# Human Structure in Six and One-Half Weeks: One Approach to Providing Foundational Anatomical Competency in an Era of Compressed Medical School Anatomy Curricula

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The University of Oklahoma College of Medicine reduced gross anatomy from a full semester, 130-hour course to a six and one-half week, 105-hour course as part of a new integrated systems-based pre-clinical curriculum. In addition to the reduction in contact hours, content from embryology, histology, and radiology were added into the course. The new curriculum incorporated best practices in the area of regular assessments, feedback, clinical application, multiple teaching modalities, and professionalism. A comparison of the components of the traditional and integrated curriculum, along with end of course evaluations and student performance revealed that the new curriculum was just as effective, if not more effective. This article also provides important lessons learned. Anat Sci Educ 8: 149–157. 

*Key words:* gross anatomy; anatomical sciences/medical education; anatomy teaching; curriculum; clinical anatomy; assessment; feedback; test-enhanced learning; effectiveness of anatomy education; undergraduate medical education

## INTRODUCTION

Curricular reform in undergraduate medical education has been stimulated in part by recent reports on the state of medical education (AAMC-HHMI, 2009; Irby et al., 2010). Many schools have moved from traditional discipline-based courses to integrated systems-based courses in the preclinical curriculum. These courses are provided in short and intensive blocks rather than extending over a full semester (Sugand et al., 2010; Klement et al., 2011). Medical schools have also moved from lecture-based methods of teaching to active learner-centered methods (Kerby et al., 2011; Kamei et al., 2012; Prober and Health, 2012), with some completely eliminating traditional anatomy lectures (Vasan et al., 2011). These types of changes have resulted in reduced time allotted to traditional anatomy courses (Drake et al., 2009; Rizzolo et al., 2010) and have created challenges and opportunities for anatomists to develop and implement new teaching techniques and strategies (Drake, 2014).

Mixed outcomes have been reported regarding the impact of integrated curricula on anatomy knowledge. Knowledge of surface anatomy has been shown to be lower in an integrated systems-based curriculum as compared to a traditional anatomy curriculum (McKeown et al., 2003). Others reported either slightly higher (Findlater et al., 2012) or equivalent (Bergman et al., 2008) student knowledge of anatomy in an integrated curricula compared to traditional anatomy curricula. When the United States Medical Licensing Examination (USMLE) Step 1 and Step 2 scores were compared from a large number of medical schools with either a traditional or integrated anatomy course, the type of anatomy course

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Received 19 September 2013; Revised 15 March 2014; Accepted 12 June 2014.

Published online 3 July 2014 in Wiley Online Library (wileyonlinelibrary.com). DOI 10.1002/ase.1476

offered (traditional or integrated) was unrelated to USMLE scores (Cuddy et al., 2013).

The anatomy course at the University of Oklahoma College of Medicine was changed from a traditional to a condensed and integrated course when the preclinical curriculum changed from a discipline-based to a systems-based curriculum in 2010. These changes, along with a more learner-centered approach were guided by education literature. While an exhaustive review of best practices in learner-centered approaches in condensed medical education courses is outside the scope of this descriptive paper, there are several overviews available (Spencer and Jordan, 1999; Kaufman, 2003; Cooke et al., 2006). For the purposes of this descriptive paper, the focus will be on regular assessments, feedback, clinical application, multiple teaching modalities, and professionalism.

Assessments are powerful learning motivators for medical students (Newble and Jaeger, 1983; Krupat and Dienstag, 2009; Wood, 2009). The goal of any assessment type should be considered to determine what content will be included, the format of the assessment, the frequency of assessment, and the type of feedback provided (Epstein, 2007). Test-enhanced learning improves content retention (Larsen et al., 2009; Butler, 2010; McDaniel et al., 2011) and has a positive effect on examination scores (Olde Bekkink et al., 2012). Repeated retrieval practice utilizing either simulation testing with standardized patients or written testing is a valuable tool to enhance learning and retention in medical training Larsen et al. (2013). More recently, Raupach et al. (2013) demonstrated that students were more motivated to learn and perform at a higher level if the stakes were high. The current Human Structure course capitalized on these findings by increasing the number of content quizzes and laboratory practical quizzes to enhance learning and retention.

Previous research has also indicated that student learning and content retention is enhanced by regular corrective feedback (Roediger and Butler, 2011). For instance, a body of literature indicates that large group teaching with audience response systems (ARS) can have positive benefits such as short-term knowledge retention (Karaman, 2011), provide an important knowledge gauge for students (Alexander et al., 2009), and increase problem-solving skills through interactive learning (Mazur, 2009). This form of assessment and feedback remains integral in the new Human Structure course.

Clinical application can be vital to anatomical education. By providing context and clinical relevance to the anatomy curriculum, student motivation, learning, and retention can be facilitated (Bergman et al. 2008). Böckers et al. (2014) examined the effect of clinical context in anatomical science education by providing students with the opportunity to learn basic surgical skills while concurrently studying gross anatomy. The results indicate that those who studied gross anatomy and basic surgical skills were more likely to remain engaged compared to those who participated in gross anatomy alone. Another study showed that 84% of medical students reported that clinical examples/scenario/cases during the teaching of anatomy enhanced their motivation (Moxham et al., 2011). To enhance clinical relevance in the current Human Structure course, clinical context activities were integrated into multiple aspects of delivery. In fact, one fifth of the current course content was focused on case-based learning. In addition, there were clinical faculties, with one of the course directors being a clinician.

By providing students with an array of multiple modalities and experiential learning opportunities, learners can meet their learning goals (Johnson et al., 2012; Drake, 2014). The literature on the merits of experiential learning in the cadaver laboratory continues to support the use of the student dissection experience (McWhorter and Forester, 2004; Korf et al., 2008; Sugand et al., 2010; Kerby, 2011). Therefore, the new Human Structure curriculum included experiential learning through laboratories and a variety of independent materials using multi-modalities such as faculty produced review documents, tutorials, and videos.

Experiences in gross anatomy courses are ripe with opportunities for development of professionalism. A review of the literature highlights a variety of ways in which anatomy education plays an important role in professionalism. Swartz (2006) described how gross anatomy promotes responsibility, teamwork, respect for patients, and social responsibility. Reciprocal peer teaching that often occurs in the context of an anatomy course also fosters professional skills such as communication, oral presentations, respect for peers and leadership (Krych et al., 2005). Using a verified psychometric instrument Pearson and Hoagland (2010) measured change in professionalism attitudes that occurred in their gross anatomy course. They reported a statistically significant change in professionalism attitudes, with an increase in student's altruism. A number of educational elements in the current Human Structure curriculum at the University of Oklahoma College of Medicine were designed to foster professionalism development and have been reported elsewhere (Vannatta and Crow, 2011; Crow et al., 2012).

This descriptive paper highlights the most significant changes implemented in the anatomy course at the University of Oklahoma College of Medicine after developing a condensed and integrated anatomy curriculum (Human Structure) and provides lessons learned. While this was not a research study, we expected that the newly enhanced but compressed anatomy format would result in comparable student outcomes compared to the old curriculum.

# DESCRIPTION

## Description of the Medical School

The current preclinical curriculum at the University of Oklahoma College of Medicine (OUCOM) includes three foundational courses in the first semester, followed by integrated systems modules in the final three semesters. Human structure is one of the early foundational courses. Each cohort has ~168 students. The analysis of outcomes included the two cohorts (2008–2009 and 2009–2010) before implementation of Human structure (as described below), and the two cohorts following the implementation (2010–2011 and 2011–2012).

## Description of the Anatomy Course

Prior to 2010, the anatomy course (called Gross Anatomy) was taught in a 16-week (130 hour) course that met 3 days per week. Students in Gross Anatomy attended 37 hours of traditional lectures, 15 hours of clinical lectures, performed ~50 hours of cadaveric dissection, and were involved in three problem-based learning (PBL) small group sessions. Assessment of student learning included three quizzes, three regional laboratory practical examinations, and three multiple choice written examinations. Four core teaching faculty lectured and assisted students in their cadaveric dissections. In addition, fourth-year students (four to eight students) served as teaching assistants in the gross anatomy laboratory. The composition of the teaching team remained the same for the new anatomy course.

The new anatomy course (called Human Structure), was initially a 5-week course that met daily up to 4 hours. This course did not include limb anatomy, histology, or embryology content (2010 iteration). These topics were covered in subsequent systems-based courses. To compensate for the compressed course time, traditional lectures were augmented by required independent readings that often introduced new material. Aside from the course length and lack of limb anatomy, histology or embryology content, the course was very similar to the second iteration (2011) of the course described next.

In 2011, limbs were added back to Human Structure, which became a 6.5-week course that met daily up to 4 hours. Traditional anatomy lecture time was limited to approximately four 50-minute sessions per week. Students in this course attended a total of 29 hours of traditional lectures and 12 hours of lectures devoted to clinical correlation. In addition to anatomy, the course included applicable embryology, histology, and radiology. Embryology and histology were presented in six hours of lectures. The embryology and histology content correlated with the anatomy content being discussed. For example, limb embryology and bone histology were presented in the same time frame as the anatomy of limbs. Throughout the first and second year, anatomy was reinforced through reviews in the systems-based courses.

During the 6.5-week course, students participated in dissections and case-based presentations. Each student was responsible for ~36 hours of cadaveric dissection. Students participated in the delivery of one oral presentation over a case-based problem to their peers. There were 42 separate cases presented by the students over the 6.5-week course. Clinical content was also enhanced through regular clinical lectures and clinicians in the laboratory.

Assessment of student learning included 7 weekly content quizzes, 7 weekly laboratory practical quizzes, and three

## Table 1.

**Comparison of Curriculum Components in Old Anatomy Course (Gross Anatomy) and the New Anatomy Course (Human Structure)**

| Description | Old Curriculum (2008-2009) | New Curriculum (2010) | | New Curriculum (2011) |
|---|---|---|---|---|
| **Course title** | Gross Anatomy | Human Structure | Musculoskeletal and Integument | Human Structure |
| Duration (weeks) | **16** | **5 (no limbs)** | **1.3 (limbs)** | **6.5** |
| **Traditional Instruction: Lectures** | | | | |
| Anatomy | 37 | 20 | 6 | 27 |
| Histology or Embryology | 0 | 0 | 3 | 6 |
| **Regular Assessments: Quizzes and Examinations** | | | | |
| Daily Audience Response System Quizzes | 33 | 20 | 6 | 27 |
| Laboratory Practical Assessments (weekly quizzes) | 3[a] | 4 | 0 | 7 |
| Weekend Quizzes | 3 | 5 | 1.5 | 7 |
| Weekly Knowledge Examinations | 0 | 0 | 0 | 4 |
| Summative Examinations | 3 | 2 | 1[b] | 3 |
| **Clinical Application** | | | | |
| Case-Based Learning Presentations | 3[c] | 32 | 10 | 42 |
| Clinician Lectures | 15 | 0 | 0 | 12 |
| **Experiential Learning and Independent Study Materials** | | | | |
| Dissection Laboratory (sessions/student) | 18 | 8 | 3 | 12 |
| Supplemental Readings | 0 | 28[d] | 2 | 32[e] |
| Animated Tutorials | 0 | 0 | 0 | 2 |
| Dissection Videos | 64 | 49 | 15 | 64 |
| Dissector | In house/ online | In house/ online | In house/ online | Commercially available |
| **Professionalism** | | | | |
| Anatomical Donor Luncheon (weeks before course) | 1 | 5 | N/A | 5 |
| Service of Gratitude and Remembrance (week of course) | Last | Last | N/A | Last |
| Peer Evaluation | 0 | 3 | 1 | 3 |
| Group Case Work (hours) | 6 | 6 | 2 | 8 |

[a]multi-regional examinations; [b]one-third of limbs content; [c]number of cases/semester; [d]supplemental reading included 17 new topics; [e]supplemental reading with no new topics;

written examinations. Table 1 provides a side-by-side comparison of the old and new anatomy curriculum. As this table shows, the most significant changes to the new curriculum were in frequency and nature of student assessments and the modalities used in content delivery.

**Regular assessments.** Regular assessments were implemented to incentivize students to keep up with the material, provide corrective feedback, and to take advantage of test-enhanced learning. These included daily audience response system (ARS) multiple-choice quizzes utilizing the TurningPoint system (Turning Technologies, LLC., Youngstown, OH) weekly laboratory practical quizzes and online weekend multiple-choice quizzes administered through Desire2Learn Integrated Learning Platform (Desire2Learn, Kitchener, ON, Canada), and weekly in-class ARS multiple-choice knowledge quizzes.

ARS multiple-choice quizzes were embedded either within or at the end of each traditional lecture. Students self-divided into groups to discuss the questions and come to consensus for each ARS question; however, each student was expected to submit an answer individually. The questions covered only content presented in that lecture session. Immediate feedback regarding the correct answer was provided. The total number of ARS points available was capped such that students could miss several ARS questions or sessions with no impact on their overall grade.

To enhance learning through regular assessment of laboratory sessions, a weekly practical quiz of dissected structures was administered. These were done in the traditional format of students rotating through stations to identify anatomical structures. Each practical contained 30 structures from those dissected during the week; students were not required to correctly identify all structures to earn full credit. A maximum of 25 points could be earned, thus a student could incorrectly identify five structures and still earn the maximum points. The goal was to provide students with regular checkpoints to assess their progress.

Each weekend, every student had the opportunity to take an online quiz of 20 randomly selected multiple-choice questions from a bank of 60–100 questions that covered the material for the week. The questions were primarily content application questions with a small number of case-based questions. Students could choose to work on the quizzes individually or within a group and were able to view the questions they missed after submitting the quiz. Each student was required to submit an individual quiz to receive points. Students were given three chances to pass; with each successive attempt, the required percentage to pass increased. If the required score was earned in the first or second attempt, students could take the quiz again (for a total of three attempts) for additional practice and to view additional items in the bank without penalty. Reasons for low performance or failure on these low-stakes examinations included students choosing to work alone rather than in a group or students simply not taking the examinations. Feedback was not provided in 2010, they were only provided their quiz score upon submission. In 2011 the students were presented with a list of missed items on submission, but correct responses were not provided.

In the second iteration of human structure, a short (5–10 item) multiple-choice knowledge ARS quiz was administered at the beginning of each week that related to the content covered in the previous week to ensure students kept up with the material and allowed the course directors to identify under-

## Table 2.

**Representative Full Rotation of Dissection Pairs**

| Dissection Days | Pairs |
|---|---|
| Day 1 | A and B |
| Day 2 | B and C |
| Day 3 | C and D |
| Day 4 | D and A |

Note: Dissection group consists of eight students subsequently divided into assigned pairs; only two pairs (four students) are present to dissect at any given time.

achieving students. This lag time of 1 week prior to retention testing has also been demonstrated to enhance student retention and retrieval performance (Roediger and Butler, 2011). In addition to weekly knowledge quizzes, students were administered three 60-point summative multiple-choice examinations online utilizing the Respondus LockDown Browser$^{TM}$ (Respondus, Redmond, WA). Questions on the summative examinations were primarily board-type, case-based, single best answer.

**Clinical application.** To provide ongoing, real-time integration of clinical concepts, practicing Clinicians, including radiologists, presented clinical cases and radiologic images associated with the anatomical region(s) of the week in the second iteration of human structure. In both 2010 and 2011, student clinical case-based problems were also incorporated. Ten groups of four students were provided a brief description of a clinical case at the beginning of each week. At the end of each week, these groups made a formal presentation of their case to the entire class and faculty. The cases related to the anatomical concepts of the week; students presented the anatomical cases as well as potential differential diagnosis, treatment options, and prognosis. All students were involved in at least one formal case presentation. To evaluate the presentations, the two course directors utilized the form presented in the Appendix. The final presentation grade was a consensus score for the group of four students. Students were provided with the evaluation form as they prepared their presentation. A short de-briefing of the case by a clinician followed each presentation. To promote small group learning similar to that in the clinic setting, students were instructed to collectively work on each aspect of the case as a group rather than dividing the case into individual tasks. Students submitted peer-evaluation of the group work.

To further enhance the clinical relevance of anatomy, students performed clinical procedures on the cadavers such as inserting central lines or performing intraosseous infusion. In addition, clinicians were present in the laboratory during dissections of regions of their specialty to explain the clinical aspects of the region while assisting students with their dissections.

**Experiential learning and multiple modalities.** A number of learning opportunities have been described earlier in this article including daily ARS quizzes, weekend quizzes, and case-based learning. In addition, students worked in interactive small groups to perform cadaveric dissection. To accommodate the restricted size of the laboratory, students were divided into groups of eight and subsequently divided into assigned pairs.

In the group of eight, only two pairs were present to dissect at any given time. To ensure continuity in dissections from day to day, two of the four-member team had dissected the previous day (see Table 2). While this made for complicated scheduling, it provided an opportunity for the "experienced" dissection pair to teach the dissected regions to those who were not involved in dissection of the previous day. Both faculty and fourth-year teaching assistants observed and evaluated the peer teaching. In addition to the valuable peer teaching that occurred, students had more unscheduled time for independent study and a better student to faculty ratio in the laboratory (Wilson et al., 2011). On the other hand, periodic student dissection has been shown to negatively impact summative examination scores (Granger and Calleson, 2007).

Independent study material of multiple modalities, primarily produced in house, were provided to facilitate learning including animated tutorials, dissection videos, on-line supplemental readings, and a commercially available dissector. To compensate for the compressed nature of the course, faculty-written supplemental readings in the first iteration of the course (2010) were designed to provide additional content not covered in lecture. Based on end of course feedback, the second iteration of the course included supplemental readings that enhanced the content covered in lecture rather than introducing new material.

**Opportunities for student professional development.** To foster professionalism, the OUCOM hosts an event in which students meet the families of their donors prior to the start of the course, called the Anatomical Donor Luncheon (Vannatta and Crow, 2007). This experience provides students the opportunity to develop communication and empathy skills. During this event, students are also introduced to a few elements of the past medical history of their donor. Many families of the donors bring items that facilitate telling the life story of their loved one. The outcomes associated with this activity have been previously described (Crow et al., 2012). Like other schools, a student-initiated Service of Gratitude and Remembrance is held at the conclusion of the course (Escobar-Poni and Poni, 2006; Pawlina et al., 2011). As part of the professionalism curriculum, students also conduct peer review of the students in their dissection group.

### Experimental Procedures: Data Collection and Statistical Methods

To determine differences in performance, if any, between Gross Anatomy (old curriculum) and Human Structure (new curriculum), data from the two cohorts immediately before and after the curriculum were analyzed. Anatomy sub-scores from USMLE Step 1 and course numeric grades were used. Overall course grades from each cohort were analyzed to ensure that students were achieving similar grades after Human Structure. Anatomy sub-scores from USMLE Step 1 were calculated by determining the number of standard deviations the sub-score was from the national mean.

To determine students' perception of the anatomy course, similar questions on course evaluations used from two cohorts before and after implementation of Human Structure were analyzed. Because the evaluation scale was changed from a five-point scale to a seven-point scale after the implementation of Human Structure, we analyzed "top box" ratings, specifically the percent of students selecting "strongly agree, slightly agree, or agree." To determine changes in student perception after including feedback during the second iteration of the Human Structure course, we also utilized "top box" ratings.

To determine student performance on examinations after feedback was implemented for quizzes, item analysis (specifically the average score on each item, or *P* value) for 42 items that were the same between 2010 and 2011 was utilized. To determine differences in performance of each of these 42 items across the two years, we conducted an analysis of the item performance in 2010 compared to 2011 using repeated measures ANOVA. To determine the effect size, a measure of educational significance, we calculated the eta squared ($\eta^2$). Because there were few identified studies in which to base our decisions, we used recommendations of $\eta^2 = 0.01$ as a small effect, $\eta^2 = 0.06$ as a medium effect size, and $\eta^2 = 0.16$ as a large effect.

The research protocol and data collection were reviewed by The University of Oklahoma Health Sciences Center Institutional Review Board and approved as exempt.

## PRELIMINARY OUTCOMES

Preliminary data suggest that the new compressed, integrated anatomy curriculum did not harm student's knowledge of anatomy, as measured by final course grades and USMLE Step 1 Anatomy sub-scores; in fact, data suggest that the curriculum may have improved anatomical knowledge. This is in contrast to a reported decline in recall and retrieval of anatomical knowledge (Blunt and Blizard, 1975). Analysis of final course grades two years before and two years after the implementation of Human Structure showed similar results, with students earning an average of 88.0 in Gross Anatomy and 88.5 in Human Structure. Importantly, after implementation of Human Structure, USMLE Step 1 anatomy sub- scores increased by almost half a standard deviation (SD ±0.50) from before implementation to after. More specifically, during the first iteration, scores rose by 0.40 standard deviations, and during the second iteration, scores rose by an additional 0.10 standard deviations above the national average. The USMLE Step 1 anatomy sub-scores of students in Human Structure reached the highest relative level seen for more than a decade at OUCOM. These findings were not related to the quality of matriculating students, since analysis indicated no significant differences of quality between cohorts during this time period (as determined by factors such as MCAT).

Learner ratings suggested that students perceived the compressed format favorably, especially after the course was fully implemented. Table 3 provides top box ratings for a subset of evaluation items that were similar both before and after implementation of Human Structure. As can be seen in Table 3, student evaluations decreased initially and then increased substantially in the second iteration of the course, slightly surpassing student evaluations in both years before the new curriculum. Importantly, ratings from the most recent course evaluations (2012–2013 and 2013–2014, data not shown) suggest that student ratings remain at high levels, and in some cases, have risen to levels above the 2011–2012 levels.

During the first iteration (2010–2011) of Human Structure, less than half (46.8%) of the students felt the workload was reasonable; however, they did feel that the weekend quizzes and case presentations encouraged them to work together as a group (Table 3). After creating a succinct and manageable list of resources and introducing all new content via face-to-face educational opportunities (lectures,

## Table 3.

**Top Box Student Percentage Ratings of Anatomy, Before (2008–2009 and 2009–2010) and After Implementation of the New Curriculum (2010–2011 and 2011–2012)**

| Items | Students cohorts[a] | | | |
|---|---|---|---|---|
| | 2008–2009 | 2009–2010 | 2010–2011 | 2011–2012 |
| The course objectives were clear | 92.5 | 96.0 | 67.2 | 96.8 |
| The examinations were reflective of the course objectives | 83.8 | 86.9 | 46.7 | 88.5 |
| The course was well organized | 86.3 | 91.9 | 44.1 | 87.3 |
| Weekly quizzes helped prepare for summative examinations | N/A | N/A | 38.5 | 81.0 |
| Workload was reasonable | N/A | N/A | 46.8 | 78.0 |
| Weekly quizzes promoted working together in a group | N/A | N/A | 90.8 | 90.5 |
| Clinical relevance of the course was made clear | N/A | N/A | N/A | 86.3 |
| Overall the course was a good (quality) course | 91.3 | 92.9 | 57.5 | 94.7 |

[a]Respondents: 2008–2009 ($n$ = 80, response rate = 48.2%); 2009–2010 ($n$ = 99, response rate = 59.3%); 2010–2011 ($n$ = 109, response rate = 64.9%), 2011–2012 ($n$ = 100, response rate = 60.6%); N/A not applicable (not asked).

laboratories), students' perception of the workload substantially improved, with 78% agreeing that the workload was reasonable during the second iteration. Even though students were involved in clinical case presentations in the 2010 iteration, comments in the end of course evaluation indicated that the clinical correlation of anatomy was not explicit to them. In the second iteration of the Human Structure course, very specific guidelines and criteria for the clinical cases were provided (i.e., they had to include a differential diagnoses, relevant anatomy, final diagnosis, treatment guidelines, prognosis, and evidence from current literature). An additional end-of-course evaluation question was added in 2011–2012 to document this. During the second iteration of the course, almost all students (86.3%) agreed or strongly agreed that through the weekly case presentations, the clinical relevance of the course content was made explicit.

As stated previously, corrective feedback was not provided for the weekend quizzes during the first year (2010) of Human Structure. End of course surveys indicated that only 35.8% of students agreed that "The weekly quizzes helped me prepare for summative examinations." After adding corrective feedback in the second iteration (2011) of the course, almost 80% agreed that the quizzes helped them prepare for the examinations. In addition, student performance on examinations also improved. The feedback was presented as a list of questions missed. Correct answers were not provided, thus stimulating further group study to correct errors.

Because ~30% of the summative examination items are changed each year to keep the examination secure, it was difficult to compare the overall examination performance between cohorts. However, forty-two identical test items that were present during both the 2010–2011 and 2011–2012 cohorts were identified and analyzed. While it was impossible to compare the examination performance between cohorts by student performance on each item due to constraints in the system that we used, we were able to use the item statistics for each of the identical items. Analysis indicated an improvement in average scores of the 42 examination items between the first (no feedback) and the second (feedback) iteration of the course (No feedback: average score = 82.9, 95% CI = 78.8–87.1; Feedback: average score = 88.4, 95% confidence interval = 85.3–91.6). This improvement was statistically and educationally significant ($P = 0.001$, $\eta^2 = 0.23$). These average scores for these items stayed at similar levels during the 2012–2013 iteration of the course. All summative examinations were administered in a secure online environment, making it very difficult for students to share test items with subsequent cohorts. With no evidence that test item security was compromised, it suggests that the improved item performance was related to receiving corrective feedback on weekend quizzes.

## DISCUSSION

This descriptive paper provides an overview of the approaches taken in designing a condensed exposition of topics in anatomy, histology and embryology by the anatomy faculty at the University of Oklahoma College of Medicine. As noted by Drake (2014) in his suggestions on restructuring in the anatomical sciences, the OUCOM anatomy curriculum included active and interactive learning, a diversity of learning resources, and clinical integration. In addition, course elements to enhance group learning such as case-solving and presentations, ARS sessions with student discussion, and weekend group quizzes, encouraged cognitive engagement (Rotgans and Schmidt, 2011) and enhanced outcomes, similar to other studies (Gasiewski et al., 2012). The course components were purposely packaged to produce a curriculum that provided our students the tools necessary to develop competence in anatomy which was then reinforced in the subsequent systems courses. The new condensed Human Structure course was as effective, if not more effective than the previous Gross Anatomy course, as determined by end of course evaluations and USMLE Step 1 anatomy subscores. A potential problem with the condensed curriculum was the loss of opportunity for spaced and repeated delivery within the context of the Human Structure course, which has previously been shown to enhance long-term knowledge storage and retrieval (Raman et al., 2010), To combat this potential issue, the addition of anatomy reviews to the subsequent systems-based courses aided OUCOM students in content retention.

A number of medical schools have successfully presented anatomy in a fully integrated curriculum by covering all anatomy content within the context of the systems-based courses (Drake et al., 2009; Klement et al., 2011). Our results suggested that delivery of head and trunk anatomy curriculum in five weeks with an integrated approach to limbs in a subsequent course was problematic as the first iteration of the anatomy curriculum was not well received. The lower ratings for this iteration of the course can be attributed to a number of factors; the course was excessively condensed and included only the more challenging aspects of anatomy (head, neck, and trunk), the workload was overwhelming with required readings that included new material on which the students were tested, and there were predictable issues in the logistical roll-out of the new curriculum that students perceived as disorganization. We propose that delivering either a dedicated anatomy course or a fully integrated, systems-based anatomy curriculum seems to be a better approach.

The current anatomy curriculum at OUCOM remains essentially the same as the 2011 curriculum described, with course ratings and USMLE anatomy sub-scores continuing in an upward trend. Anatomy education at OUCOM is a multifaceted approach that includes multiple teaching and resource modalities, clinical cases, clinical correlation lectures, radiology, peer teaching, and team learning, similar to that described by others (Pereira et al., 2007; Johnson et al., 2012), albeit much shorter in duration. It has been encouraging to see that sufficient anatomical training can be provided to prepare students for continued medical studies and successful board results in a short 6.5-week course.

### Limitations

These preliminary results have many limitations. These results reflect only one school, limiting the generalizability of the findings. Additionally, while outcomes indicated that students performed similarly to the previous Gross Anatomy course, preliminary results are limited. However, this descriptive paper was meant to provide preliminary data and lessons learned regarding various innovations to address decreased time for teaching anatomy to medical students.

## LESSONS LEARNED

During our implementation of the course, we learned many lessons, including the following:

- When administering quizzes for test-enhanced learning, providing feedback substantially improves the learning experience. As stated by Boulet (2008), providing just a score with no feedback provides no pedagogical benefit to testing. During the first iteration of Human Structure, no feedback was provided. During subsequent course iterations, corrective feedback was provided on missed quiz items, resulting in a dramatic increase in student evaluations of the effectiveness of the activity as well as increased performance on examinations.
- When providing multimodal independent study resources in a condensed course, resist the urge to use these resources to introduce new material. During the first iteration of the course, multiple independent study resources were provided to compensate for the reduced hours in the curriculum. However, too many required resources seemed to be overwhelming to students and did not add to their knowledge base. Therefore, our data suggest that curriculum designers should not try to cover the same amount of content by merely making material that cannot be covered within the reduced hours as independent study. As noted by Prober and Heath (2011) in their description of a flipped classroom, there are limits on the amount of additional homework that can be assigned. And in hindsight, including a flipped classroom element to this base of independent learning resources could maximize student benefit through student engagement to reinforce their learning.
- Promote group work wherever possible. Group work was promoted throughout all aspects of the course, including weekend quizzes, dissection, and student clinical case problems. Evaluation of these activities suggested that they promoted students working together, a necessary skill for the clinical care of patients. Rotgans and Schmidt (2011) measured cognitive engagement through the various phases of a problem-based exercise and found that the level of engagement was increased when students discuss what they have learned with the group. This is supported by other studies that evaluated student engagement and learning outcomes in discussion-based group work using a variety of learning activities (Horowitz, 2010; Smith et al., 2011; Gasiewski et al., 2012).
- Ensure that explicit guidance is provided when assigning clinical case problems. While student clinical case problems were assigned during the first iteration of the course, adequate guidance for the students was lacking as they attempted to solve the case. Interestingly, qualitative analysis of student written comments on the end-of-course evaluation as well as student focus groups indicated that the clinical relevance of the course was not explicit (data not shown). After creating specific guidelines and objectives for the exercise, almost all students felt that the clinical relevance of the course was explicit. The faculty also perceived that the student presentations were stronger in anatomical correlation to clinical content with specific guidance provided.
- Anatomy content should be presented uninterrupted within a condensed anatomy course. Not including limbs in the first iteration of the course proved to be problematic. During that iteration, the Human Structure course covered only the head, neck, and trunk anatomy. Anecdotally, students perform better on assessments of limb anatomy knowledge when compared to performance on head, neck, and trunk anatomy. Students also perceive that course grades can be “padded” with assessments of limb knowledge. By removing the limb regions, the content of the course included only the more difficult anatomy topics and was overwhelming for the students as noted in students’ evaluation of the course. After extending the course length and including the limbs in 2011, student perceptions of the course substantially improved.

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## APPENDIX

Scoring rubric used by course directors for assessing student performance in the clinical case study presentations.

**Oral Case Presentation Grading Rubric (Completed by course directors)**

| **Construction** | 3 points possible | Points |
|---|---|---|
| | No errors in text | 0.5 |
| | References cited | 0.5 |
| | Text easy to read (appropriate font and size) | 0.5 |
| | Professional slide design | 0.5 |
| | Contenteasily understood (i.e. They may serve as future study guide for board exam preparation). | 1.0 |
| **Content** | Medical Knowledge – 3 points possible | |
| | Accurately list possible diagnoses | 0.5 |
| | Explained reasons for inclusion in list of diagnoses | 0.5 |
| | Accurately presented anatomical features | 0.5 |
| | Included information from current literature | 0.25 |
| | Final Diagnosis was supported by evidence | 0.5 |
| | Current treatment options presented | 0.25 |
| | Prognosis presented | 0.25 |
| | Demonstrated mastery of the topics during question and answer period | 0.25 |
| **Communication** | 3 points possible | |
| | Presentation was well-articulated | 0.5 |
| | Logical flow of ideas | 0.25 |
| | Smooth transitions | 0.25 |
| | Easy to understand | 0.25 |
| | Projected voice so everyone could hear | 0.25 |
| | Key points emphasized | 0.5 |
| | Presentation was engaging | 0.5 |
| | Presentation was well-paced | 0.25 |
| | Terms pronounced correctly | 0.25 |
| **Professionalism** | 3 points possible | |
| | Slides were loaded to the PC prior to the session | 0.25 |
| | Students ready to go immediately after previous group | 0.25 |
| | Dressed appropriately | 0.5 |
| | Respectful of each other and the class | 0.5 |
| | Ended on time | 0.5 |
| | Professional attitude during the presentation | 0.5 |
| | Contributed equal amount as group members to the oral presentation | 0.5 |
| | Total Points Earned | 12 pts |

Comments: