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Integrated Case-Based Learning Session for Breast and Upper Limb Anatomy

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Abstract

Introduction: Medical students are frequently introduced to medical school curricula through anatomy coursework, which often includes histology and embryology content. As medical education has increasingly emphasized integration of content areas, use of activities such as case-based learning (CBL) sessions has grown. Little published work has demonstrated the effectiveness of CBL sessions in integrating anatomy, embryology, and histology on first-year medical students' ability to improve content mastery and adapt their study techniques. **Methods:** We developed a CBL session that included anatomy, embryology, and histology content covering the upper extremity and breast pathology that was taught to incoming first-year medical students ($N = 51$) during a prematriculation program in the summers of 2022 and 2023. The session involved completion of an individual pre- and postsession quiz; group completion of clinical cases involving image interpretation, matching exercises, and construction of diagrams, flowcharts, or tables; and a postsession survey with Likert-style and free-response questions about preparation and session effectiveness. **Results:** Postsession quiz scores significantly improved ($p < .001$). On the postsession survey (response rate: 59%), students commented that they enjoyed the real-life application and integration of the cases and that the sessions improved their understanding of the connections between content areas. Other comments demonstrated that students were evaluating and adapting their study approach in preparation for the sessions, often using techniques introduced and practiced in the sessions. **Discussion:** CBL sessions can provide opportunities to incoming first-year medical students to practice, adapt, and evaluate study techniques while delivering integrated content.

Keywords

Anatomy, Embryology, Study Strategies, Case-Based Learning, Gross Anatomy, Histology, Pathology

Educational Objectives

By the end of this activity, learners will be able to:

1. Apply basic anatomy of the breast, pectoral, and axillary regions to a clinical case.
2. Describe the anatomical relationships of the breast, pectoral, and axillary regions.
3. Interpret histological images and relate these to a clinically relevant scenario.
4. Describe the development of the muscles and nervous system structures.
5. Practice strategies for learning anatomy.

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Introduction

The topics of anatomy (i.e., gross anatomy, histology, and embryology) are often taught early in the first-year medical curriculum. Traditional modes of gross anatomy instruction include dissection, prosection, and traditional lectures; more recently, computer-based learning, such as 3D models and online image banks, has emerged.[1] However, these teaching methods do not offer many opportunities for integrating clinical knowledge, particularly with gross anatomy. Recent calls advocate for increased integration between the basic and clinical sciences and more opportunities for students to engage in critical thinking and innovation.[2] This has resulted in a significant reduction in the number of course hours dedicated to gross anatomy and histology and an increased presence of gross anatomy, histology, and embryology as components of integrated curricula rather than as stand-alone courses.[3] While increased integration of basic and clinical sciences content has been shown to improve retention,[4] the decrease in time dedicated to these foundational topics puts

increased pressure on students to learn the already high-volume, complex information.

According to the AAMC, students who are members of racial and ethnic groups that are "underrepresented in the medical profession relative to their numbers in the general population" are considered to be underrepresented in medicine (URiM).[5] These students are particularly susceptible to such pressures, as they are more likely to enter medical school with a lower MCAT score and GPA than their White and Asian colleagues.[5] These differences in academic achievement have been shown to persist beyond the initial stages of medical school, with an NBME review demonstrating that White students perform better on USMLE Step 1, Step 2 CK (Clinical Knowledge), and Step 3 exams compared to URiM students even when controlling for factors such as undergraduate GPA and MCAT score.[6]

Prematriculation programs are one approach that medical schools have increasingly been using to ease this transition and encourage the success of students. These programs target incoming medical students, some of whom are considered URiM,[7] and typically provide an introduction to the first-year curriculum.[7-10] While further research is needed to more robustly assess the efficacy of these programs, there is evidence to suggest that they help students retain material,[8,10] increase confidence and make connections among peers,[10-12] and improve academic performance[13]; they may even be useful for identifying students truly at risk of academic difficulties in medical school.[13]

Preparing students for professional curricula is arguably the primary goal of prematriculation programs, and many medical education curricula utilize an active learning method called case-based learning (CBL), which is an effective means of integrating the basic and clinical sciences through clinical cases and presentations.[14-16] CBL sessions encourage application of knowledge while engaging critical thinking skills and are well received by students due to their real-life application, interactive nature, and utility in identifying knowledge gaps.[14-16] Because of these characteristics, CBL is ideally suited for teaching students basic science and clinical knowledge as well as how to effectively use and adapt study techniques. While some undergraduate courses are incorporating CBL into their curricula,[17] CBL is used more frequently with upper-level students such as those in medical, nursing, and graduate school.[18] Many students entering medical school may be unfamiliar with this teaching method, which can create difficulties in learning the content, as adjusting to CBL can be challenging for students with less prerequisite knowledge and/or experience with this teaching method, especially if the case questions are more open-ended.[19]

Numerous publications in *MedEdPORTAL* focus on one or more of the concepts of anatomy, embryology, and histology.[20-26] While some are designed to be accessible to first-year medical students,[21-25,27] few integrate all three content areas,[21-23,27] and none do so for basic, foundational concepts of histology and embryology. We identified an opportunity to implement integrated anatomy CBLs in our prematriculation program, known as the Leadership, Engagement, Achievement, Development (LEAD) Scholars program, at the Indiana University School of Medicine (IUSM). The program was developed to support the transition of students, especially those considered URiM based on the AAMC definition, into their first year of medical school. The first of three CBLs utilized in the program is described here.

Our CBL session fills a gap by integrating three anatomical content areas at a level appropriate to the knowledge base of first-year medical students at the start of their medical training. The case presents a clinical scenario based around the upper limb and challenges students to apply knowledge of anatomy and the foundational concepts of embryology and histology. An additional novelty of our case session is that we designed it to provide opportunities for students to practice and adapt study techniques within the exercises of the session, which is an important skill for students to master early to facilitate success throughout medical school.

Methods

Curricular Context

The CBL was completed as a component of the LEAD Scholars prematriculation program, which took place over one 4-week period during the summer of 2022 and again in 2023 immediately before the first year of medical school. Participating students were either matriculating first-year medical students ($n = 43$) or medical students repeating their first year ($n = 15$). During the first week of the program, students received instruction in personal and professional development as well as study strategies for success in medical education. During the following 2-week period, which was meant to simulate the pace and volume of the first of three blocks of the first-year medical anatomy course at IUSM (i.e., Human Structure), students received 21 prerecorded lectures, each an hour long, covering regional gross anatomy of the upper limb, early embryology, histology of basic tissues, and an introduction to radiology

(Table 1). Students also participated in seven 2-hour gross anatomy lab sessions where they alternated regional dissection and examining prosected (i.e., previously dissected) donors with the assistance of instructors and an online dissector. In the final week of the program, students participated in three CBL small-group sessions (one per day) before taking final exams. A 40-item gross lab practical primarily assessed the identification of structures, with one-quarter of questions assessing the function or clinical relevance of a tagged structure. An 80-item, computer-based examination assessed lecture content in gross anatomy, histology, and embryology and included 15 items based on histology imaging. These examinations were comparable in structure and question types to those the students would encounter in the integrated Human Structure course.

The three CBL sessions integrated all content areas covered in the 2-week instructional period. The first session, described here, covered the anatomy, embryology, and histology of the upper limb, breast, and associated structures.

Team Formation

Students were assigned alphabetically to groups of six to eight, which also included each member of their laboratory dissection group. Students had already had 2 weeks of experience with their lab group members, so this helped provide a safe space for them to discuss the answers to questions. Small groups of this size (as supported by the literature) were large enough to promote interaction but not too large to risk the voices of some members not being heard.[28]

Description of Advance Preparation Resources

Session objectives, a list of preparation resources, and prework activities were located on the Canvas learning management system at the start of the course. Assigned prework (Appendix A) included reviewing specific lectures related to the case (breast, pectoral region, and axilla; brachial plexus lesions; etc.) and completion of laboratory sessions. Lectures and laboratory sessions were scheduled in the first 2 weeks of the program and were listed as a reminder to review. Also included in the prework were two tables for students to complete. The tables helped the students to synthesize information prior to the event and were an effective tool for compartmentalizing information for recall and retention.

Learning Activity

The sessions were primarily facilitated in 2022 by a third-year medical student who developed all elements of the session and in 2023 by a doctoral student in anatomy education. A faculty member in the IUSM Department of Anatomy, Cell Biology & Physiology who was an instructor for the Human Structure course oversaw development of the sessions and was present as an assistant facilitator. The sessions took place in a large team-based learning (TBL) classroom with U-shaped tables, each equipped with a computer and TV monitor. Facilitators utilized a central computer to project a PowerPoint onto the students' screens and could release the monitors for the students to begin working on activities associated with the CBL at their own computer stations. One student was the lead for each group and entered responses to the questions from the computer at their station (other students could complete the assignments on their personal devices, such as laptops and tablets, if they desired). Between the activities, a facilitator debrief took place to answer the questions interactively with the groups. Students completed pre- and postsession quizzes and a postsession survey on their own devices.

At the beginning of the session, students were given 15 minutes to individually complete the 10-item presession quiz (Appendix B), which included questions on gross anatomy, histology, and embryology. This quiz was closed book and closed note. Following completion of the quiz (which was not reviewed), students worked as a group to answer the questions and address the tasks in the CBL (Appendix C); the facilitator presented the PowerPoint (Appendix D) and followed the timing constraints given in its slides. The facilitator stopped to debrief, address the questions in the activity, and answer any other questions before moving to the next activity. Each case consisted of clinical scenarios and questions that required students to interpret

Table 1. Lecture Topic and Sequence by Discipline

Lecture Topic and Sequence	Discipline
Superficial and deep back	Gross anatomy
Vertebral column and spinal cord	Gross anatomy
Introduction to histology and epithelial tissue	Histology
Introduction to radiology	Radiology
Breast, pectoral region, and axilla	Gross anatomy
Shoulder and scapular region	Gross anatomy
Neurulation and somite formation	Embryology
Muscle, nerve, and connective tissues	Histology
Arm and cubital fossa	Gross anatomy
Extensor forearm	Gross anatomy
Flexor forearm	Gross anatomy
Palm of the hand	Gross anatomy
Lesions of the brachial plexus	Gross anatomy
Autonomic nervous system	Gross anatomy
Radiology of the back and upper limb	Radiology
Thoracic wall and lungs	Gross anatomy
Middle mediastinum	Gross anatomy
Superior and posterior mediastinum	Gross anatomy
Radiology of the thorax	Radiology
Histology of the heart and lungs	Histology
Embryology of the heart	Embryology

images, complete matching exercises, and make diagrams, flowcharts, or tables; these were fully integrated, asking students to recall and apply information from all three disciplines of gross anatomy, embryology, and histology. After all case activities had been completed, students individually took the postsession quiz (Appendix B), which was identical to the presession quiz (except for mixing of question and response order), and filled out the voluntary postsession survey (Appendix E). In all, the session was completed in approximately 3 hours (Appendix D gives the timing of each activity).

Evaluation

To evaluate students' preparedness and the sessions' effectiveness, students completed individual pre- and postsession quizzes (Appendix B), as well as a postsession survey (Appendix E). The pre- and postsession quizzes featured multiple-choice knowledge questions to gauge whether the case and resultant discussion were effective in improving students' knowledge. The postsession survey was administered directly after the session to elicit students' feedback on whether the CBL successfully integrated the content areas and facilitated their learning. Students rated their level of agreement with five items using a 5-point Likert scale (1 = *strongly disagree,* 5 = *strongly agree*). The survey also included open-ended questions that encouraged students to reflect on their preparation and general perceptions of the session. Pre- and postsession quiz scores were compared using a Wilcoxon signed rank test. Response rate and average statement agreement were calculated for the Likert items. Free responses were analyzed using content analysis.

This project was deemed exempt by the Indiana University Institutional Review Board.

Results

Fifty-one students participated in the CBL session (2022: $n = 12$, 2023: $n = 39$). Students performed significantly better on the postsession quiz, with the averages at 57% and 69%, respectively ($p < .001$).

Overall, 30 of the 51 students (2022: $n = 10$, 2023: $n = 20$) completed the postsession survey (59% response rate). The CBL was well received by students, who all agreed the session improved their understanding of the material, integrated anatomy content, and was well organized (Table 2). Free responses indicated students enjoyed the small-group collaboration and being able to work in teams. Others commented on the effectiveness of the facilitator discussions, with one student stating that "the large group discussion helped to solidify the content." While many students noted that they had reviewed the lectures and begun making notes, they could have improved their study techniques for the session by including self-testing and other active recall techniques.

Table 2. Postsession Survey Responses ($N = 30$)

Item[a]	*M*	*SD*
The session improved my understanding of course material.	4.7	0.6
The session appropriately connected anatomy, histology, and embryology content.	4.8	0.4
The lectures appropriately prepared me to apply content in this session.	4.6	0.6
The session was well organized.	4.8	0.5
The session was at an appropriate depth of content.	4.8	0.5

[a]Rated on a 5-point scale (1 = *strongly disagree,* 5 = *strongly agree*).

Discussion

The fast-paced, high-volume nature of medical education curricula presents a uniquely challenging situation to incoming students to quickly adapt their study techniques to meet this demand. Medical educators have called for an increased emphasis on integrated content,[2] providing an opportunity for more active learning sessions within medical education. The CBL session we describe addresses both of these areas by incorporating opportunities for students to practice study techniques within a session with fully integrated content. This session offers the opportunity to ease students' transition into the rigorous medical school curriculum and to introduce core content areas in a low-stakes environment.

Our results demonstrate that CBL sessions are a viable means of providing opportunities to incoming first-year medical students to practice, adapt, and evaluate study techniques while delivering integrated anatomy, embryology, and histology content. The significant improvement in scores between the pre- and postsession quizzes suggests that the session activities and accompanying discussion helped to further students' knowledge and understanding of the content. This is further supported by the postsession survey results, where all students agreed the session improved their understanding of the material through the real-life application of the cases and allowed them to evaluate the effectiveness of their study techniques. Together, our results indicate that the activities and content within the sessions encouraged students to evaluate their own study techniques and, perhaps more importantly, reflect on how they might change them to be more effective going forward. This engaged students in a form of self-regulated learning, a process involving cycles of preparation (based on factors such as past knowledge and experience), strategy implementation, and outcome evaluation (which gives information on the efficacy of

a student's preparation and allows the opportunity for changes to occur for the next cycle).[29] This process of self-reflection and evaluation is an important step in students' development of self-regulated learning strategies, which are critical for success in higher education environments such as medicine.[30]

The generalizability of our results is limited by a small sample size of students in a formative, prematriculation program at a single institution. The prematriculation program invited a small, select group of students whose participation was entirely voluntary. Thus, scores on assessments were formative and did not impact students' current standing in the program or in medical school. These factors may have influenced students' study techniques and motivation to study outside the scheduled program time. Despite this, our results demonstrate the utility of CBL sessions for both integrating content and teaching study techniques to incoming medical students and support other research suggesting that CBL encourages students to engage in self-directed learning and identify learning gaps and strategies to fill them.[14,16] Our work expands the already robust literature highlighting the utility of CBL for medical education and integrating content[14-16] by demonstrating an efficient means with which to introduce students early in training to study strategies for approaching integrated anatomy content with a clinical focus.

Future directions include conducting a follow-up to explore the degree to which students implement changes to their study strategies following the session, to explore the strategies they ultimately find useful within their medical school courses, and to determine whether the integrated CBL sessions assist them in making connections between anatomy, histology, and embryology content in the Human Structure course.

We developed a CBL session accessible to incoming first-year medical students that integrated three core content areas of medical anatomy education as well as incorporating opportunities to practice and evaluate study strategies useful for succeeding in medical education. Especially as medical knowledge continues to increase while the time allotted for teaching it remains stable, educational modalities such as these that efficiently teach a number of concepts and skills will continue to grow in value and importance.

Appendices

A. Required Prework.docx

B. Pre- and Postsession Quiz.docx

C. CBL Questions and Activities Key.docx

D. Case 1 Facilitator Slides & Instructions.pptx

E. Postsession Survey.docx

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

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Ethical Approval

The Indiana University Institutional Review Board deemed further review of this project not necessary.

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