Boning Up on Active Learning Exercises for Teaching Skeletal System Anatomy: Pre-Class Accountability is Key

Justin F. Shaffer*
*Corresponding Author: j.shaffer@uci.edu

HAPS Educator. Vol 21, No. 1, pp. 44-47. Published April 2017.
doi: 10.21692/haps.2017.007

Shaffer J.F. (2017). Boning Up on Active Learning Exercises for Teaching Skeletal System Anatomy: Pre-Class Accountability is Key. *HAPS Educator* 21: 44-47. doi: 10.21692/haps.2017.007

Boning Up on Active Learning Exercises for Teaching Skeletal System Anatomy: Pre-Class Accountability is Key

Justin F. Shaffer, PhD

Department of Developmental and Cell Biology, University of California, Irvine, 4234 McGaugh Hall, Irvine, CA 92697-2300
j.shaffer@uci.edu

Abstract

Active learning has been shown to improve learning outcomes for students in a variety of courses, including anatomy and physiology. However, designing active learning exercises may be more challenging for certain topics than for others. For example, learning the anatomy of the skeletal system may be difficult for some students because of the relatively simplistic manner in which skeletal system structures are named and described. Despite this potential challenge, active learning exercises can easily be developed for the skeletal system (or any system) if students are held accountable for learning prior to class via a high structure or flipped course design. In this article, specific active learning exercises for teaching skeletal system anatomy are detailed and recommendations are made for how to implement similar active learning activities in other courses.

Key words: active learning, high structure, flipped classroom, skeletal system, anatomy

Introduction

Active learning, the process of teaching that engages students in the learning process as opposed to passively listening to a lecture, has gained popularity recently in all science, technology, engineering, and math (STEM) fields and anatomy and physiology is no exception. Not only is teaching with active learning more engaging, exciting, and fun, but also research has shown that active learning is an effective way to improve student performance and learning. In a meta-analysis of over 200 published scientific studies, Freeman *et al*. (2014) found that student performance on examinations was on average ~6% higher in a variety of STEM courses that used active learning as compared to courses taught using traditional lecturing. Moreover, they found that students in courses taught with traditional lecturing were one and a half times more likely to fail than those taught in courses that used active learning methods. As the dropout, failure, and withdrawal (DFW) rate can be high in anatomy and physiology courses (Harris *et al.* 2004, Sturges *et al.* 2016), active learning may be just what is needed to help students succeed.

Teaching with active learning can take a variety of forms including: having students solve case studies in small groups; polling the class with personal response system software (iClicker, Turning Point, Top Hat, Learning Catalytics, etc.); having students draw or complete hands-on projects; or simply having students talk to each other to quickly answer a question (Bonwell and Eison 1991, Allen and Tanner 2005). When I first began teaching an undergraduate human anatomy course, I wanted to employ as many active learning methods as possible. However, I thought that it might prove to be more difficult to use active learning methods for teaching some topics, or aspects of anatomy, compared to others. For example, I thought it would be relatively easy to use active learning methods to teach the anatomy and physiology of the nervous system since students could be asked to draw concept maps to make connections between the nervous system and components of other systems of the body. In addition, students could be asked to solve clinical case studies concerning muscular innervation problems. Furthermore, drawing could be used to illustrate the paths that peripheral nerves travel through the body. It is easy to use active learning to teach anatomical parts of the cardiovascular system by asking students to draw the path of blood through the pulmonary and systemic circuits. In addition, teaching epithelial lining components of the digestive system can be done using compare and contrast tables. Finally, the muscular system lends itself to active learning as students can stand up to move their limbs and palpate various muscles to note their locations and actions.

However, I had a great deal of difficulty devising an active learning lesson plan for the skeletal system. I was not sure how to develop an engaging lesson for teaching bone names and markings. The use of anatomical models for hands-on active learning exercises would have been ideal, however, this was not feasible in a large class (>100 students). Knowing the benefits of active learning, however, I was committed to using active learning to teach my course, even for the skeletal system. Therefore, I designed some activities, tried them out, and refined them over the years.

I found that the key to making these active learning exercises effective is *holding students accountable for learning prior to class*. If students come to class without any prior preparation or exposure to the topic at hand, they will need to rely on the instructor to provide them with content to use for active learning exercises. However, if students prepare before class, either by reading their textbooks, watching videos, or

continued on next page

completing pre-class assignments, class time can become a practice session. I can ask students a series of questions to test the knowledge they acquired prior to class or have them complete exercises on their own or in a group. Each of these strategies allows students to assess their own knowledge. This is valuable since frequent assessment and retrieval practice have been shown to improve learning (Roediger and Karpicke 2006, Butler and Roediger 2007, Karpicke and Blunt 2011). Therefore, not only does this method allow for an easier way to incorporate active learning exercises into lessons, it may also help students learn more than they would have done on their own.

Courses that include frequent assessment (e.g., pre-class content acquisition and graded assignments, in-class active learning, and weekly graded review assignments) are called high structure courses (Freeman *et al.* 2011, Haak *et al.* 2011, Eddy and Hogan 2014). These courses are referred to as "high structure" because there are many checkpoints built in for formative and summative assessment. In a similar vein, courses that include a pre-class learning component to facilitate the inclusion of in-class active learning exercises as well as formative assessments are referred to as flipped classes (O'Flaherty and Phillips 2015). In the case of my upper-division high structure undergraduate human anatomy course (Shaffer 2016), students acquire content prior to class through custom reading guides that are designed to help students read their textbook. To test what they learned from reading, students are assessed through graded on-line pre-class assignments. In class, students are engaged through individual and group active learning exercises. Finally, students complete graded on-line weekly review quizzes that allow them to study in smaller chunks each week to help them prepare for larger summative exams (Shaffer 2016). Through this high structure course design, students come to class prepared and are ready to further test their knowledge. The students have both in-class and out-of-class opportunities to practice applying what they have learned, and to better master the course content. While this course design requires a large amount of student work and preparation, student performance in my course has been exceptional with the pass rate typically greater than 90%. In addition, students rate the structure of the course components very positively and frequently describe this course as one of their favorite college courses (Shaffer 2016).

Below are some specific examples of active learning exercises that I have designed to help teach skeletal system anatomy. I use these activities in the lecture component of my large enrollment (~140 students), high structure, undergraduate human anatomy course (Shaffer 2016). Each of these activities is preceded by a pre-class assignment that holds students accountable for learning content before they come to class. These activities can be easily modified for different class sizes, and the basic design of the activities can be used as the basis for similar activities when teaching other organ systems.

Example 1: Labeling the Skull

This activity was designed to help students ease into gross skeletal anatomy. The learning objectives of this activity are for students to be able to identify skull bones and markings, as well as develop good study habits. This activity can be adapted for virtually any organ or structure in the body, but I especially like to use it for the skull since we cover the skull early on in our course, usually in the second or third week of class. Introduced at this time, the activity can promote good study habits that students can use throughout the course.

For this activity, you will need to make copies of a worksheet with various views of the skull. For example, you may include an anterior view and a lateral view on one side of the worksheet, and a posterior view and an inferior view on the back of the worksheet. You can use images that come with your textbook or atlas or find freely available images on the web. Label one side of the worksheet "A" and the other side "B".

Ask your students to put their notes and books away and pass out one worksheet per student. Set a timer for two minutes and tell them to label everything that they can on side "A." Once the time is up, tell them to flip it over to side "B" and again give them two minutes to label everything they can. Once the time is up, project a slide (or have written on the board) a list of all of the structures that students should be able to identify on the four views of the skull that they have on their worksheet. In my course, students should be able to identify 48 different structures (bones and markings). Give the students another two minutes to identify any structures that they may have not initially labeled. Finally, give students two minutes to trade worksheets with each other to check each other's labeling. When the time is up, have the students return the worksheets to their owners and debrief them on the activity (see below). The entire activity should take about 10 minutes to complete.

This activity not only provides students with practice labeling the skull, but it also teaches good study habits for anatomy and physiology courses. Remind students that labeling blank images can be an excellent way to study and identify structures and that it may be more effective than simply looking at the labeled images in the textbook. Students can opt to print out or draw the various views of the skull and label the bones and markings from memory. I tell students that everything they need to know is in their textbook and thus they should check their work when class is over.

Example 2: Comparing and Contrasting Vertebral Characteristics

While most anatomy and physiology textbooks depict the typical structures of cervical, thoracic, and lumbar vertebrae, they may only show one representative vertebrae for each region e.g. C5, T6 or L2. This may lead students to believe that all vertebrae of a certain type are identical or very similar, which is not the case. The learning objectives for this

continued on next page

activity are for students to be able to compare and contrast the characteristics of cervical, thoracic, and lumbar vertebrae and to be able to describe how the vertebral characteristics change along the length of the vertebral column.

For this activity, you will need a PowerPoint slide or a worksheet that contains several images of vertebrae. In my course, I show the following eight different images of vertebrae: left lateral views of C4, T6, T12, and L2, and superior views of C7, T2, T12, and L5. T12 is especially important to include as at first glance it appears to share more characteristics of a lumbar vertebra rather than thoracic. You can use images from your textbook or atlas or find freely available images on the web. I use images from the Thieme Atlas of Anatomy (Gilroy *et al.* 2012.) as they provide many views the vertebrae.

As a warm-up activity in class, give students two minutes to compare and contrast vertebrae characteristics with each other e.g. shape of the vertebral foramen, body shape, spinous process angle, movements allowed, etc. Then show the PowerPoint slide or pass out the handout of unlabeled vertebrae. Give students one minute to identify each vertebra as cervical, thoracic, or lumbar. Then ask the class using a personal response system or by show of fingers how many vertebrae are from the thoracic region. Then give students one minute to discuss their answer with their neighbors and re-poll the class. Usually at this point very few students identify all of the vertebrae correctly. Reveal the true number of thoracic vertebrae on the PowerPoint or handout and ask students to identify those vertebrae. After one more minute of discussion you can reveal the identities of each vertebrae and then lead a class discussion about vertebral characteristics and regional variations in structure. I usually compare the images of T2 and T12 to show how thoracic vertebrae differ from superior to inferior and then I compare T12 and L2 to show how inferior thoracic vertebrae begin to resemble lumbar vertebrae in size and shape. The entire activity should take about 10 minutes to complete.

Other Brief Examples

Below are some other examples of active learning exercises that you can use when teaching skeletal system anatomy. These activities should take two minutes or less in each case, but can be expanded as needed.

- Give students a list of bone markings and have them work together to identify what bones they belong to and what their functions are.
- Have students draw a superior view of a thoracic vertebrae from memory and label the structures.
- Show students an image of a bone (e.g. the humerus) with a few leader lines labeled A, B, C, D, and E and ask students to identify a specific marking using a classroom response system.
- Show students an image of the bones of the hand and ask them to determine if the image is an anterior or posterior view, and additionally if this is an image of the left or right hand. For example, show an anterior view of the right hand and after students work to determine left/right and anterior/posterior, you can have a discussion about how to determine bones and structures from different views.
- Provide a clinical vignette or case to add medical context and have students identify the bones involved. For example: "A 31-year-old female went to the ER with severe swelling and pain in the metatarsal and tarsal regions after a climbing accident. X-rays showed fractures in the most lateral metatarsal and the tarsal immediately proximal to it. What bones did she fracture?"

Conclusion

By holding students accountable before class it is possible to turn any class session and any topic into a practice lesson using active learning exercises. Not only will this enliven class and make it more engaging, but students will also be practicing the application of their knowledge thus enhancing their learning in the process. Developing and using these exercises has shown me that active learning can be incorporated into lessons about skeletal system anatomy and now I would not think of teaching it any other way. Indeed, I teach most of my lessons using a similar approach and each one is not only engaging but also fun. All of my course materials (syllabus, lessons, reading guides, exams, etc.) are available upon request.

Acknowledgement

I would like to thank Corey Johnson for assistance in the initial design of my course. I would also like to thank my anatomy students for participating in these active learning exercises and for constantly giving me feedback on my teaching.

About the author

Justin F. Shaffer PhD is an Assistant Teaching Professor in the Department of Developmental and Cell Biology at the University of California Irvine. He teaches undergraduate human anatomy, introductory biology, and non-majors science courses. He conducts research on the efficacy of high structure pedagogies in college science courses.

continued on next page

Literature cited

Allen D and Tanner K (2005) Infusing active learning into the large-enrollment biology class: seven strategies, from the simple to complex. *Cell Biol Educ* 4: 262-268. doi: 10.1187/cbe.05-08-0113.

Bonwell CC and Eison JA (1991) Active learning: creating excitement in the classroom. ASHE-ERIC higher education report,. Washington, DC: School of Education and Human Development, George Washington University, p xix, 104 p.

Butler AC and Roediger HL (2007) Testing improves long-term retention in a simulated classroom setting. *Eur J Cogn Psychol* 19: 514-527. doi: 10.1080/09541440701326097.

Eddy SL and Hogan KA (2014) Getting under the hood: how and for whom does increasing course structure work? *CBE Life Sci Educ* 13: 453-468. doi: 10.1187/cbe.14-03-0050.

Freeman S, Eddy SL, McDonough M, Smith MK, Okoroafor N, Jordt H and Wenderoth, MP (2014) Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America* 111, 8410-8415. doi: 10.1073/pnas.1319030111.

Freeman S, Haak D and Wenderoth MP (2011) Increased course structure improves performance in introductory biology. *CBE Life Sci Educ* 10: 175-186. doi: 10.1187/cbe.10-08-0105.

Gilroy AM, MacPherson BR, Ross LM, Schuenke M, Schulte E, Schumacher U, Voll M and Wesker K (2012) Atlas of Anatomy. Stuttgart: Thieme.

Haak DC, HilleRisLambers J, Pitre E and Freeman S (2011) Increased structure and active learning reduce the achievement gap in introductory biology. *Science* 332: 1213-1216. doi: 10.1126/science.1204820.

Harris DE, Hannum L and Gupta S (2004) Contributing factors to student success in anatomy & physiology: Lower outside workload & better preparation. *Am Biol Teach* 66: 168-+. doi: Doi 10.1662/0002-7685(2004)066[0168:Cftssi]2.0.Co;2.

Karpicke JD and Blunt JR (2011) Retrieval Practice Produces More Learning than Elaborative Studying with Concept Mapping. *Science* 331: 772-775. doi: 10.1126/science.1199327.

O'Flaherty J and Phillips C (2015) The use of flipped classrooms in higher education: A scoping review. *Internet High Educ* 25: 85-95. doi: 10.1016/j.iheduc.2015.02.002.

Roediger HL and Karpicke JD (2006) Test-enhanced learning - Taking memory tests improves long-term retention. *Psychol Sci* 17: 249-255. doi: DOI 10.1111/j.1467-9280.2006.01693.x.

Shaffer JF (2016) Student performance in and perceptions of a high structure undergraduate human anatomy course. *Anatomical sciences education* 9: 516-528. doi: 10.1002/ase.1608.

Sturges D, Maurer TW, Allen D, Gatch DB and Shankar P (2016) Academic performance in human anatomy and physiology classes: a 2-yr study of academic motivation and grade expectation. *Adv Physiol Educ* 40: 26-31. doi: 10.1152/advan.00091.2015.

■

Back to TOC