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Using Near-Peer Teaching to Address Concepts of Cystic Fibrosis in Undergraduate Medical Learners

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Abstract

Introduction: Cystic fibrosis (CF) is a high-yield undergraduate medical education topic that lends itself to adaptability of content. We used a CF case paired with activities to deliver content in a near-peer teaching session. First-year (M1) and second-year (M2) medical students contributed acquired knowledge of protein structure and obstructive lung disease, respectively, to generate a concept map and address discussion questions. **Methods:** Combined groups of M1 and M2 students reviewed a CF case and a concept map prompt. For 30 minutes, they created a concept map describing connections between molecular biology and clinical manifestations. We summarized by reviewing concept maps and discussion questions. The efficacy of the session was determined by comparing exam performance of class attenders and nonattenders (M2) and performance on questions related and unrelated to the exercise (M1). We also determined students' perception of the session and incorporation of additional core competencies. **Results:** M2 students' performance was 3.8% higher ($p = .296$) and M1 students' performance was 1.8% higher ($p = .286$) than their respective controls. Students commented positively on the exercise and perceived more than one core competency as part of the session. **Discussion:** Although there was no significant improvement in exam performance, this curriculum used near-peer teaching to reinforce previously learned material and apply recently acquired material in an engaging format without detriment to either group. This method can be adapted to different learner groups and provides an opportunity to deliver and assess other core medical competencies.

Keywords
Near-Peer Teaching, Molecular Biology, Pulmonary Physiology, Pulmonary Pathophysiology, Concept Mapping, Protein Structure, Case-Based Learning, Flipped Classroom, Pulmonary Medicine

Educational Objectives

At the end of this session, learners will be able to:

1. Evaluate how changes in amino acids can alter enzyme structure or function leading to clinical presentations.
2. Utilize forward genetics to determine the cause of the presenting symptoms in a clinical case.
3. Identify (first-year medical students) or describe (second-year medical students) the pathophysiological effects of varying degrees of lung tissue consolidation on ventilation/perfusion ratio, blood gases, and arterial pH.
4. Identify (first-year medical students) or describe (second-year medical students) the effect of localized pulmonary hypoxia on pulmonary blood flow and pressure.

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Introduction

Near-peer teaching (NPT) has become a recognized and effective delivery tool in medical education. This approach has been implemented across a range of learners (first- through fourth-year medical students) in both preclinical and clinical settings.[1,2] Regardless of the educational stage of the learners, students find this type of learning to be an engaging and positive experience.[3] Based on this, we developed a curriculum combining first-year (M1) and second-year (M2) medical students in an NPT activity to deliver basic content and clinical concepts in a single session. Because NPT and delivery of medical knowledge content in a clinical context enhance retention and perceived relevance of scientific material,[1,2] our goal was to include both aspects in this session.

Cystic fibrosis (CF) is a commonly addressed genetic disorder in medical school curricula. In a search of the medical school objectives database,[4] CF appeared in eight independent objectives across three disciplines (genetics, microbiology, and physiology) and one national society (Council on Medical Student Education in Pediatrics). Additionally, this presentation, along with associated complications, heritability, and treatments, was indexed on several occasions in a commonly used student reference.[5] Based on the importance of CF and the ability of the curriculum to encompass a broad range of topic areas, we were able to develop a case providing content topics for our M1 and M2 students to explore together.

Despite the importance of CF as a disease process, there are few resources currently in *MedEdPORTAL* covering this topic[6,7] and none designed to include NPT. This curriculum gives educators a resource for incorporating an NPT session into their course as well as two activities (a concept map and discussion questions) paired with a case of CF. We chose concept mapping and discussion questions as our application activities since both of these learning activities have been shown to engage students and enhance learning.[8] These tasks are also very amenable to including the range of concepts needed to ensure engagement by both peer groups. For example, concept mapping allows learners to visually organize concepts (e.g., basic science and clinical terms) to illustrate the relationships between them. The process of concept mapping is ideal for integration, and by using a list of specific topics generated for the session, one can guide the learner to explore specific facets of CF. The curriculum, as presented here, can be used directly as a classroom activity or as a template to develop an alternative case that meets the particular alignment of M1 and M2 curricula.

This curriculum represents an interactive activity combining M1 and M2 curricular content to (1) enhance clinical relevance and content integration and (2) incorporate an NPT activity in a preclinical curriculum. This approach can be adapted by generating cases that encompass the synergistic content of an M1 or M2 curriculum and can be used to facilitate interdisciplinary learning, remove restrictive curricular boundaries, and broaden physician education.

Methods

Curricular Structure, Prior Knowledge, and Development

We delivered this curriculum at the University of South Carolina School of Medicine, Greenville, during the 2014-2015 academic year. This M1-M2 integrated session was delivered when M1 students were in the molecular and cellular foundations of medicine module and the M2 students were in the cardiopulmonary module. For our session, the M1 curriculum had previously covered protein structure and function (M1 content was presented during molecular and cellular foundations), while the M2 curriculum had covered pulmonary pathophysiology and obstructive lung disease (M2 content from the cardiopulmonary system). This allowed for integration of concepts related to basic protein structure-function and cellular biology with pulmonary pathophysiology. The M1-M2 session functioned as a capstone class, facilitating the integration of the prior week's material. The curriculum was designed by a biochemist and physiologist blending two methods of application—discussion questions and concept mapping—both of which foster higher-level thinking skills. To identify concept-mapping concepts, we used best practices[9] and determined critical elements of the case that would integrate learning for the M1 and M2 students. A resource guide to help illustrate the process of concept mapping is provided in Appendix A.

Discussion questions were developed using previously described criteria.[10] To deliver the curriculum, we used a multidisciplinary space where each group worked at a table including a computer monitor and the faculty facilitator could control the projected material from the podium computer or from any group monitor. All learners were able to participate in the session, which was scheduled during a regular class time. No learner groups were excluded. Participation in these curricular elements were optional as per programmatic standards. The study was approved by the Virginia Tech Carilion School of Medicine Institutional Review Board, which had no ethical concerns.

Implementation

Prior to the class session, we gave students the session learning objectives and concepts for concept mapping, but no other preparation materials. At the start of the 2-hour session, we divided the classes into small groups of eight to 10 students with an even distribution of M1 and M2 students across the groups. We gave each small group the case (Appendix B) and concept-mapping prompt with key terms (Appendix C) to address a clinical sign or symptom in the case. Student discussion questions (Appendix D) were not given to the small groups until after the concept map had been constructed and discussed. We tasked the small groups to generate a concept map to connect the underlying genetic causes of CF with the patient's respiratory distress (Appendices A and E); a total time of 30 minutes was allocated for the generation of the concept map. Generating the integrated concept map required knowledge provided by both M1 and M2 students to link the underlying biochemical mechanism of disease with the identified sign or symptom. It was important to be clear on these instructions and how students should be using this time.

Within the first 5-10 minutes after students had been given the case and concepts, we refocused all students and asked if any of the small groups were having difficulty with a specific concept or aspect of the case. By doing this, we were able to address any concerns or student misconceptions early on, alleviating unintended frustration with the session. During this concept-mapping time, we (a biochemist and a pulmonary physiologist) circulated through the room and answered questions within the small groups. It was common for several small groups to have similar questions, and when this occurred, we used the opportunity to clarify the misconception or question with the whole group of learners. This tactic was especially useful when few faculty were present; it was more efficient to address common questions as a whole group versus with each small group. Following the concept-mapping exercise, we reviewed key elements of the concept maps with the whole group (see Appendix F for summary rubric and concept map). We did this by asking leading questions to small groups and eliciting the involvement of other small groups to elaborate on initial answers (see Appendix E for examples of questions to start discussion). At the conclusion of the concept-mapping activity (55 minutes total), we presented all small groups with discussion questions (Appendix D) to further apply and integrate material; small groups were given 20 minutes to work on the questions. The session concluded with a full-class discussion (20 minutes) of the questions and a final summary using the rubric and example map (Appendix F). During this activity, we permitted students to use any resources (e.g., internet, textbooks, peers, or faculty) to complete the task. It should be noted that concept mapping was a routine exercise for this group of students.

Assessment

We developed and implemented Step 1–style multiple-choice questions (MCQs) to assess student performance (Appendix G). The MCQs were part of a summative exam at the end of the module. As summative questions were not available for publication, similar formative questions are provided in Appendix G as examples. Questions were designed by instructors to incorporate material from the integrated activity presented here. We linked all questions to session-level objectives and presented them as part of the module summative exam. The session was attended by nearly all M1 students, but only 11 M2 students attended. Consequently, our analysis of exam performance was different for the two groups.

To assess the impact on M2 students, we compared performance on the MCQs described above for those individuals who attended the session versus those students who did not.

As nearly all M1 students attended the session, we compared question performance on material reinforced in the M1-M2 activity versus performance on M1 material delivered the week before and the week after that was presented in the M1-only classroom with no near-peer interactions.

The analysis performed included data related to this single session only, compared to a previous publication where the impact of multiple sessions was addressed.[11] Therefore, the data presented here are unique in pertaining only to this session on CF. This is also the only publication to include the details and resources for the class exercise, example concept map, concept-mapping resources, and rubric. We also assessed student's perception of the integration of competencies (medical knowledge, interprofessional and communication skills, practice-based learning, professionalism, systems-based practice, and patient care) into the session and general student perceptions of the curriculum.

Results

Seventy-eight M1 and 11 M2 students attended the session. This represented near-100% participation for the M1 students. The M2 students who attended the combined session scored 85.5% $\pm$ 5.0% on the summative MCQs when compared to 81.7% $\pm$ 4.0% for students who did not attend (Figure); this increase was not significant ($p = .296$, two-tailed t test). There was also no significant difference between the M1 performance (Figure) on the content integrated in the M1-M2 session (85.8% $\pm$ 2.0%), compared to an average performance on content delivered in the surrounding weeks (84.0% $\pm$ 2.0%; $p = .286$, two-tailed t test). This addressed a potential concern that the inclusion of peer teachers in this integrated session might compromise the delivery of medical knowledge, which apparently was not the case.

Both learner groups reported perceiving that the session incorporated more competencies than medical knowledge. For the full data set, see LeClair and Binks.[11] None of these core competencies were directly assessed during or after the curriculum.

Open comments provided by M1 and M2 students were all positive in nature ($n = 6$) and suggested that both the session and M2s' interaction in the session were assets. Example comments included the following: "They [the activities] were fantastic, an excellent part of the course. Thank you for allowing the M2 facilitators to help us on these exercises. Their input was valuable and they helped us to understand the material better." One comment alluded to the potential impact on academic

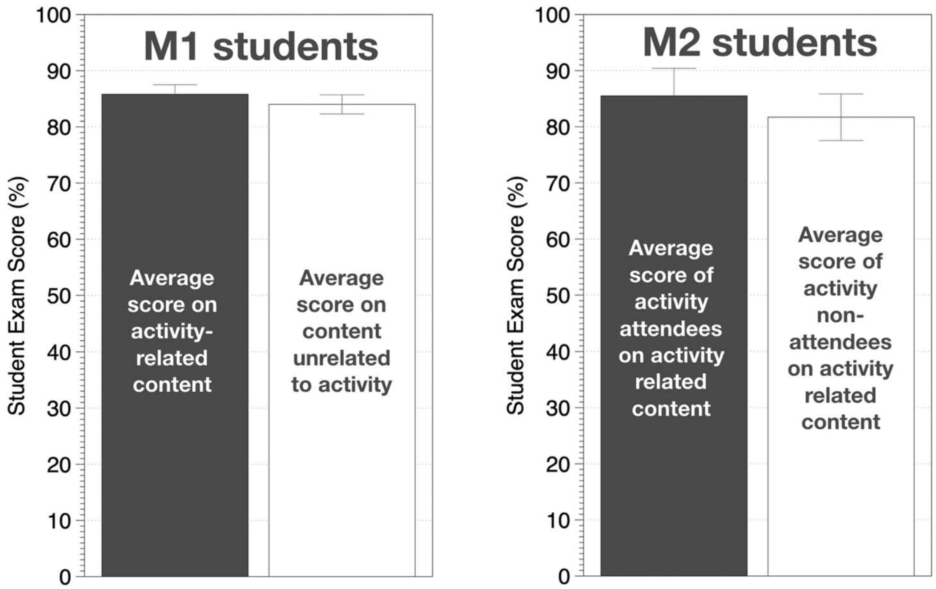

Figure. Comparison of first-year medical student (M1) performance ($M \pm SD$) on exam questions relating to the curriculum and content unrelated to the session (first panel). The second panel shows the performance ($M \pm SD$) of second-year medical students (M2) on exam questions that related to the material for students who attended the session and those who did not.

culture, stating, "Helped foster relationships as well that extended to help outside the classroom."

Discussion

We developed and implemented an NPT session on CF that integrated basic science material in a clinical context. The exercise was developed to vertically integrate medical knowledge in a near-peer case-based format,[1] and although we found no statistically significant differences in performance on MCQs between attendees and nonattendees, students commented positively on the overall experience. Students also perceived the incorporation of additional core competencies into the session, which could be explored further. Despite students perceiving that competencies beyond medical knowledge were being delivered in the session[11] and despite M1 and M2 students being asked to apply their respective knowledge bases in a single integrated exercise, there was no negative impact on exam performance. This outcome is important as many faculty often perceive integrated activities to come at a cost to medical knowledge or learning.[9]

Our students did not demonstrate any improved performance due to engaging in this session, despite other studies demonstrating the positive impact of team-based and interactive learning.[12,13] There are several potential reasons why our analysis did not show any significant improvement (3.8% for M2s, 1.8% for M1s). First, the M1 students were being taught within a block (molecular and cellular foundations module) that was exclusively delivered in a team-based learning format,[14,15] so this activity (besides the inclusion of M2 students) was not a large deviation from other classroom sessions. As part of this course, concept mapping was a routine activity; however, if this is a new activity within a curricular structure, emphasis on process and rationale for using the method may be helpful. M2 students had participated in the molecular and cellular foundations module the previous year and were therefore also facile with this learning activity. Appendix A provides details regarding the use and implementation of concept mapping; sharing this with students in advance of the session may be helpful. In contrast, the M2 students were being taught in a mixed methodology block, and their performance also did not change as a result of this session.

Second, there were numerous factors that our analysis did not account for. The analysis of M1 data compared the performance on the content associated with the session with performance delivered in prior and subsequent weeks, so differences in content and the faculty delivering it may have confounded proper interpretation. The analysis of M2 performance compared exam results of those who attended the session with those who did not, and these self-selecting groups may not have had matching characteristics. Additionally, the assessment focused only on the acquisition of medical knowledge. Had we diversified assessment to include additional competencies, it is likely that we would have observed significant differences both in the learning and also between the M2 students who did versus those who did not participate.

This curriculum required substantial coordination across two different sets of learners and between two faculty of differing disciplines. Although the generation of the session and class scheduling were time consuming, the session was rewarding for the students (see comments in the results). This exercise was facilitated by a physiologist and biochemist; therefore, the focus on content integration was largely restricted to those two content areas. In future iterations or for other programs, this focus could be easily adjusted to include alternative disciplines by modifying concept-mapping terms and the learning objectives for students. Alternatively, the session could readily be adapted for an interprofessional audience that could include pharmacologists and genetic counselors. An additional feature of the session was that its format allowed for the incorporation of additional core medical competencies[16] that could be assessed in a formative and/or summative fashion. Students who engaged in the session perceived that it addressed the competencies of medical knowledge, professionalism, interprofessional and communication skills, and patient care.[11]

The results of this study are limited by several factors. First, the imbalance in learners involved (large ratio of M1s to M2s) suggests that the curriculum may not reflect a true NPT endeavor, but more closely resemble team facilitation. Our low M2 attendance is a fairly common phenomenon in many programs, and the rationale for the lack of student engagement spans many factors, such as convenience, efficiency, and quality of delivery.[17] Low M2 attendance may impact the ability to perform this session. Additionally, medical students are more likely to use third-party resources for studying.[18] Despite poor attendance by medical students, it has been demonstrated that they are challenged by identifying key resources,[19] reinforcing the need for expert guided educational experiences such as the session presented here. It is also difficult to conclude there was no impact on the learners involved as we assessed only medical knowledge through institutionally developed exam questions with limited evidence of validity. In future iterations, it would be instructive to use validated questions (e.g., purchased from the National Board of Medical Examiners) and assess across a larger group of students. Additionally, it would be useful to develop instruments to assess several of the other core competencies the students perceived to be part of the session. We also recognize that aligning preclinical content to implement this curriculum may be unrealistic for many programs; however, this could be easily addressed by including third- or fourth-year students in the activity with M1s and M2s. Many programs have educational electives during the clerkship years, and this would be an ideal session for those students to engage in.

Conclusion

We developed and delivered a basic science exercise that integrated content across the M1 and M2 years. Integrating M1 and M2 learning provided an opportunity for students to connect clinical presentations with basic science material essential for clinical reasoning, reinforced the proceeding week's/year's material, and allowed self-assessment through NPT. The potential to use this NPT environment to enhance retention of core competencies could translate into higher-performing M3 and M4 students, as previously demonstrated for medical knowledge.[20]

Appendices

A. Concept Mapping Facilitator Guide.docx
B. Case of Cystic Fibrosis.docx
C. Concept Map Prompt Cystic Fibrosis.docx
D. Cystic Fibrosis Discussion Questions.docx
E. Cystic Fibrosis Facilitator Guide.docx
F. Cystic Fibrosis Concept Map and Rubric.docx
G. Example Assessment Questions.docx

All appendices are peer reviewed as integral parts of the Original Publication.

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Ethical Approval
The Virginia Tech Carilion School of Medicine Institutional Review Board approved this study.

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