Clay Modeling in a Sophomore-Level Anatomy Laboratory: Will Active Learning Improve Student Performance?

Darby Carlson, Surabhi Chandra, Nicholas Hobbs, and Janet Steele

Corresponding Author: carlsondj@unk.edu

HAPS Educator. Vol 23 (2), pp. 358-365. Published August 2019.

https://doi.org/10.21692/haps.2019.008

Carlson D, Chandra S, Hobbs N, and Steele J (2019). Clay Modeling in a Sophomore-Level Anatomy Laboratory: Will Active Learning Improve Student Performance? *HAPS Educator* 23 (2): 358-65. https://doi.org/10.21692/haps.2019.008

Clay Modeling in a Sophomore-Level Anatomy Laboratory: Will Active Learning Improve Student Performance?

Darby Carlson, MS, Surabhi Chandra, PhD, Nicholas Hobbs, PhD, and Janet Steele, PhD
Department of Biology, University of Nebraska at Kearney, Kearney, NE 68849
carlsondj@unk.edu, chandras2@unk.edu, hobbsjn@unk.edu, steelej@unk.edu

Abstract
The purpose of this study was to examine the impact of active learning on student performance in a sophomore-level anatomy and physiology course. Exam grades of students from two consecutive fall semesters were compared. In the first year of the study, students (n=180) used skeletons, plastic muscular manikins, and illustrations to learn the musculoskeletal system while in the second year of the study, students (n=186) also constructed clay models for more active learning. There was no significant difference in average final grade between years, suggesting no difference in overall student ability. For the two laboratory exams over the musculoskeletal system, students who participated in clay modeling performed lower than students who had only skeletons, manikins, and illustrations, and significantly fewer students earned a grade of C (70%) or better on the exams. Surveyed students found active learning useful for visualizing the muscles but few thought clay modeling improved their exam performance. https://doi.org/10.21692/haps.2019.008

Key words: active learning, anatomy laboratory, clay models, formative assessment, student buy-in

Introduction
There is ample evidence that active learning has a positive effect on student performance (Freeman et al. 2014; Michael 2006). Some forms of active learning, however, have been shown to be more effective than others. Lombardi et al. (2014) observed that students who used plastic models, rather than preserved organ dissections or virtual dissections, scored significantly higher on both initial and follow-up exams despite student perceptions that the organ dissections were of more value. Fancovicova and Prokop (2014) noted that students who had access to multiple forms of active learning performed at a higher level than students who had access to only one form of active learning. Herur et al. (2011) found that students who participated in active learning had higher levels of retention 15 and 30 days after the class than those who learned by passive means. The level of student engagement has also been shown to impact learning. LaDage et al. (2018) found that students who engaged in direct manipulation of a model, as compared to students who merely watched another person manipulate the model or listened to a lecture, performed significantly better on initial assessment. The results of this study, however, did not demonstrate any differences in retention based on learning technique. Kooloos et al. (2014), however, observed that students who attentively observed others build clay models showed higher increases in anatomical knowledge than those students building the models and concluded that engagement in and focus on the task were keys to learning.

Clay modeling has been used to promote understanding of internal organs (Shipley, 2010), the brain (Akle et al. 2018; Kooloos et al. 2014), the nervous system (Herur et al. 2011), and the musculoskeletal system (Bareither et al. 2013; DeHoff et al. 2011; Motoike et al. 2009; Waters et al. 2005; Water et al. 2011). Motoike et al. (2009) found that students who built clay models on human manikins were better able to identify muscles on human models than were students who performed cat dissection. Students who constructed clay models also performed higher on exams than students who performed preserved organism dissection (DeHoff et al. 2011; Waters et al. 2005). Bareither et al. (2013) observed that, while students who participated in active learning showed greater increases in knowledge gain than students who did not engage in active learning, there were no differences among students who built clay models compared to students who completed written modules. Moreover, there were no differences in three-month retention between the groups.

Students who are the first in their immediate family to attend college (i.e., first-generation students) have been shown to benefit from active learning (Eddy and Hogan 2014), and generation status has been shown to be more influential than other fixed characteristics on student buy-in to active learning (Brazeal and Couch 2017). At the University of Nebraska at Kearney, first-generation students make up better than 40% of undergraduate enrollment. Therefore, when funds became available over the summer, new supplies in the form

continued on next page

of clay models were purchased with the goal of improving student learning through active learning techniques. In previous years students learned muscle attachments and actions using information provided in tables, illustrations, isolated bones, skeletons, and muscular manikins only. It was anticipated that creating the clay models, where students could place the muscles on the models and better visualize the attachments and actions, would improve student learning. The purpose of this study was to determine if supplementing the current laboratory teaching materials with active learning through the construction of clay models would improve student performance on exams over the anatomy of the musculoskeletal system in a sophomore-level anatomy and physiology course.

Methods

Approval was obtained from the Institutional Review Board at the University of Nebraska at Kearney (protocol 010919-1; exempt status). The study used existing data from students enrolled in Biology 225, Anatomy and Physiology I, Fall 2017 and Fall 2018 semesters. Biology 225 is the first of a two-semester course sequence and college-level chemistry is the required prerequisite. In addition, students enrolled in Biology 226 Anatomy and Physiology II spring 2019 were surveyed regarding their opinions of the utility of the clay models they had used in laboratory the previous semester.

There were nine laboratory sections both semesters, each with one instructor and as many as 24 students. Plastic human half-skeletons and clay kits (Anatomy in Clay®, Zahourek Systems, Inc. and Affiliates, Loveland, CO) were purchased in the summer of 2018. Enough kits were purchased so that if every lab was at maximum enrollment students could still work in pairs. The investment per student in purchasing these kits was $162, approximately eight times the $20 laboratory fee for the course.

The laboratory portion of the course was divided into three, five-week sections. Each section included four weeks of laboratory activities followed by a laboratory practical exam. The first laboratory practical exam covered basic terminology and organization, movements through membranes, tissues, integumentary system, basic microscopic and macroscopic anatomy of bones, and types of joints. The second laboratory exam covered the bones and bone features, joints, and muscles of the upper body plus neuromuscular physiology. Students constructed clay models for three of the four laboratory periods prior to the exam. The third laboratory exam covered the bones and bone features, joints, and muscles of the lower body plus central nervous system anatomy. Students again constructed clay models for three of the four laboratory periods prior to the exam. Weekly laboratory activities were identical each year and each week's laboratory had clear objectives. The laboratory was not dissection or cadaver-based. Students used complete skeletons (e.g., Max the Classic Skeleton with Muscle Insertions and Origins, catalog number S-A11, 3B Scientific, Tucker, GA), isolated bones, muscular manikins (e.g., ¾ Life-Size Dual-Sex Muscle Figure, 45-part, catalog number S-B50, 3B Scientific, Tucker, GA), isolated limb muscular models (e.g., ¾ Life-Size Muscle Arm, 6-part, catalog number S-M10, 3B Scientific, Tucker, GA), and illustrations, to learn the required structures and were tested using these same materials. Students in Fall 2018 also worked in pairs to create clay models of the musculature on human half-skeletons, which were used for the laboratories covered in the second and third laboratory exams. Following each laboratory introduction that highlighted the regional bones, muscles, and joints, the students were allowed to work with the models and/or complete other laboratory exercises. The students were instructed to pay attention to certain features of the muscles that would be important when constructing the models. These features included whether the muscles were superficial or deep as well as their origins and insertions. Students were not told the order of muscles to place on the models or how many they should complete that week. No instructions were given on the amount of clay or the amount of detail that should be used in each muscle design. Students were encouraged to use the models as a learning tool and knew they were not going to be graded on the activity. Completed student-built clay models were used in laboratory examinations two and three in 2018 (Fall semester).

All laboratory exams required students to observe physical displays and answer questions about the display. Each exam had 25 stations with either three questions (exam one; 75 points possible) or four questions (exams two and three; 100 points possible) per station, and students had one hour and 45 minutes to complete the exam. Students were permitted to go to the stations in any order and could return to a station as many times as they wanted to during the exam period. Students had an alphabetical list of potential terms they could use to answer the questions and credit was deducted for spelling errors. The terms on the list had to be combined for multiple-word answers, and students wrote their answers in numbered blanks on a paper answer sheet. Examples of typical questions for exams two and three from a muscular manikin, an illustration, a clay model, and an isolated bone are shown in Figure 1.

continued on next page

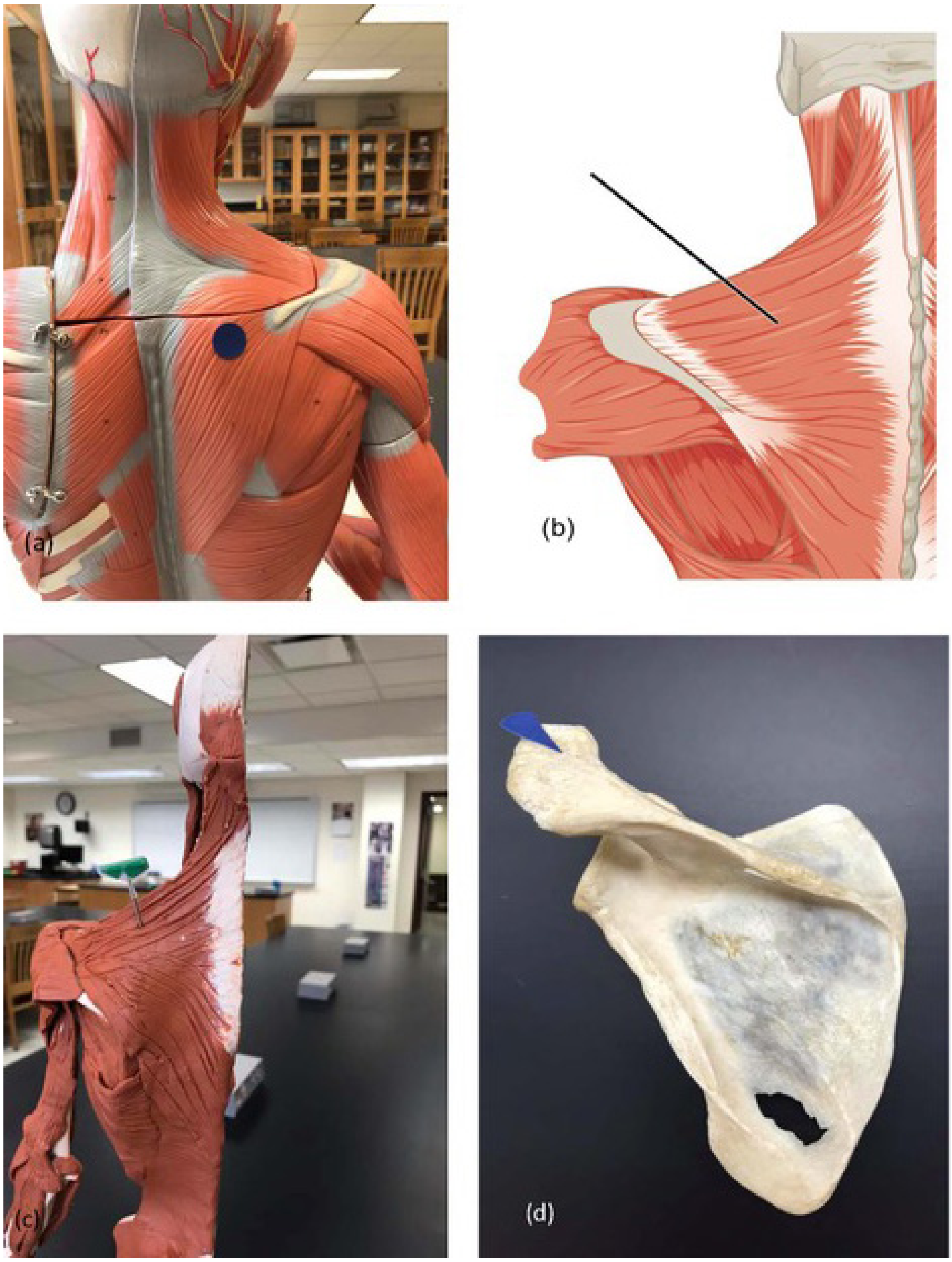

Figure 1. *Examples of presentations of questions over the trapezius muscle from a manikin (a), illustration (b), clay model (c), and isolated bone (d; portion of trapezius insertion indicated by blue arrow). Questions from the manikin, illustration, and clay model asked students to identify the muscle or to identify the origin, insertion, or one action of the muscle. Example of wording for a question from the manikin is as follows: "Identify the origin of the muscle indicated by the blue dot. This muscle inserts on the clavicle and on the spine and acromion process of the scapula, and its actions are to rotate, retract, elevate, and depress the scapula." Example of wording for a question from an isolated bone is as follows: "Identify the bone feature indicated by the blue arrow." Part B is modified from a figure authored by OpenStax college (https://commons.wikimedia.org/wiki/File:1117_Muscles_of_the_Neck_Upper_Back.png) that is licensed under the Creative Commons Attribution 3.0 Unported licence.*

The questions and set up of the exams were identical with the exception of substituting student-built clay models as the visual display for about 10 questions on exams two and three in 2018 (Fall semester).

With the exception of the clay modeling activity and university closure on a day in which lab exams were given that resulted in rescheduling, all other aspects of the course, including the content, number, and scheduling of lecture exams as well as the timing of Fall break and Thanksgiving break relative to laboratory exams, were identical each year. Only students who completed all aspects of the course were included in data analysis. Exam performance (percentage correct) was analyzed between years using a student's two-tailed t-test. Student performance within year and between years was analyzed using a two-way ANOVA. Chi-squared analysis was performed to determine if there were a difference in the percentage of students in the classes who earned a grade of C (70%). Significance was ascribed for $p<0.05$.

Results

A total of 180 and 186 students completed all aspects of the course in Fall 2017 and Fall 2018, respectively. There was no difference in student performance on exams one or two between years, but student performance on exam three was significantly higher ($p = 0.004$) in 2017 (Table 1).

continued on next page

In 2017 there was a significant difference in student performance on the exams within year but in 2018 there was no difference in student performance within year ($F (2,728) = 17.42$, $p < 0.0001$). Chi-squared analysis determined there was no difference in the percentage of students earning a final grade of C or higher between years but there was a significant difference in the percentage of C or higher grades on the practical exams (Table 2).

A total of 50 students out of the 150 students enrolled in Biology 226 completed the survey (Table 3). In general, a majority of students agreed that the clay models improved their ability to visualize layering of the muscles and muscle attachments, but opinions were more evenly split regarding whether the clay models helped them see muscle agonists and antagonists or were a valuable learning tool. Most students disagreed that the clay models improved their exam performance.

Year	Exam 1	Exam 2	Exam 3
2017 (n=180)	77.2 ± 13.2	79.8 ± 13.6	82.1 ± 16.8
2018 (n=186)	78.4 ± 14.1	76.7 ± 17.2	76.2 ± 21.4

* significantly different from exam three, Fall 2017, p = 0.004

Table 1. *Laboratory practical exam results (average percentage correct ± SD) for Anatomy and Physiology I students who completed all aspects of the course. Exam questions were identical both years. In 2018 laboratory exercises covering the musculoskeletal system in preparation for exams two and three were supplemented with clay modeling activities, and these models were used for some exam questions. Data were analyzed using a student's two-tailed t-test and two-way ANOVA. Significance was ascribed for p<0.05.*

Year	Exams 2 and 3	Final grade
2017	81.4	79.4
2018	72.3	76.9

Table 2. *Percentage of students earning a grade of C or better (70% or higher). Chi-squared analysis determined that the difference in the percentage of C or better grades on exams two and three was significantly different between years. The percentage of students earning a final grade of C in the class, however, was not significantly different between years.*

Statement	Agree	Disagree	Neutral
The clay models improved my ability to visualize the layering of the muscles.	74	20	6
The clay models improved my ability to visualize the muscle attachments.	54	40	6
The clay models allowed me to better visualize antagonistic muscle groups.	48	40	12
The clay models were a valuable learning tool.	46	48	6
The clay models allowed me to make connections between muscles with similar actions.	44	42	14
The clay models improved my performance on the laboratory exams.	30	54	16

Table 3. *Results of survey asking students the utility of clay models in the anatomy and physiology laboratory. A total of 50 students completed the survey. Numbers represent percent of responses.*

continued on next page

Discussion

The results of this study suggest that inclusion of the hands-on modeling activity did not increase student learning as measured by exam performance; in fact, student performance was lower than the previous year on exam two (p=0.063) and significantly lower than the previous year on exam three. It is important to note that student performance on laboratory exam one serves as a control in that the course materials were presented in identical fashion both years and there was no difference in student performance on that exam. In addition, the final overall grades for students were also not significantly different (2017 average 78.8 $\pm$ 11.7 percent; 2018 average 77.7 $\pm$ 13.6 percent). Therefore, the overall academic performance of students participating in the study each year was similar. Moreover, four of the five laboratory instructors were the same both years, the laboratory exercises were organized in such a way that learning objectives were clear, and grading instructions and criteria for exams were very clear so as to ensure consistency in grading across instructors. Therefore, it is not unreasonable to suggest that differences in student performance on exams two and three were influenced by the learning materials.

Student performance on exam one was the lowest of the three exams in 2017 and student performance increased on each subsequent exam. In contrast, the highest average of the three exams in 2018 was exam one and student performance slightly, but not significantly, decreased with each subsequent exam. During the previous ten years (2007-2016), student performance in this class was lowest on the first practical exam six times and highest on the second practical exam nine times; student performance on the third exam was lowest three times and highest once. 2018 was the only time during this 12-year period (2007-2018) that student performance on the practical exams decreased with each subsequent exam.

Student interest in the clay models waned noticeably over the course of the semester to the extent that many students did not use the clay models at all in preparation for exam three. This is consistent with the results of our survey (Table 3) in which the majority of students indicated they did not think clay modeling improved their performance on the exam. As observed by Brazeal and Couch (2017), students must buy in to the approach in order for it to have an impact on learning. If the learning activity promotes activity for the sake of activity but not student learning, student disengagement will result (Smith and Cardaciotto 2011). In addition, the amount of structure provided by the instructor has an impact on exam performance (Reinhardt and Rosen, 2012). In order to keep the laboratory experiences similar, no additional direction or structure was provided to the students in the current study as to how to incorporate the clay models into their learning. There was an example model to which laboratory instructors built a muscle each laboratory period, but this was the only additional direction provided.

It is critical that faculty employ proven methods to incorporate effective active learning into their class (Goodman et al. 2018). Clay models have been shown to be an effective learning tool (Akle et al. 2018; DeHoff et al. 2011; Haspel et al. 2014; Oh et al. 2009; Waters et al. 2005; Waters et al. 2011), but it has also been shown that students and faculty have different perceptions regarding active learning (Tsang and Harris 2016). No course credit was assigned to the clay models, so even though students worked in pairs some individuals were left to do all the work while their partners did little or nothing. This led to frustration and questions from students as to whether or not their non-participatory partner could lose credit in some way for not helping create the clay model. Some students, including very high achieving students, focused only on the immediate value of the activity in terms of course credit (or lack thereof) in the form of points.

Adding course credit (points) to the clay modeling activity would most likely improve participation but, given that the majority of students did not think clay modeling improved their exam performance (Table 3), activity without a perceived purpose is not an effective learning strategy (Smith and Cardaciotto 2011). Brazeal and Couch (2017) demonstrated that unfixed student qualities, such as their perception of whether or not the activity is relevant or challenging, were a higher predictor of student buy-in than fixed student qualities. Akle et al. (2018) observed that some students viewed clay modeling as juvenile at first but came to realize the activity contributed in a meaningful way to the learning process.

Disinterest by some high-achieving students may have led marginally-performing students who might have benefited from the hands-on activity to abandon the models. The significant decrease in the percentage of students earning a grade of C or better on the exams may reflect not only abandonment of the clay models but failure to then follow through on the existing formative assessment techniques for the skeletons, manikins, and models. While faculty are often reluctant to try new techniques due to the time commitment to develop the technique (Miller and Metz 2014) or anticipated student resistance (Brazeal and Couch 2017; Smith and Cardaciotto 2011), the instructors in the current study were excited to have a new hands-on learning technique and the lack of student buy-in was not expected.

Fancovicova and Prokop (2014) found that students who used a combination of active learning methods showed greater achievement than students who used only one active learning method. While we had hoped the addition of clay modeling would have improved student performance, we already used multiple teaching tools in our laboratory; therefore, the addition of the clay modeling could have been one modality too many for some students and overwhelmed them. As Kooloos et al. (2014) concluded, students must focus their attention and engage in the exercise in order for learning to take place. Our laboratory period was one hour and 50 minutes, which included

continued on next page

time for a weekly quiz, direction from the instructor, getting supplies ready, and cleaning up the workspace. Therefore, students often had only 60-75 minutes to work on the clay models, and it was challenging for some students to complete the clay models during the laboratory period. Each week an average of eleven new muscles were assigned (range eight to fourteen), so students had as little as five minutes to devote to each new muscle and may have hurried to build the models without focusing on what it was they were to learn. That left little if any time for the students to make use of the other learning materials available to them, such as the muscular manikin and isolated muscular limb models. In order to make the clay modeling more effective in future, the labs might be redesigned to have fewer muscles each week with muscles being included in more labs throughout the semester as well as clear objectives with the clay model outlined in the student's manual. Alternatively, fewer muscles could be assigned to the clay models with specific questions assigned. For example, in the laboratory exercise focusing on muscles of the hip and thigh, perhaps only the muscles of the quadriceps group might be assigned to the clay model with specific questions regarding the order in which they must be placed on the model. This could help reinforce concepts related to "superficial" versus "deep" muscles as well as reinforce why the *rectus femoris* has different actions from the other muscles of the quadriceps group.

In order to keep the classes as identical as possible so as to assess the impact of the clay models themselves, no changes were made to the instructions for the laboratory activities or to the in-class formative assessment worksheets. The lack of any formative assessment techniques specific to the clay models, however, likely had a role in both student buy-in and subsequent exam performance. Haspel et al. (2014) successfully incorporated these same clay models in the anatomy and physiology laboratory at a large community college. Incorporation of the clay models into the laboratories at the community college was not done, however, until the instructors had undergone specialized training in their use, a new custom laboratory manual had been developed, and all the instructional materials had been completely revised. With this extensive preparation, 96% of the faculty felt the clay modeling was an effective learning experience. Student performance on exams improved significantly over the previous year, but at the end of the term only 51% of the students felt clay modeling was a positive experience (Haspel et al. 2014).

At our institution, the clay models had been on a "wish list" for years, were eagerly purchased when funds became available, and were incorporated into the classroom scarcely a month later as a supplement to the existing materials. In conclusion, the results of this study suggest that active learning strategies must be employed with proper considerations to factors such as student involvement, instructional details, and time restrictions of the laboratory period in order to see improved student performance.

About the Authors

Darby Carlson, MS, is a Senior Lecturer of Biology at the University of Nebraska at Kearney (UNK). His primary teaching responsibilities are microbiology lecture and laboratory, anatomy and physiology laboratory, and genetics laboratory.

Surabhi Chandra, PhD, is an Associate Professor of Biology at UNK. Her primary teaching responsibilities are anatomy and physiology laboratory, cell biology, techniques in molecular biology, medical terminology, and pharmacology of diseases.

Nicholas Hobbs, PhD, is an Assistant Professor of Biology at UNK. His primary teaching responsibilities are human physiology, advanced physiology, and developmental biology.

Janet Steele, PhD, is a Professor of Biology at UNK. Her primary teaching responsibilities are undergraduate anatomy and physiology lecture and laboratory.

Literature cited

Akle V, Pena-Silva RA, Valencia DM, Rincon-Perez CW. 2018. Validation of clay modeling as a learning tool for the periventricular structures of the human brain. *Anat. Sci. Educ*. 11: 137-145. https://doi:10.ase.1719.

Bareither ML, Arbel V, Growe M, Muszczynski E, Rudd A, Marone JR. 2013. Clay modeling versus written modules as effective interventions in understanding human anatomy. *Anat. Sci. Educ*. 6: 170-176. https://doi:10.1002/ase.1321.

Brazeal KR, Couch BA. 2017. Student buy-in toward formative assessments: the influence of student factors and importance for course success. *J. Microbiol. Biol. Educ*. 18: 1-10. https://doi:10.1128/jmbe.v18i1.1235.

DeHoff ME, Clark KL, Meganathan K. 2011. Learning outcomes and student-perceived value of clay modeling and cat dissection in undergraduate human anatomy and physiology. *Adv. Physiol. Educ*. 35: 68-75. https://doi:10.1152/advan.00094.2010.

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

Fancovicova J, Prokop P. 2014. The effects of 3D plastic models of animals and cadaveric dissection on students' perceptions of the internal organs of animals. *J. Baltic Sci. Educ*. 13:767-775.

Freeman S, Eddy SL, McDonough M, Smith MK, Okoroafor N, Jordt H, Wenderoth MP. 2014. Active learning increases student performance in science, engineering, and mathematics. *PNAS* 111: 8410-8415. https://doi:10.1073/pnas.1319030111.

continued on next page

Goodman BE, Barker MK, Cooke JE. 2018. Best practices in active and student-centered learning in physiology classes. *Adv. Physiol. Educ*. 42: 417-423. https://doi:10.1152/advan.00064.2018.

Haspel C, Motoike HK, Lenchner E. 2014. The implementation of clay modeling and rat dissection into the human anatomy and physiology curriculum of a large urban community college. *Anat. Sci. Educ*. 7: 38-46. https://doi:10.1002.ase.1369.

Herur A, Kolagi S, Chinagudi, S, Manjula R, Patil S. 2011. Active learning by play dough modeling in the medical profession. *Adv. Physiol. Educ*. 35: 241-243. https://doi.10.0015/advan.000087.2010.

Kooloos JGM, Schepens-Franke AN, Bergman EM, Donders RART, Vorstenbosch MATM. 2014. Anatomical knowledge gain through a clay-modeling exercise compared to live and video observations. *Anat. Sci. Educ*. 7: 420-429. https://doi.10.1002/ase.1443.

LaDage L, Tornello SL, Vallejera JM, Baker EE, Yan Y, Chowdhury A. 2018. Variation in behavioral engagement during an active learning activity leads to differential knowledge gains in college students. *Adv. Physiol. Educ.* 42: 99-103. https://doi:10.1152/advan.00150.2017.

Lombardi SA, Hicks RE, Thompson KV, Marbach-Ad G. 2014. Are all hands-on learning activities equally effective? Effect of using plastic models, organ dissections, and virtual dissection on student learning and perceptions. *Adv. Physiol. Educ*. 38: 80-86. https://doi:10.1152/advan.00154.2012.

Michael J. 2006. Where's the evidence that active learning works? *Adv. Physiol. Educ.* 30: 159-167. https://doi:10.1152/advan.00053.2006.

Miller CJ, Metz MJ. 2014. A comparison of professional-level faculty and student perceptions of active learning: its current use, effectiveness, and barriers. *Adv. Physiol. Educ*. 38: 246-252. https://doi:10.1152/advan.00014.2014.

Motoike HK, O'Kane RL, Lenchner E, Haspel C. 2009. Clay modeling as a method to learn human muscles: a community college study. *Anat. Sci. Educ*. 2: 19-23. https://doi.10.1002.ase.61.

Oh CS, Kim JY, Choe YH. 2009. Learning of cross-sectional anatomy using clay models. *Anat. Sci. Educ.* 2: 156-159. https://doi:10.1002/ase.92.

Reinhardt CH, Rosen EN. 2012. How much structuring is beneficial with regard to examination scores? A prospective study of three forms of active learning. Adv. Physiol. Educ. 36: 207-212. https://doi:10.1152/advan.00108.2011.

Shipley G. 2010. Creating clay models of a human torso as an alternative to dissection. *Am. Biol. Teacher* 72: 146-147. https://doi.org/10.1525/abt.2010.72.3.3.

Smith CV, Cardaciotto L. 2011. Is active learning like broccoli? Student perceptions of active learning in large lecture classes. *J. Scholarsh. Teach. Learn*. 11: 53-61.

Tsang A, Harris DM. 2016. Faculty and second-year medical student perceptions of active learning in an integrated curriculum. *Adv. Physiol. Educ.* 40: 446-453. https://doi:10.1152/advan.00079.2016.

Waters JR, Van Meter P, Perrotti W, Drogo S, Cyr RJ. 2005. Cat dissection vs. sculpting human structures in clay: an analysis of two approaches to undergraduate human anatomy laboratory education. *Adv. Physiol. Educ*. 29: 27-34. https://doi:10.1152/advan.00033.2004.

Waters JR, Van Meter P, Perrotti W, Drogo S, Cyr RJ. 2011. Human clay models versus cat dissection: how the similarities between the classroom and the exam affects student performance. *Adv. Physiol. Educ*. 35: 227-236. https://doi:10.1152/advan.00030.2009.

■

Back to TOC