The Gross Anatomy Laboratory: A Novel Venue for Critical Thinking and Interdisciplinary Teaching in Dental Education

Kevin C. Rowland, PhD; Anita Joy, BDS, PhD

Abstract: Reports on the status of dental education have concluded that there is a need for various types of curricular reform, making recommendations that include better integration of basic, behavioral, and clinical sciences, increased case-based teaching, emphasis on student-driven learning, and creation of lifelong learners. Dental schools faced with decreasing contact hours, increasing teaching material, and technological advancements have experimented with alternate curricular strategies. At Southern Illinois University School of Dental Medicine, curricular changes have begun with a series of integrated biomedical sciences courses. During the process of planning and implementing the integrated courses, a novel venue—the gross anatomy laboratory—was used to introduce all Year 1 students to critical thinking, self-directed learning, and the scientific method. The venture included student-driven documentation of anatomical variations encountered in the laboratory using robust scientific methods, thorough literature review, and subsequent presentation of findings in peer review settings. Students responded positively, with over 75% agreeing the experience intellectually challenged them. This article describes the process of re-envisioning the gross anatomy laboratory as an effective venue for small group-based, student-driven projects that focus on key pedagogical concepts to encourage the development of lifelong learners.

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The curriculum at Southern Illinois University School of Dental Medicine (SIU-SDM) aims to instill in students the qualities of critical thinking, self-directed learning, and scientific inquiry. The curricular efforts toward biomedical and clinical integration at SIU-SDM include a novel approach that uses anatomical variations encountered in the gross anatomy laboratory to integrate pathophysiological and clinical applications. We anticipated our pedagogic effort would require students to build on existing skills and/or develop new skills, including literature review, self-evaluation, and critical thinking.

The discipline of anatomical sciences, which traditionally formed the foundation of a medical/dental education, has often been at the forefront of curricular reform. In the early 1900s, anatomy instruction, both lectures and laboratory sessions, was delivered using more than 1,000 contact hours.1,2 Following the Flexner report on medical education in 1910 and the Gies report on dental education in 1926, time devoted to anatomy instruction was restricted, ranging from 480 to 1,185 hours and averaging 780 hours.3 Faced with restricted hours but increased content, novel proposals to integrate histology and gross, topographic, and clinical anatomy across all four years of the curriculum were put forward, but unfortunately gained little momentum.4 It was not until the early 1990s, almost 60 years after the first recommendations for integrated teaching were published, that medical and dental curricula began a transformation from traditional, silo-based, discipline-specific approaches to a broader, multidisciplinary, integrated approach.5,6 Along with the traditional-to-integrated curricular transitions, a growing trend was the collapse of independent anatomy and physiology departments and their assimilation into more research-focused or clinical departments like biomedical sciences, cell biology, or surgery.7,8 In the era of integrative and interprofessional education, some dental schools have now successfully transitioned to integrated methods of teaching the biomedical sciences.

With the evolving U.S. health care delivery system, academia should evolve to prepare future clinicians with the proficiency required to meet...
society’s ever-changing health needs. The Commission on Dental Accreditation (CODA) emphasizes that dental educators should “demonstrate and teach critical thinking, promote self-directed learning, encourage scientific discovery, emphasize integration of knowledge, and foster collaborations with other healthcare professionals.” Innovative curricular strategies may be adopted by schools in order to enhance learning experiences and to effectively train students. Restructuring of curricular layouts have largely focused on interdisciplinary and integrated basic/clinical science courses, while interactive approaches such as team-based/small-group interactive sessions and case-based and problem-based learning have led to the creation of innovative, clinically relevant curricula.

At SIU-SDM, curricular changes have begun with a series of integrated biomedical sciences courses. During the process of planning and implementing the integrated courses, a novel venue—the gross anatomy laboratory—was used to introduce Year 1 dental students to critical thinking, self-directed learning, and the scientific method. The purpose of this article is to describe the process of re-envisioning the gross anatomy laboratory as an effective venue for small group-based, student-driven projects that focus on key pedagogical concepts to encourage the development of lifelong learners.

Integrated Biomedical Instruction at SIU-SDM

Educators in the biomedical sciences typically use one of three teaching approaches: traditional discipline-based, integrated block/systems, or problem-based learning. In order to keep the study of biomedical sciences relevant to the practice of future health care professionals, irrespective of the teaching approach utilized, educators have been integrating clinically relevant topics using new imaging technologies, surgical/procedural principles, virtual learning experiences, case-based learning, problem-based learning, humanities, and ethics.

The SIU-SDM was one of the universities at the forefront of curricular reform in the 1980s which resulted in the adoption of a core curriculum and an integrated approach to teaching. Over time, further curricular changes resulted in the dissolution of the integrated approach, and a discipline-specific approach was instituted. Currently, curricular changes focused on interdisciplinary and interprofessional integration are being “re-adopted” at SIU-SDM. Interdisciplinary integration is being carried out in a phased manner with the institution of a human systems-based course and a human craniofacial-specific course that integrates the disciplines of anatomy (histology and gross), physiology, biochemistry, cell biology, and select topics in microbiology. Planning and implementation of the integrated courses have eliminated redundant topics, enhanced emphasis on relevant clinical correlations, created integrated exams with case-based scenarios, and reduced the number of discipline-specific exams during Year 1. The integrated courses are delivered through a lecture-lab format, with corresponding gross anatomy laboratory sessions aligned to parallel the systems-based lectures.

While integrated teaching in the classroom setting was successfully implemented and well received by students, teaching in the gross anatomy laboratory setting had still remained purely discipline-specific. The teaching and learning in the gross anatomy laboratory revolved around traditional dissection of a specific region, identification of specific structures within the dissected region, review of anatomical relationships, and discussion of appropriate clinical correlations. The absence of integrated teaching within this laboratory was a stark revelation. Absence of integrated teaching could be attributed to several factors, including specialized training required by faculty, time required to complete a specific dissection for review, and lack of precedent or direction for the faculty. In light of curricular changes being instituted at SIU-SDM, we created an additional integrated/interdisciplinary teaching and learning program by using anatomical variations encountered in the gross anatomy laboratory.

Although various forms of integrated teaching in the laboratory are used in several medical schools, the described program is relatively unique in a dental school setting. The faculty and laboratory facilities at SIU-SDM are not shared with a medical school, but are one of the very few stand-alone facilities in the country located within a dental school. In order to enhance the students’ learning experience, faculty members are encouraged to participate in faculty development programs targeted towards improving teaching skills and integrated/interprofessional teaching strategies. Additionally, faculty members regularly participate and present at national meetings focusing on pedagogy as well as discipline-specific topics. In addition to augmenting the dissection experience for students, the integrated gross anatomy
laboratory sessions were evaluated using surveys to gauge students’ subjective assessments to help us enhance their development in critical thinking, self-directed learning, and exploration of the scientific method. Furthermore, our program aims to build a foundation for interprofessional education and lifelong learning.

**Approach**

This study was reviewed by the SIU Institutional Review Board and received an exempt status (IRB # 12-1016-4). Over a two-year period (2013 and 2014), 102 Year 1 dental students were involved in the integrated/interdisciplinary gross anatomy laboratory program. Students were divided into 14 groups (seven groups each year), with each group assigned to a single cadaver. Students identified and documented anatomical variations and/or pathologies encountered during routine dissection, which included fibroma in the thoracic wall, small cell lung carcinoma, breast implants secondary to breast cancer, bullous emphysema, coronary artery bypass, retroaortic left renal vein, gastric carcinoma, ectopic parathyroid glands, and bivariant (double) superior rectus muscle. The integrated laboratory approach extended beyond mere “note-taking,” and students were expected to research the anatomical variation including documentation, use of appropriate diagnostic methodologies, literature review, and dissemination of data.

The general scheme that students followed is shown in Table 1. Documentation of the anatomical variation(s) encountered included detailed dissection, recording findings, photographing relevant dissections/structures, collecting samples from the area of interest for any required histological evaluations, establishing a differential diagnosis, and determining a final diagnosis based on documented features and histological analysis (if any). Students actively researched the variations and formulated diagnoses in consultation with SDM faculty, including the oral medicine/pain specialist, oral pathologist, radiologist, internist, oral surgeon, and biomedical faculty.

The literature review was the key component of integration, giving students the opportunity to review pertinent literature not only on the pathology encountered, but also normal, expected anatomy/histology and pathophysiology, along with a study of pharmacological interventions. Students were required to provide an in-depth management plan for such patients in a dental setting.

**Outcomes**

Students worked in teams to compile each case and presented their findings at a research forum. Selected presentations were prepared as manuscripts by students for submission to peer-reviewed journals. Following through with the case presentation is important in developing critical thinking and problem-solving skills and also helps in dissemination of knowledge. Students also participated in a perception survey to evaluate the integrated courses on four overarching parameters: instructional effectiveness, intellectual challenges, use of technology, and overall experience. Survey questions that targeted the integrated gross laboratory experience were included in the intellectual challenges parameter. Of the 51 students surveyed in each of the two years, 78.9%

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**Table 1. Protocol followed by students in gross anatomy laboratory at Southern Illinois University School of Dental Medicine to document anatomical variations and present their findings**

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
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<tbody>
<tr>
<td>1. Identification</td>
<td>a) Identify suspected anatomical variation(s)</td>
</tr>
<tr>
<td>2. Documentation</td>
<td>a) Photograph, measure, acquire samples for histology (if needed)</td>
</tr>
<tr>
<td></td>
<td>b) Formulate differential diagnosis</td>
</tr>
<tr>
<td>3. Literature review</td>
<td>a) Perform thorough literature review with periodic faculty consultation</td>
</tr>
<tr>
<td></td>
<td>b) Carry out histological analyses, if appropriate</td>
</tr>
<tr>
<td></td>
<td>c) Consult with specialists to formulate final diagnosis</td>
</tr>
<tr>
<td>4. Presentation</td>
<td>a) Present findings to systems course faculty</td>
</tr>
<tr>
<td></td>
<td>b) Further investigation if required</td>
</tr>
<tr>
<td></td>
<td>c) Variations presented in lab session to all students</td>
</tr>
<tr>
<td></td>
<td>d) Select variations presented during School of Dental Medicine Research Day</td>
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</table>
and 80.0% responded positively to being intellectually challenged during the gross laboratory sessions in 2013 and 2014, respectively (Figure 1).

As we continue to institute changes across the entire curriculum at SIU-SDM, continuous assessments of the program instituted will be carried out using surveys to target current students, as well as graduates who would have experienced the new curriculum at SIU-SDM. With regard to contributions of the integrated courses in general and the gross anatomy laboratory specifically, Table 2 gives a brief overview of achievements thus far and an outline of expected future outcomes.

The Way Forward

CODA’s core principles aim to “promote an educational environment conducive to change, innovation, and continuous improvement in dental educational programs.” The core principles include, among others, critical thinking, self-directed learning, scientific discovery, and integration of knowledge. As dental educators, we often view each of these core principles as individual, independent, and unrelated entities and look to multiple venues within the curriculum to achieve our goal of developing lifelong learners. One of the keys for students to develop into lifelong learners is “learning how to learn”—a skill that cannot be taught in the classroom. An innovative approach incorporating student-driven learning, clinically relevant curricula, and integrated teaching is critical to developing lifelong learners.

The curricular changes instituted within a single venue, the gross anatomy laboratory at SIU-SDM, have shown that pedagogical principles of critical thinking, self-directed learning, scientific discovery, and integrated knowledge can be successfully introduced and developed early on in the dental curriculum. By laying a strong foundation, it

![Figure 1. Survey results from two classes of Year 1 students who were taught biomedical sciences in the new, integrated curriculum at Southern Illinois University School of Dental Medicine](image)

Note: The 5-point Likert survey targeted students’ gross anatomy laboratory experience under the Intellectual Challenges section. Almost 79% of students reported they were highly challenged during the gross anatomy laboratory sessions, especially those sessions that involved documentation of anatomical variations. Overall, 85% of Year 1 students responded positively to the newly instituted integrated biomedical science curriculum.
is possible to train our students to learn. As students advance through the curriculum, these principles should be reinforced at various levels and in various settings.

Providing information devoid of context is not an optimal teaching method, resulting in mere memorization of facts with no ability to apply the information, whereas providing contextual information helps students better retain concepts and develop higher orders of learning, including application, evaluation, analysis, and synthesis. In addition to introducing important pedagogical principles, the integrated gross anatomy laboratory approach could allow students to achieve higher orders of learning. Concurrent with the integrated teaching methodology adopted, a novel virtual anatomy dissection tool has been introduced as an invaluable supplement to the laboratory sessions. The efficacy of this teaching and learning tool is currently being evaluated.

The future of dental education depends largely on the willingness of faculty to lead transformative change, despite the fact that the influencing variables are often uncontrolled. Rather than settle for the status quo or developing “more of the same,” dental educators will benefit by embracing the concept of “disruptive innovations.”

Curriculum reform often is initiated as a result of national or institutional directives, but reform is most effective when it occurs at the teacher-student interface. The daunting task of developing lifelong learners may become less challenging by taking small, albeit significant steps towards curricular change that shift the focus from the sheer quantity of information provided to the quality of student learning.

Table 2. Overview of outcomes of integrated biomedical science curriculum for Year 1 students at Southern Illinois University School of Dental Medicine

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Achieved/Anticipated</th>
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<tr>
<td>Year 1 students presenting table clinics during Research Day</td>
<td>8 students presented in 2013 and 2014</td>
</tr>
<tr>
<td>Decompressed curriculum</td>
<td>Curriculum decompressed in Year 1 Further curriculum decompression expected across all 4 years</td>
</tr>
<tr>
<td>Increased interdisciplinary teaching</td>
<td>Partially achieved in the biomedical sciences Continued integration of biomedical sciences and clinical disciplines currently under way</td>
</tr>
<tr>
<td>Student satisfaction</td>
<td>In surveys from first two years, trend towards positive student experiences</td>
</tr>
<tr>
<td>Faculty satisfaction</td>
<td>Participating faculty have strong commitment and interest</td>
</tr>
<tr>
<td>Higher NBDE Part 1 pass rates</td>
<td>Data forthcoming</td>
</tr>
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REFERENCES