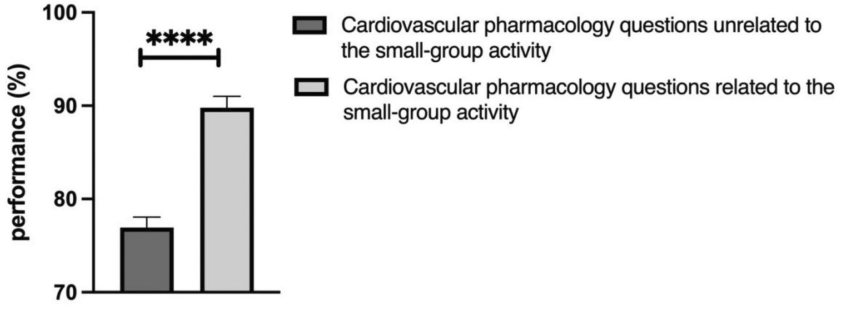

FIGURE 1 Students' performance on Cardiovascular pharmacology questions related and unrelated to the small group activity ($n = 201$). Results are presented as mean ± SEM; paired *t*-test, ****$p < .0001$.

TABLE 1 Students' perceptions of the small-group facilitators

Statements	Evaluation scores Mean (SD)
(1) The instructor was effective overall	4.7 (0.7)
(2) The instructor's teaching/facilitation skills facilitated my mastery of the learning objectives	4.7 (0.6)
(3) The instructor created a respectful learning environment	4.7 (0.6)

Note: Mean evaluation scores from a total of 192 students (response rate 96%) were analyzed. Responses based on a Likert scale of 1 to 5 where 1 = strongly disagree, 2 = disagree, 3 = neither agree or disagree, 4 = agree, 5 = strongly agree.

4 | DISCUSSION

This small-group activity was designed to facilitate students' understanding of antihypertensive drugs as well as drugs used to treat angina pectoris. Despite the small number of questions on the assessment that were mapped to the activity, we were able to demonstrate enhanced student performance on these questions compared to other pharmacology questions on the assessment.

Feedback received from students, and quantitative and qualitative facilitator evaluations, have been extremely positive. Based on these results, we believe that this small-group activity was a worthwhile learning experience for health sciences students such as medical and pharmacy students in their pre-clerkship years.

Learning in a small-group setting has grown in popularity in medical education due to its active collaborative and dynamic approach.[15] Students actively work together in teams, assimilating knowledge, solving problems, and teaching each other.[16–18] This type of active learning helps students develop the critical thinking, communication, and problem-solving skills necessary to become competent health care providers within a team.[4,19] It is important to learn how to find a balance between listening and participation, how to give and accept feedback, and how to explain things to colleagues. By encouraging students to explain and elaborate, small-group activities promote conceptual understanding,[20] which helps the learner to apply concepts to new scenarios and clinical problems. The use of constructed-response questions in our small-group activity may further enhance conceptual understanding. In constructed-response questions, students compose their own answers in a free response to real-world (e.g., clinical) problems. It is widely accepted that constructed-response questions test higher-order cognitive processes compared to closed-ended questions, such as multiple-choice questions.[21] Constructed-response questions also facilitate retrieval practice, the recall of information from long-term memory, which builds and further strengthens memory.[22] In contrast to multiple-choice questions, constructed-response questions require students to use their own words and emphasize "how" and "why" questions about important concepts. This strategy of elaborative interrogation (asking and explaining why and how things work) further promotes long-term knowledge retention.[23]

One limitation of this study is the small number of exam questions that were mapped to this activity. We hope that this number can increase in future iterations of the course. While some students use third-party resources to study for assessments,[24] it is unlikely that such resources would selectively enhance the performance on questions mapped to the small-group activity. One potential challenge in the implementation of this activity is the successful recruitment of small-group facilitators. Facilitators need to have a deep understanding of important concepts in cardiovascular physiology and pharmacology. This is the first "organ system" course and the study of the cardiovascular system is quite challenging. We believe that facilitators need to be content experts to properly answer students' questions. As it is difficult to schedule an in-person training session that all facilitators are able to attend, we provide a video in which one of the authors goes over the cases and provides suggestions for increasing student engagement. We also offer a Zoom training 2 days before the actual activity. In addition, we provide detailed facilitators' notes that review important physiological concepts that are crucial for understanding the pharmacology of the drugs discussed in the cases. The video and notes allow the facilitators to prepare for the session at a time and pace of their choosing.

We believe that our small-group exercise can be utilized in many different settings and can be easily adapted to different curricula. For example, if the availability of qualified facilitators is a limiting factor, our cases could be used in a large-group problem-solving session with just one instructor leading the exercise. Alternatively, the cases can be used in a team-based learning session, in which students are put into groups in a large lecture hall and then work together in teams to solve the problems. After a set time, the instructor goes over the answers to the problems, to ensure that everyone understands the core concepts. These small-group exercises also can be used as an independent study module with students trying to answer the questions by themselves before reading the detailed explanations or watching the video.

This activity, therefore, represents a flexible method for the learning of cardiovascular drugs that can be utilized in many different curricula and can be adapted to a variety of schools' needs. Using constructed-response questions throughout the activity encourages students to use their own words in explaining why and how things work. This can promote conceptual understanding and further deepen students' knowledge of cardiovascular drugs.

AUTHOR CONTRIBUTIONS

K.B., S.S and N.L. designed the study; K.B. performed the analysis and drafted the manuscript. All authors aided in interpreting the results, worked on the manuscript, and approved the final manuscript.

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DISCLOSURES

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as all data created or analyzed in this study are detailed in the figures and tables in the manuscript.

ETHICS STATEMENT

This study received exemption for full review from the Institutional Review Board of UC San Diego (Protocol Number 801818).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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