

EDUCATOR

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Images in Multiple-Choice Questions

Large-Scale Anatomy Outreach

HAPS Curriculum & Instruction Lab Survey:
Demographics

HAPS Curriculum & Instruction Lab Survey:
Activities and Learning Outcomes

Using Foods to Teach Histology

4 Questions During a 5-Minute Meeting

Review of Online Anatomy Education
during the Pandemic

Alternative Grading in A&P

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~ SUMMER 2023 ~

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The Impact of the Images in Multiple-choice Questions on Anatomy Examination Scores of Nursing Students

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Abstract

Visualizing effects of images on improved anatomical knowledge are evident in medical and allied health students, but this phenomenon has rarely been assessed in nursing students. To assess the visualizing effect of images on improving anatomical knowledge and to use images as one of the methods of gross anatomical knowledge assessment in nursing students, the present study was repeated over two semesters. The results show that the percent class average (%) was significantly ($P < 0.006$) increased with the inclusion of more anatomical images in a multiple-choice anatomy exam compared to a similar exam with fewer images and was significantly ($P < 0.002$) decreased by reducing the number of images by 50% compared to image-rich exams. However, examinations with an equal number of images did not alter the class average. The percent score of individual questions from the examinations with images plus text was significantly ($P < 0.001$) higher than the same questions with text only in both semesters. The findings of this study indicate that image inclusion in anatomy examinations can improve learning and knowledge, may help reduce cognitive load, recall anatomical knowledge, and provide a hint to an exam question.

<https://doi.org/10.21692/haps.2023.011>

Key words: anatomy, physiology, images, visualization, nursing, knowledge retention, technology

Introduction

Human anatomy and physiology are considered foundational courses for medical, allied health, and nursing disciplines and serve as a prerequisite for clinical and subsequent years of these disciplines (Estai & Bunt, 2016; McVicar et al., 2014; Young et al., 2016). A variety of assessment methods are available to determine the learning outcomes of anatomical knowledge. These include but are not limited to, multiple choice questions (MCQ), matching questions, written essay questions, short answer questions (Pandey & Zimitat, 2007), labelling and identifying tagged structures (spotting) in specimens in practical examinations, and objective structured clinical examinations (Vorstenbosch et al., 2013; Sagoo et al., 2021). Included are also process questionnaires, the Structure of Observed Learning Outcomes Taxonomy (Pandey & Zimitat, 2007), and the use of various visual aids (Butcher 2006; Vorsteinbosch et al., 2013; Pickering 2015; Notebaert 2017). Images have been used as one of the most common methods of anatomical knowledge assessment by anatomy educators (Vorstenbosch et al., 2013; Notebaert et al., 2016; Sagoo et al., 2021) in the evaluation of students' academic performance, knowledge, competence, and clinical and problem-solving skills (Charlin et al., 2010; Pelgrim et al., 2011).

For the last two decades, due to the explosion in teaching technologies, many anatomy programs have shifted away from cadaveric dissections and prosections (Parker 2002; Bianchi et al., 2020). This may be due in part to changes in anatomy curricula such as increasing costs of cadavers, fewer hours for cadaveric dissection, strict ethics approval processes, and unwanted hazardous side effects (Parker 2002; McMenamin et al., 2014; Mutalik & Belsare, 2016) and emotional trauma associated with cadaveric dissection (Parker 2002; McMenamin et al., 2014; Mutalik & Belsare, 2016). While there has been a continuous increase in student enrollment in anatomy classes, the instructor-to-student interaction hours continue to decrease (McLachlan & Pattern, 2006; Drake et al., 2009; Drake 2014; Vogl 2017). There has been a shift from practical and oral examinations toward written assessment methods and the inclusion of many visual aids (Rowland et al., 2011). As a result, anatomy programs rely on alternate methods to support the teaching and learning of human anatomy (McLachlan 2004; Saxena et al., 2008; Drake et al., 2009; Attardi et al., 2016; Estai & Bunt, 2016; Narnaware & Neumeier, 2021a; Narnaware 2021b).

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The use of images in teaching and learning of anatomy by educators and students in the form of Microsoft PowerPoint® presentations and examinations is routine practice (Pandey & Zimitat, 2009; Vorstenbosch et al., 2013; Notebaert et al., 2016; Sagoo et al., 2021). Similarly, anatomy textbooks mainly consist of a myriad of images, line diagrams, color drawings, photographs, radiographs or animations (Wieslow et al., 2010; Inuwa et al., 2011), and the use of computers, the internet, and various teaching technologies have added a vast and varied number of images to be used by anatomy educators and students (Park et al., 2011; Attardi et al., 2016; Bianchi et al., 2020).

In addition, recent advances in multimedia representations with a plethora of body images provide an additional advantage of visualization to anatomy educators and students (Butcher 2006; Brazina et al., 2014; Estai & Bunt, 2016; Afsharpour et al., 2018). According to many research studies, these multimedia representations include verbal and visual information (Shaffer 2016). The visual representations include cadaveric dissection and prosections (Anyanwu & Ugochukwu, 2010; Souza et al., 2016; Montayre & Sparks, 2017), histological slides (Holland et al., 2015), preserved specimens, simulated laboratories, skeletons and mannequins (Fujieda & Okubo, 2016), anatomic models (Nowinski et al., 2009), plastination (Estai & Bunt, 2016), clay models (Oh et al., 2009), computer-generated three-dimensional (3D) images and 3D printing (McMenamin et al., 2014; Attardi et al., 2016; Backhouse et al., 2017; Zilverschoon et al., 2017; Ruddy et al., 2019). Some anatomy educators also display images through educational videos and YouTube® videos (Saxena et al., 2008; Barry et al., 2016), interactive live digital imaging (Preim & Saalfeld 2018; So et al., 2018; Ruddy et al., 2019), mobile media devices (e.g. smartphones and tablets) (McNally et al., 2017; Raman 2015), while others use social media such as Facebook® (Pickering 2015; Pickering & Bickerdike 2017), Google® (Phelan et al., 2017), Twitter® (Hennesey et al., 2016) and iTunes® or podcasts and screencasts (Pickering 2015; Estai & Bunt, 2016). Others have been incorporating advanced teaching technologies such as virtual reality and 3D visualization goggles (Marta et al., 2017; Phelan et al., 2017), a virtual human cadaver (Anatomage Table; Bianchi et al., 2020; Narnaware & Neumeier 2021), while others have incorporated visual aids such as “living anatomy” that includes ultrasound, body painting (Reeves et al., 2004; So et al., 2017), and use imaging techniques (e.g. X-rays, CT-scans and MRIs) to explain anatomical structures and to familiarize the students with images (So et al., 2017; Ruddy, et al., 2019). However, most of the studies enumerated above have evaluated the impact of visual aids on the study of a limited number of organ systems or anatomical regions, such as the cardiovascular system (Butcher 2006), or the head, neck, and trunk anatomy (Pandey & Zimitat, 2007; Vorstenbosch et al., 2013). Therefore, the impact of using images in studying systemic gross anatomy remains to be assessed.

Numerous studies have shown that visualization with images can lead to improved factual learning (Butcher, 2006), knowledge retention (Balemans et al., 2016; Narnaware & Neumeier, 2020a), spatial ability, and recall of anatomical knowledge, as well as reduction of examination anxiety and stress, and alteration of cognitive load; it may provide hints to answering questions in anatomy examinations (Mayer & Moreno, 2003; Mayer 2005; Butcher 2006; Crips & Sweiry, 2006; Bartholomme & Bromme, 2009; Pickering 2015; Notebaert 2017). These visual aids studies, however, mainly focused on students’ cognitive load, exam stress, and anxiety, but little is known on their impact on the students’ academic performance.

In Canada, many nursing programs use didactic, passive teaching and learning of anatomy; a few exceptional programs incorporate laboratories without cadaveric dissections (Barton et al., 2016; Alfaro et al., 2018). The impact of the use of images on improving anatomical knowledge has only been investigated in a limited number of studies (Alfaro et al., 2018). Previous studies on the use of visual aids were mainly focused on medical and allied health programs (Pickering 2015; Notebaert 2017), particularly in relation to exam anxiety and stress (Mayer & Anderson, 1992; Sweller 1998; Mayer & Moreno, 2003), memorization, knowledge retention, and cognitive load (Butcher 2006; Crisp & Sweiry, 2006; Bartholomme & Bromme, 2009). These aspects, however, have rarely been assessed in nursing students.

The Department of Health and Science, Faculty of Nursing at MacEwan University in Western Canada has a student-centered nursing curriculum. However, teaching and learning of gross human anatomy in this program is impacted by the low number of instructional hours compared with other nursing programs without a laboratory component in anatomy and physiology in Canada, the United States, and Europe (Diaz-Mancha et al., 2016; Narnaware & Neumeier, 2020; 2021b). Recently, we reported that nursing students retained 71.0% of their first-year anatomical knowledge in their second year (Narnaware & Neumeier, 2019, 2020b) and 51.6% in third-year studies (Narnaware & Neumeier, 2021c). We have initiated many interventional strategies to improve students’ long-term retention of anatomical and physiological knowledge, including the use of modern teaching technology (Narnaware & Neumeier, 2021a), content reinforcement (Narnaware & Chahal, 2019), and online and in- class activities (Narnaware et al., 2019). Despite human anatomy being considered a ‘visual science’ and an image-reliant subject, the impact of images on anatomy exam scores in nursing students has not yet been assessed. The objectives of the present study are: 1) to use images as one of the methods of gross anatomical knowledge assessment, 2) to determine the impact of images on gross anatomy examination scores, and 3) to evaluate the use of images as interventional strategies to improve learning and knowledge of the human body in first-year nursing students.

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Materials and Methods

Design and participants

This study was conducted in Fall 2017 and Winter 2018. The participants were enrolled in the first year of the Bachelor of Science in Nursing program at MacEwan University. Two sections of gross human anatomy, comprising 70-80 students each, were taught by conventional didactic teaching using Microsoft PowerPoint® presentations and a three-dimensional (3D) virtual human cadaver- the Anatomage Table (Anatomage, Inc., California, USA) that the Faculty of Nursing purchased in 2015 (Narnaware & Neumeier, 2021b). This course was taught in a lecture format for 80 minutes two days a week for 13 weeks in each semester; there was no laboratory. The majority of the participants were females (85.4%) with an average age of 21.4 ± 5.38 (means \pm SD); the male participants (14.6%) had an average age of 21.8 ± 4.73 .

Examinations

This study consisted of three midterms and a final examination with MCQs. The first mid-term (Exam #1) for both cohorts consisted of 66 MCQs and covered the introduction to anatomy, tissues, the integumentary system, bone tissues, articulations (joints), muscular tissue, and the appendicular skeleton (pectoral girdle - bones, muscles, nerves, and blood vessels). The second mid-term (Exam #2) consisted of 62 MCQs and covered the appendicular skeleton (upper limb: bones, muscles, nerves, and blood vessels) and axial skeleton (skull bones and muscle and blood vessels), the cardiovascular system (the heart and blood vessels) and the lymphatic system. The third mid-term (Exam #3) consisted of 65- 66 MCQs and covered the axial skeleton (vertebral column and rib cage - bones, muscles, nerves, and blood vessels) and the respiratory system, nervous system (nervous tissues, spinal cord, spinal nerves, brain and cranial nerves), autonomic nervous system (ANS) and the special senses. The final examination was cumulative, with an emphasis of a few chapters from the third midterm examination, i.e., the brain and the cranial nerves, ANS, special senses, and respiratory system, and covered the appendicular skeleton (pelvic girdle and lower limb - bones, muscles, nerves, and blood vessels), and the digestive, urinary and reproductive systems. The final exam consisted of 120 MCQs. Anatomy Exam #1 in section BN01 included 13 images (more images), whereas section BN02 included 5 images (fewer images). This order was reversed in Exam #2. In this exam, the section BN02 quiz included 11 images (more images), whereas section BN01 included 4 images (fewer images). Exam #3 included 5 images and the final exam consisted of 9 images in both sections (same number of images) (Table 1). The images were taken from lecture material with identification text and labelling removed and numbering adjusted for test items (see Figure 2). The exact order of images in both anatomy cohorts was repeated in Winter 2018, except in that semester, Exam #1, section BN03 consisted of 10 images in one section

and 5 images in section BN04. This order was reversed in Exam #2. Exam #3 and the final examination included 4 and 9 images in both sections (BN03 & BN04).

Data analyses

All examinations were given to the students in both cohorts in both semesters in paper format. The MCQ answer sheets were collected at each examination's end and sent to the university's scanning center for optical scoring. The results were returned to the Principal Investigator (PI) in a pdf file with students' answers, score data, statistics such as average mean percent score with standard deviation (SD), confidence interval, and test reliability that included Kuder- Richardson Formula 20, coefficient (Cronbach) alpha and confidence intervals. The data from three midterms and finals exams from Fall 2017 and Winter 2018 with more, less or the same number of images were subjected to statistical evaluation using R 4.2.1 (R Statistical Software, R Core Team, Vienna, Austria), and results were expressed as a class mean with standard deviation (\pm SD). Individual percent scores of questions with images plus text versus text only, simplified image versus detailed image, and an individual tissue/organ with image plus text versus text only were also subjected to statistical evaluation. Because Exam #3 and the final exam consisted of equal images in both sections, the data were pooled and expressed as Exam #3 (Figures 1 and 2, A & B) for both semesters. Two sample t-test was performed to compare class averages with more versus less images within each semester, whereas two-way ANOVA with no interaction and a randomized block design was used to compare class averages with more versus less images between two semesters for exam #1 and Exam #2 (Fall-2017 vs. Winter-2018). A one-way ANOVA was conducted for exams #3 and final with the same number of images for both semesters (Fall- 2017 vs. Winter-2018). The Chi-square was used to evaluate correct versus incorrect answer data, and Fisher's Z-test was performed to compare the percent rating of individual questions with text plus images versus text only. The differences were considered to be significant at $P < 0.05$ for all the exams and percent scores of individual questions. Graphs were prepared with Microsoft Excel® spreadsheet software for Microsoft Windows® (Microsoft Corp., Redmond, WA). Bar graphs were generated showing means (\pm SD). The differences were considered to be significant at $P < 0.05$ for all the exams and percent scores of individual questions. Graphs were prepared with Microsoft Excel® spreadsheet software for Windows® (Microsoft Corp., Redmond, WA). Bar graphs were generated showing means (\pm SD).

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Results

Impact of the More Images versus Less on the Mean Class Score

The inclusion of images in anatomy examinations resulted in significant changes in the mean class average and percent rating of individual questions based on images. Results from the Fall 2017 study show that the inclusion of more anatomical images in a multiple-choice anatomy exam (Exam #1, section BN01 significantly ($P < 0.006$) increased the percent class average compared to a similar exam with fewer images (Exam #1, section BN02, Table 1). Reducing the number of images to less than 50% in anatomy Exam #2, section BN01 resulted in a significant decrease ($P < 0.002$) in the percent class average compared to an image-rich exam #2, section BN02. However, for Exam #3 and the final exam, which contained an equal number of images in both sections (BN01 & BN02), the percent class average did not differ (Table 1).

Exams	Sections	Number of Students (n)	Number of Images	Number of Questions	% Class Average (\pm SD)	P-value
Fall - 2017						
Exam #1	BN01	79	13	66	75.9 \pm 6.2	
Exam #1	BN02	76	05	66	73.3 \pm 6.6*	0.006
Exam #2	BN02	76	11	62	74.4 \pm 7.3	
Exam #2	BN01	74	04	62	71.1 \pm 9.0*	0.002
Exam #3	BN01	77	5	65	69.1 \pm 7.2	
Exam #3	BN02	72	5	66	71.9 \pm 7.8	0.43
Final Exam	BN01	75	9	120	70.9 \pm 11.5	
Final Exam	BN02	72	9	120	70.8 \pm 13.0	0.48

Table 1. The impact of more versus fewer images on the percent class average in the Fall 2017. Results are expressed as mean \pm SD and converted into percent class average. * $P < 0.006$ section BN01 and BN02.

In Winter 2018, yielded similar but slightly different results were obtained. The percent class average was highly significant ($P < 0.001$) in anatomy Exam #1, section BN03, with more images compared to a similar exam with fewer images (Exam #1, section BN04, Table 2). However, reducing the number of images by 50% in anatomy Exam #2, section BN03 resulted in a significant decrease ($P < 0.0005$) in the percent class average compared to an image-rich Exam #2

in section BN04 (Table 2). For Exam #3 and the final exam, which contained an equal number of images in both sections (BN03 & BN04), the percent class average did not differ (Table 2). However, percent class average was significantly lower ($P < 0.006$) for the final exam in Winter 2018 compared to the final exam in Fall-2017.

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Exams	Sections	Number of Students (n)	Number of Images	Number of Questions	% Class Average (± SD)	P-value
Winter - 2018						
Exam #1	BN03	69	10	66	76.3 ± 6.5	
Exam #1	BN04	59	05	66	70.6 ± 6.3**	0.001
Exam #2	BN04	59	10	62	72.2 ± 7.3	
Exam #2	BN03	69	05	62	64.6 ± 10.0**	0.0005
Exam #3	BN03	69	04	65	72.4 ± 6.0	
Exam #3	BN04	59	04	66	69.3 ± 7.4	0.96
Final Exam	BN03	65	13	120	69.5 ± 11.3	
Final Exam	BN04	57	13	120	67.3 ± 14.8†	0.003

Table 2. The impact of more versus fewer images on the percent class average in the Winter 2018. Results are expressed as mean ± SD and converted into percent class average. **P<0.001 compared to section BN03 and BN04. †P<0.003 compared to Fall-2017.

Percent Scores of Individual Questions with Images Plus Text Versus Text Only

The percent score of an individual question based on images significantly increased by 23.4% in Exam #1 (P<0.001). Similarly, the percent score of an individual question based on images in Exam #2 was significant and increased by

10.5% (P<0.001; Figure 1A) in Fall 2017 compared to the overall mean score of exams with text only. However, the percent score of individual questions based on images was only increased by 0.7% in Exam #3 with the same number of images with text only.

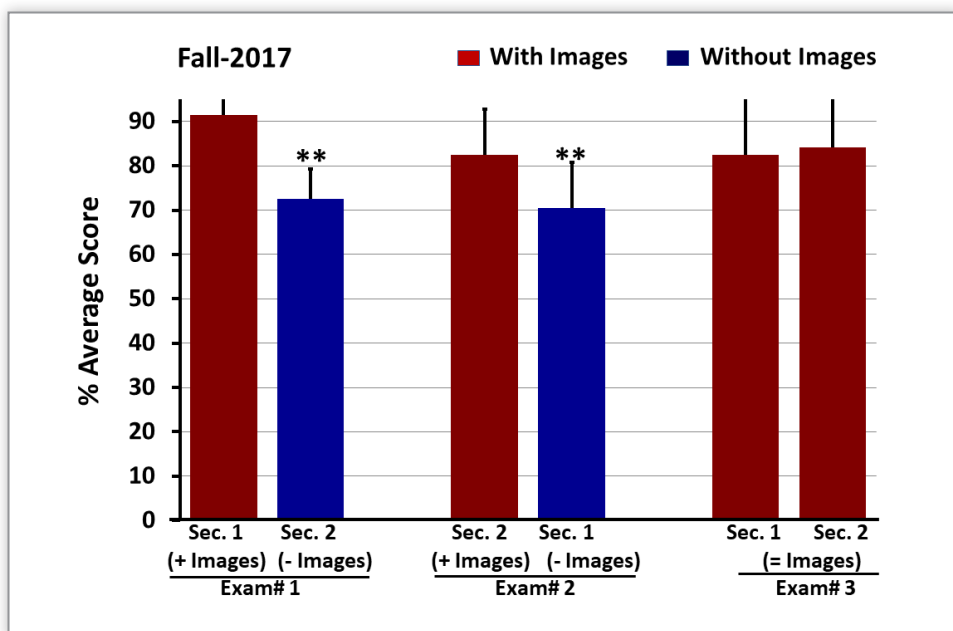


Figure 1A. The percent scores of all questions with text plus images versus the same questions with text only in Fall 2017. Results are expressed as mean ± SD and converted into percent class average. **P<0.01 section 1 compared to section 2.

continued on next page

In Winter 2018, the percent scores of individual questions based on images plus text increased by 13.5% in Exam #1 and 10.2% in Exam #2 compared to an overall mean score with text only (Figure 1B). This score was increased by 5.4% in Exam #3 compared to the same number of images with text only.

Percent Scores of Selected Tissues/Organs with Images Plus Text Versus Text Only

The percent scores of the selected tissues with images plus text were increased by 30% compared to the same tissues with text only (86.8 ± 12.1 (\pm SD) % vs. 65.5 ± 28.0 (\pm SD) (Table 3).

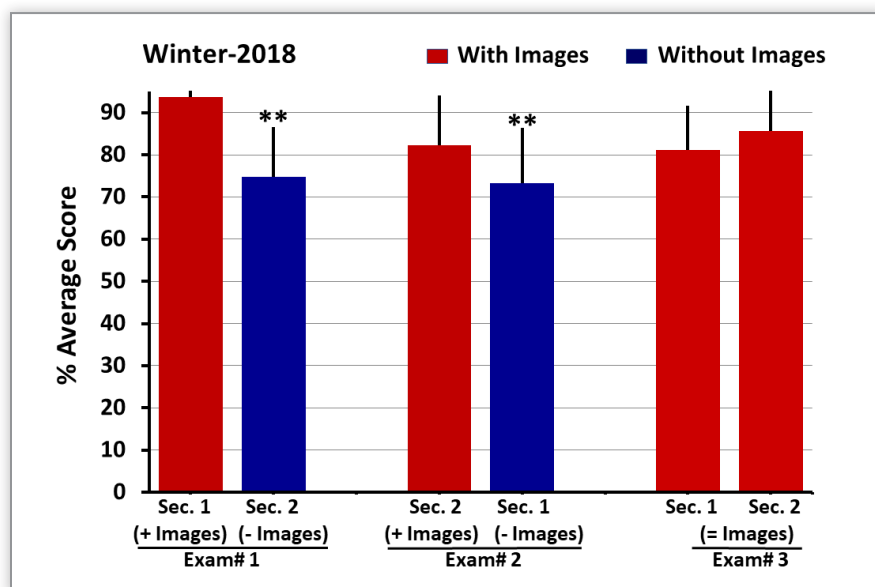


Figure 1B. The percent scores of all questions with text plus images versus the same questions with text only in Winter 2018. Results are expressed as mean \pm SD and converted into percent class average. ****P<0.01** section 1 compared to section 2.

Image description	Text + Images (%)	Text Only (%)
Directional terms	92.4	82.4
Directional terms	91.1	76.3
Planes and Sections	97.4	17.1
Intercellular Junctions	96.2	73.6
Section through Skin	91.1	65.8
Skeletal Muscle Layers	70.8	15.7
Structure of Scapula	68.3	64.4

Table 3. An Example of the Percent Score of Individual Questions with Images + Text or Text Only on Selected Topics.

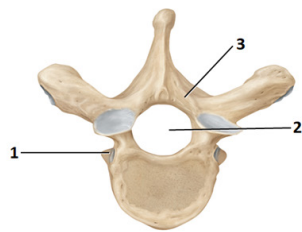
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Percent Scores of an Individual Image Plus Text Versus Text Only

The overall mean score of individual questions with reference images plus text was significantly higher ($P < 0.05$) compared to the same questions with text only (Figure 2).

Percent Scores of Simplified Images Versus Detailed Images

The percent score of simplified images plus text was significantly ($P < 0.05$) higher than detailed images plus text (93.6 ± 4.0 (\pm SD) vs. 81.9 ± 3.0 (\pm SD) (Figure 3).



Questions	% Score with Text + Image	% Score with Text only
1. Which structure serves as the attachment site for the 'facet for the head of the rib'?	56.9%	25.9%
2. Which structure serves as a passage for the spinal cord?	79.2%	68.8%
3. Which structure separates the transverse process from the spinous process?	68.0%	59.7%

Figure 2. An example of the inclusion of images of human thoracic vertebrae as a reference image for one anatomy examination. The percent score of three pooled questions was calculated using this figure with image plus text compared to the same questions with text only. *0.05 compared to text only.

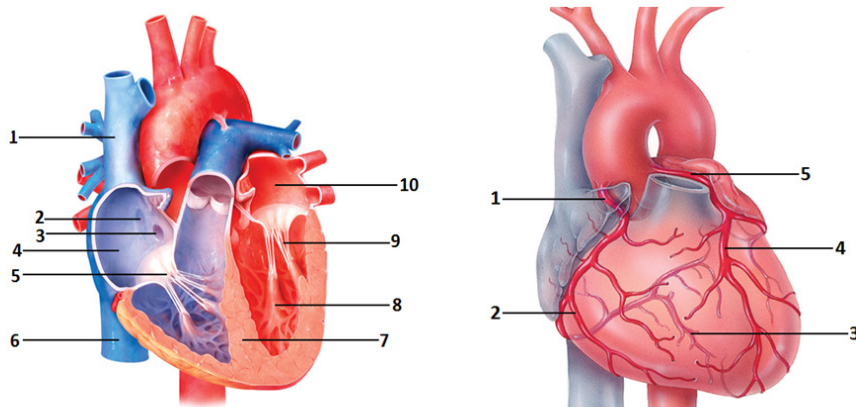


Figure 3. Percent scores of simplified images versus detailed images of selected anatomical structures

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Discussion

Anatomy educators routinely use myriad images to explain anatomy to students to stimulate visual learning (Bartholomme & Bromme, 2009; Vorstenbosch et al., 2013; Notebaert 2017). The present study shows that anatomy students had an advantage when images were included in their MCQ anatomy exams. This was tested in several ways: more images versus fewer images, images plus text vs. text only, and simplified images vs. detailed images. Moreover, the percent score of individual questions based on images plus text or scores of questions on tissues/organs or a single reference image with text significantly increased the class mean average compared with questions with text only. This indicates that images can provide a visualizing effect (Butcher 2006; Vorstenbosch et al., 2013). Image-linked visualizing effects have been shown to support the cognitive processes necessary for deep understanding (Butcher, 2006), effective memorization (Pandey & Zimitat, 2007), and learning and improved knowledge of the human body and academic performance (Notebaert et al., 2013; Pickering 2015).

The literature on the effect of the use of images on anatomy learning outcomes is varied and inconclusive. For example, a pilot study conducted on medical students by Holland et al., (2015) using 195 histology images showed no significant differences in item difficulty (proportion of students answering correctly), item discrimination (a correlation between answering a specific exam item correctly and performing well on the exam), and item point biserial correlation between question items containing images plus text versus text only. The opposite results were reported by Peeck (1993) for participants reading from a text without a picture; they were found to be more motivated and interested in continuing reading compared with those who read the same text accompanied by a poor diagram. Berends & van Lieshout (2009) pointed out that despite taking longer to answer questions, poor-performing students in their study reported that images were helpful. This contrasts with other studies where students found images unnecessary (Crips & Sweiry, 2006). The poor examination performance, lower accuracy, and slower response time on exam items were found to be associated with increasing working memory load, cognitive load, and students' inability to answer items in examinations (Mayer & Moreno, 2003; Sweller 1994).

On the other hand, a study by Vorstenbosch et al. (2013) on medical students reported lower item difficulty, item discrimination, and item point biserial in test items on fetal circulation containing images compared to images with an answer list. While using cross-sectional images of the abdominal organs and vessels around the heart, the same authors reported greater item difficulty and item discrimination. In a most recent study by Sagoo et al. (2021) using anatomical and radiological images of the bones and soft tissues the second- year medical students scored

significantly higher on questions with images compared to questions without images. Similarly, in pre-nursing students, Notebaert (2017) reported that even though examination item discrimination and difficulty were not altered for MCQs with text containing reference images compared to MCQs with text only, students with text and reference images achieved higher academic performance compared to those with text only. This indicates that including reference images in MCQ exams had no influence on item difficulty and item discrimination. In a review of 55 experiments, however, Levie & Lentz (1982) reported that 85% of studies showed improved knowledge retention with an illustrated text (with the inclusion of images) compared with text alone, while Hunt (1978) demonstrated that 85% of students correctly answered a question with an image of a barium swallow versus students given the same question accompanied by a written X-ray report. The addition of appropriate illustrated images in anatomy exams by others has shown similar outcomes to those enumerated above in terms of improving and increasing academic performance (Carney & Levine, 2002; Mayer & Moreno, 2003; Mayer, 2015; Sagoo et al., 2021). The visualizing effects of images in exams also improved students' spatial ability; students with high spatial ability better understood exam items (drawings, photographs, specimens, and radiographs) and performed better overall in the exam (Vorstenbosch et al., 2013). These discrepancies and inconclusive results from the studies cited above could stem from many causes. These include the number of questions and images used to assess the students in these studies, the types and quality of images used, the degree of details in the images, the analytical methods used, and whether or not the students found these images relevant, helpful and essential to answer the questions (Butcher, 2006; Crisp & Sweiry, 2006; Berends & van Lieshout, 2009; Holland et al., 2013; Vorstenbosch et al., 2013; Pickering 2015; Notebaert 2017).

The present study shows that including images with accompanying text in anatomy exams containing MCQs improved the class performance compared to MCQs with text only. This is consistent with the use of anatomical images in pre- nursing students (Notebaert et al., 2017), anatomy drawing screencasts (Pickering, 2015), and histological images (Vorstenbosch et al., 2013; Holland et al., 2015; Pickering 2015), anatomical and radiological images of bones and soft tissues in medical (Sagoo et al., 2021) and allied-health students (Skinder- Meredith 2010). Improved class performance of anatomy students in exams containing more images and images plus text compared to text only in the present study may be attributed partly to visualizing effects of the Anatomage Table used in the present study (Biachi et al., 2020; Narnaware & Neumeier, 2021a). Thus, the present study indicates that image inclusion in anatomy exams increased exam test scores, improved knowledge and learning of the human body, and promoted active learning, similar to the findings by others in medicine (Pickering 2014;

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Notebaert 2017; Sagoo et al., 2021) and allied-health (Skinder-Meredith 2010) students. A variation in number of images and class averages between nursing students enrolled in the Fall 2017 and Winter 2018 semesters may have contributed to a number of factors such as a semester (fall vs winter), student cohorts, number of students, questions in the exams and images, whether reference images being simple vs. detailed and perceptiveness of visualizing effects of images by an individual student (Hunt 1978; McVicar et al., 2014; Notebaert 2017; Vorstenbosch et al., 2013). However, due to the large amount of data collected from three mid-terms and a final exam in both the fall and winter semesters, item difficulty, item discrimination, and biserial point were not determined in the present study and will form the basis of a separate future communication.

The notion that overly excessive details can reduce learners' ability to process essential information (Mayer & Moreno, 2003) was supported in the present study. We compared the simplified images (fewer details) versus detailed images (more information) over two semesters (see Figure 3).

The percent scores of individual questions with simplified images (e.g. heart markings) with five numerical labels were significantly higher than those for detailed images (e.g. heart's internal anatomy) with ten numerical labels. Extraneous information such as extra lines and labels, was eliminated in the simplified images. This helped students avoid spending too much time and attention on the images (Crips & Sweiry, 2006). Increased exam scores with more images or simplified images indicate that the students may have had a greater motivation to study when images were accompanied by a text (Peeck 1993; Ainsworth & Loizou, 2003). Simplified images have been shown to promote factual learning, and students learned more from simplified images than from illustrated images and made fewer comprehension errors than detailed images (Levie & Lentz, 1982; Butcher 2006). This can be explained in two ways: firstly, reducing diagrammatic details such as irrelevant words and only highlighting important information in a question with images can promote students' learning (Mayer et al., 2001; Bartholome & Bromme, 2009; Vorstenbosch secondly, as images provide visual cues, visual information is processed much faster than verbal information (Bartholome & Bromme, 2009). In addition, learning from text and pictures supports mapping (numerical labels versus highlighting), reduces the student's cognitive load and visual search from images (Carlson et al., 2003; Bartholome & Bromme, 2009), their working memory load, and improves understanding and coherence (Mayer & Gallini, 1990; Mayer & Anderson, 1992; Mayer et al., 2001). It also supports students' comprehension and enhances integration between visual images and text during their learning (Butcher 2006). Others have also reported that simplified images reduce comprehension error and support information integration during learning (Butcher 2006); they also decrease item difficulty and item discrimination (Vorstenbosch et al., 2013),

improve visualization and memorization (Pandey & Zimitat, 2007) and promote active learning (Pickering 2014).

Several theories have emerged concerning the visualizing effects of images. The improved learning outcome of the anatomy examinations with images with text compared to those with text-only observed in the present study could be attributed to the coherence and mental model development theory proposed by Bartholome & Bromme (2009) and Mayer et al. (2001). These authors stated that learning from pictures and text may stem from the fact that learners are required to select the relevant verbal and pictorial information from working memory that can then be organized in the central nervous system for processing to form a verbal and a pictorial/visual mental model. Then, the next step involves the comprehension process that integrates the information from both text and pictures. Finally, text and image information complement each other, thus fostering learning (Schnotz 2002). According to Mayer et al. (2001), words and pictures are processed in two different processing systems. Visual cues provide greater prompting (to labeled anatomical structures) than text only, encouraging students to use their free capacity for conceptual integration and processing (Bartholome & Bromme, 2009).

On the other hand, cognitive load theory (CLT) proposed by Mayer & Moreno (2003) and the Multimedia Learning Theory by Mayer (2010) describes words and pictures from examination questions that enter the sensory memory via 'dual channel' (verbal and pictorial), then being organized within the working memory during the examination. Here, it can be integrated with the schemata from the long-term memory created when the student engages with the images during studying. Improved class performance with the inclusion of a greater number of images or more simplified images observed in the present study may be partly because visual resources were more likely to be 'read' and processed faster than text only (Winn 1987).

Limitations of this study

There were two key limitations throughout this study. The use of images in the assessment of anatomical knowledge is diverse, implying that the type of image used is an important factor interacting with the test item's content. Secondly, due to the large number of students involved and the vast number of images used in the exams, results on item difficulty, item discrimination, and point biserial points are not included in the current data interpretation. As supported by others, image inclusion can reduce exam anxiety, improve confidence, and spatial ability, alter the cognitive load, and help long-term knowledge retention was not assessed. In addition, students' opinions on whether images were helpful remain to be clarified in the present study. This study also did not evaluate the individual questions using images vs texts only in the previous exams, and therefore, long-term knowledge retention and learning could not be assessed.

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Conclusions

The present study highlights the significant impact of anatomical images on improving the understanding of gross human anatomy in nursing students. It also shows that they may reduce the cognitive load, increase spatial ability, help recall knowledge, and provide cues to exam question answers. Therefore, the inclusion of images in anatomy exams in a nursing curriculum that does not include a lab or cadaveric dissection should be considered an assessment method of learning outcomes of gross anatomy. The images can be used as an interventional strategy to improve long-term knowledge retention in nursing students. Therefore, when designing a curriculum to improve the learning outcomes in gross anatomy, emphasis should be placed on the inclusion of simplified structural diagrams of the body. The present study, conducted the first time on nursing students in Canada, indicates that visual representation appears to be the most effective when designed to support nursing students' cognitive processes integral for their enhanced understanding (Butcher 2006). This adds to available evidence that a "multimodal" approach using simplified body images should be incorporated into teaching and learning gross human anatomy to nursing students. Moreover, the inclusion of visual aids should be considered one of the active learning pedagogies to improve learning outcomes of human anatomy.

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Literature Cited

- Afsharpour, S., Gonsalves, A., Hosek, R., & Partin, E. (2018). Analysis of immediate student outcomes following a change in gross anatomy laboratory teaching methodology. *Journal of Chiropractic Education, 32*(2), 98-106. <https://doi.org/10.7899/JCE-17-7>
- Alfaro, P., Larouche, S. S., Ventura, N. M., Hudon, J., & Noel, G. P. (2019). Nursing and medical students near-peer activity in the anatomy laboratory: format for success. *Advances in Medical Education and Practice, 7*, 769-780. <https://doi.org/10.2147/AMEP.S209412>
- Ainsworth, S., & Th Loizou, A. (2003). The effects of self-explaining when learning with text or diagrams. *Cognitive science, 27*(4), 669-681. https://doi.org/10.1207/s15516709cog2704_5
- Anyanwu, G. E., & Ugochukwu, A. I. (2010). Impact of the use of cadaver on student's ability to pass anatomy examination. *Anatomy, 4*(1), 28-34. <https://doi.org/10.2399/ana.09.022>
- Attardi, S.M., Choi, S., Barnett, J., & Rogers, K.A. (2016). Mixed methods of student evaluation of an on-line systemic human anatomy course with laboratory. *Anatomical sciences education 9*(3), 272-285. <https://doi.org/10.1002/ase.1584>
- Backhouse, M., Fitzpatrick, M., Hutchinson, J., Thandi, C. S., & Keenan, I. D. (2017). Improvements in anatomy knowledge when utilizing a novel cyclical "observe-reflect-draw-edit-repeat" learning process. *Anatomical sciences education, 10*(1), 7-22. <https://doi.org/10.1002/ase.1616>
- Balemans, M. C., Kooloos, J. G., Donders, A. R. T., & Van der Zee, C. E. (2016). Actual drawing of histological images improves knowledge retention. *Anatomical Sciences Education, 9*(1), 60-70. <https://doi.org/10.1002/ase.1545>
- Barry, D. S., Marzouk, F., Chulak-Oglu, K., Bennett, D., Tierney, P., & O'Keeffe, G. W. (2016). Anatomy education for the YouTube generation. *Anatomical sciences education, 9*(1), 90-96. <https://doi.org/10.1002/ase.1550>

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- Barton, M. J., Johnston, A., & Todorovic, M. (2016). Cadaver-based anatomy for nurses: a real learning experience. *Australian Nursing and Midwifery Journal*, 24(3), 41. <http://hdl.handle.net/10072/339267>
- Bartholomé, T., & Bromme, R. (2009). Coherence formation when learning from text and pictures: What kind of support for whom?. *Journal of Educational Psychology*, 101(2), 282-293. <https://doi.org/10.1037/a0014312>
- Berends, I. E., & Van Lieshout, E. C. (2009). The effect of illustrations in arithmetic problem-solving: Effects of increased cognitive load. *Learning and Instruction*, 19(4), 345-353. <https://doi.org/10.1016/j.learninstruc.2008.06.012>
- Bianchi, S., Bernardi, S., Perilli, E., Cipollone, C., Di Biasi, J., & Macchiarelli, G. (2020). Evaluation of effectiveness of digital technologies during anatomy learning in nursing school. *Applied Sciences*, 10(7), 2357. <https://doi.org/10.3390/app10072357>
- Brazina, D., Fojtik, R., & Rombova, Z. (2014). 3D visualization in teaching anatomy. *Procedia-Social and Behavioral Sciences*, 143, 367-371. <https://doi.org/10.1016/j.sbspro.2014.07.496>
- Butcher, K. R. (2006). Learning from text with diagrams: Promoting mental model development and inference generation. *Journal of educational psychology*, 98(1), 182. <https://doi.org/10.1037/0022-0663.98.1.182>
- Carlson, R., Chandler, P., & Sweller, J. (2003). Learning and understanding science instructional material. *Journal of educational psychology*, 95(3), 629. <https://doi.org/10.1037/0022-0663.95.3.629>
- Charlin, B., Gagnon, R., Lubarsky, S., Lambert, C., Meterissian, S., Chalk, C., ... & van der Vleuten, C. (2010). Assessment in the context of uncertainty using the script concordance test: more meaning for scores. *Teaching and learning in medicine*, 22(3), 180-186. <https://doi.org/10.1080/10401334.2010.488197>
- Crisp, V., & Sweiry, E. (2006). Can a picture ruin a thousand words? The effects of visual resources in exam questions. *Educational Research*, 48(2), 139-154. <https://doi.org/10.1080/00131880600732249>
- Díaz-Mancha, J. A., Castillo-López, J. M., Munuera-Martinez, P. V., Fernández-Seguín, L. M., Polo-Padillo, J., & Heredia-Rizo, A. M. (2016). A comparison of fourth-year health sciences students' knowledge of gross lower and upper limb anatomy: a cross-sectional study. *Journal of Manipulative and Physiological Therapeutics*, 39(6), 450-457. <https://doi.org/10.1016/j.jmpt.2016.05.007>
- Drake, R. L. (2014). A retrospective and prospective look at medical education in the United States: Trends shaping anatomical sciences education. *Journal of anatomy*, 224(3), 256-260. <https://doi.org/10.1111/joa.12054>
- Drake, R. L., McBride, J. M., Lachman, N., & Pawlina, W. (2009). Medical education in the anatomical sciences: The winds of change continue to blow. *Anatomical sciences education*, 2(6), 253-259. <https://doi.org/10.1002/ase.117>
- Estai, M., & Bunt, S. (2016). Best teaching practices in anatomy education: A critical review. *Annals of Anatomy-Anatomischer Anzeiger*, 208, 151-157. <https://doi.org/10.1016/j.aanat.2016.02.010>
- Fujieda, K., & Okubo, K. (2016). A reusable anatomically segmented digital mannequin for public health communication. *Journal of Visual Communication in Medicine*, 39(1-2), 18-26. <https://doi.org/10.1080/17453054.2016.1182473>
- Gernsbacher, M. A. (2013). *Language comprehension as structure building*. Psychology Press. <https://doi.org/10.4324/9780203772157>
- Hennessy, C. M., Kirkpatrick, E., Smith, C. F., & Border, S. (2016). Social media and anatomy education: Using twitter to enhance the student learning experience in anatomy. *Anatomical sciences education*, 9(6), 505-515. [https://doi.org/10.1016/S0140-6736\(00\)03649-7](https://doi.org/10.1016/S0140-6736(00)03649-7)
- Holland, J., O'Sullivan, R., & Arnett, R. (2015). Is a picture worth a thousand words: an analysis of the difficulty and discrimination parameters of illustrated vs. text-alone vignettes in histology multiple choice questions. *BMC Medical Education*, 15(1), 1-9. <https://doi.org/10.1186/s12909-015-0452-9>
- Hunt, D. R. (1978). Illustrated multiple choice examinations. *Medical Education*, 12(6), 417-420. <https://doi.org/10.1111/j.1365-2923.1978.tb01420.x>
- Inuwa, I. M., Al Rawahy, M., Taranikanti, V., & Habbal, O. (2011). Anatomy "steepchase" online: Necessity sometimes is the catalyst for innovation. *Anatomical Sciences Education*, 4(2), 115-118. <https://doi.org/10.1002/ase.188>
- Levie, W. H., & Lentz, R. (1982). Effects of text illustrations: A review of research. *Ectj*, 30(4), 195-232. <https://doi.org/10.1007/BF02765184>
- Fairén González, M., Farrés, M., Moyes Ardiaca, J., & Insa, E. (2017). Virtual Reality to teach anatomy. In *Eurographics 2017: education papers* (pp. 51-58). European Association for Computer Graphics (Eurographics). <http://dx.doi.org/10.2312/eged.20171026>

- Mayer, R. E., Heiser, J., & Lonn, S. (2001). Cognitive constraints on multimedia learning: When presenting more material results in less understanding. *Journal of educational psychology, 93*(1), 187. <https://doi.org/10.1037/0022-0663.93.1.187>
- Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational psychologist, 38*(1), 43-52. <https://doi.org/10.1207/S15326985EP38016>
- Mayer, R. E. (2005). Cognitive Theory of Multimedia Learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 31–48). Cambridge University Press. <https://doi.org/10.1017/CBO9780511816819.004>
- Mayer, R. E. (2009). Multimedia Learning. Cambridge: Cambridge University Press. <https://doi.org/10.1017/CBO9780511811678>
- Mayer, R. E., & Gallini, J. K. (1990). When is an illustration worth ten thousand words?. *Journal of educational psychology, 82*(4), 715. <https://doi.org/10.1037/0022-0663.82.4.715>
- Mayer, R. E., & Anderson, R. B. (1992). The instructive animation: Helping students build connections between words and pictures in multimedia learning. *Journal of Educational Psychology, 84*(4), 444–452. <https://doi.org/10.1037/0022-0663.84.4.444>
- Mayer, R. E. (2010). Applying the science of learning to medical education. *Medical education, 44*(6), 543-549. <https://doi.org/10.1111/j.1365-2923.2010.03624.x>
- McLachlan, J. C. (2004). New path for teaching anatomy: living anatomy and medical imaging vs. dissection. *The Anatomical Record Part B: The New Anatomist: An Official Publication of the American Association of Anatomists, 281*(1), 4-5. <https://doi.org/10.1002/ar.b.20040>
- McLachlan, J. C., & Patten, D. (2006). Anatomy teaching: ghosts of the past, present and future. *Medical education, 40*(3), 243-253. <https://doi.org/10.1111/j.1365-2929.2006.02401.x>
- McMenamin, P. G., Quayle, M. R., McHenry, C. R., & Adams, J. W. (2014). The production of anatomical teaching resources using three-dimensional (3D) printing technology. *Anatomical sciences education, 7*(6), 479-486. <https://doi.org/10.1002/ase.1475>
- McNally, G., Frey, R., & Crossan, M. (2017). Nurse manager and student nurse perceptions of the use of personal smartphones or tablets and the adjunct applications, as an educational tool in clinical settings. *Nurse education in practice, 23*, 1-7. <https://doi.org/10.1016/j.nepr.2016.12.004>
- McVicar, A., Andrew, S., & Kemble, R. (2014). Biosciences within the pre-registration (pre-requisite) curriculum: An integrative literature review of curriculum interventions 1990–2012. *Nurse education today, 34*(4), 560-568. <https://doi.org/10.1016/j.nedt.2013.08.012>
- Montayre, J., & Sparks, T. (2017). Important yet unnecessary: nursing students' perceptions of anatomy and physiology laboratory sessions. *Teaching and Learning in Nursing, 12*(3), 216-219. <https://doi.org/10.1016/j.teln.2017.03.009>
- Mutalik, M., & Belsare, S. (2016). Methods to learn human anatomy: perceptions of medical students in paraclinical and clinical phases regarding cadaver dissection and other learning methods. *International Journal of Research in Medical Sciences, 4*(7), 2536-2541. <http://dx.doi.org/10.18203/2320-6012>
- Narnaware, Y., & Burleson, K. M. (2018, April). *An impact of images on anatomy scores in nursing students*. [Presented poster presentation]. American Association of Anatomist (AAA) Annual Meeting held in San Diego, California, USA. <https://hdl.handle.net/20.500.14078/2126>
- Narnaware, Y., & Chahal, P. (2019). Impact of the on-line and in-class activities on class average in anatomy & physiology in nursing students. [Presented poster presentation]. Human Anatomy and Physiology Society (HAPS) Annual Meeting held in Portland, Oregon, USA. <https://hdl.handle.net/20.500.14078/2128>
- Narnaware, Y., Neumeier, M., J. Claudio Gutierrez., Chahal, P. 2020d. The Impact of Content Reinforcement on Physiological Knowledge Retention in Nursing Students. Human Anatomy and Physiology Society Educator Journal (HAPS Educator) (Commemorative Conference Edition), p. 34. Retrieved from: https://cdn.ymaws.com/www.hapsweb.org/resource/resmgr/educator_archive/2020HAPS-SpecialEdition-Full.pdf
- Narnaware, Y., & Neumeier, M. (2020). Second-year nursing students' retention of gross anatomical knowledge. *Anatomical sciences education, 13*(2), 230-236. <https://doi.org/10.1002/ase.1906>
- Narnaware, Y. R., & Neumeier, M. (2021). Use of a virtual human cadaver to improve knowledge of human anatomy in nursing students. *Teaching and Learning in Nursing, 16*(4), 309-314. <https://doi.org/10.1016/j.teln.2021.06.003>
- Narnaware, Y. (2021). Never heard that before! Bioscience knowledge retention in undergraduate nursing education. *HAPS Educator, 25*(2), 77-81. <https://doi.org/10.21692/haps.2021.009>

- Narnaware, Y., & Neumeier, M. (2021). Anatomical Knowledge Retention in Third-Year Nursing Students. *The FASEB Journal*, 35(S1). <https://doi.org/10.1096/fasebj.2021.35.S1.02686>
- Narnaware, Y., & Neumeier, M. (2020). Second-year nursing students' retention of gross anatomical knowledge. *Anatomical sciences education*, 13(2), 230-236. <https://doi.org/10.1002/ase.1906>
- Notebaert, A. J. (2017). The effect of images on item statistics in multiple choice anatomy examinations. *Anatomical Sciences Education*, 10(1), 68-78. <https://doi.org/10.1002/ase.1637>
- Nowinski, W. L., Thirunavuukarasuu, A., Ananthasubramaniam, A., Chua, B. C., Qian, G., Nowinska, N. G., et al. (2009). Automatic testing and assessment of neuroanatomy using a digital brain atlas: Method and development of computer-and mobile-based applications. *Anatomical sciences education*, 2(5), 244-252. <https://doi.org/10.1002/ase.106>
- Oh, C. S., Kim, J. Y., & Choe, Y. H. (2009). Learning of cross-sectional anatomy using clay models. *Anatomical sciences education*, 2(4), 156-159. <https://doi.org/10.1002/ase.92>
- Pandey, P., & Zimitat, C. (2007). Medical students' learning of anatomy: memorisation, understanding and visualisation. *Medical education*, 41(1), 7-14. <https://doi.org/10.1111/j.1365-2929.2006.02643.x>
- Parker, L. M. (2002). Anatomical dissection: why are we cutting it out? Dissection in undergraduate teaching. *ANZ journal of surgery*, 72(12), 910-912. <https://doi.org/10.1046/j.1445-2197.2002.02596.x>
- Peeck, J. (1993). Increasing picture effects in learning from illustrated text. *Learning and instruction*, 3(3), 227-238. [https://doi.org/10.1016/0959-4752\(93\)90006-L](https://doi.org/10.1016/0959-4752(93)90006-L)
- Phelan, N., Davy, S., O'Keeffe, G. W., & Barry, D. S. (2017). Googling in anatomy education: Can google trends inform educators of national online search patterns of anatomical syllabi?. *Anatomical Sciences Education*, 10(2), 152-159. <https://doi.org/10.1002/ase.1641>
- Pelgrim, E. A., Kramer, A. W. M., Mokkink, H. G., Van den Elsen, L., Grol, R. P. T. M., & Van der Vleuten, C. P. M. (2011). In-training assessment using direct observation of single-patient encounters: a literature review. *Advances in health sciences education*, 16, 131-142. <https://doi.org/10.1007/s10459-010-9235-6>
- Pickering, J. D., & Bickerdike, S. R. (2017). Medical student use of Facebook to support preparation for anatomy assessments. *Anatomical sciences education*, 10(3), 205-214. <https://doi.org/10.1002/ase.1663>
- Pickering, J. D. (2015). Anatomy drawing screencasts: Enabling flexible learning for medical students. *Anatomical sciences education*, 8(3), 249-257. <https://doi.org/10.1002/ase.1480>
- Preim, B., & Saalfeld, P. (2018). A survey of virtual human anatomy education systems. *Computers & Graphics*, 71, 132-153. <https://doi.org/10.1016/j.cag.2018.01.005>
- Raman, J. (2015). Mobile technology in nursing education: where do we go from here? A review of the literature. *Nurse education today*, 35(5), 663-672. <https://doi.org/10.1016/j.nedt.2015.01.018>
- Reeves, R. E., Aschenbrenner, J. E., Wordinger, R. J., Roque, R. S., & Sheedlo, H. J. (2004). Improved dissection efficiency in the human gross anatomy laboratory by the integration of computers and modern technology. *Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the British Association of Clinical Anatomists*, 17(4), 337-344. <https://doi.org/10.1002/ca.10245>
- Rowland, S., Ahmed, K., Davies, D. C., Ashrafian, H., Patel, V., Darzi, A., et al. (2011). Assessment of anatomical knowledge for clinical practice: perceptions of clinicians and students. *Surgical and radiologic anatomy*, 33, 263-269. <https://doi.org/10.1007/s00276-010-0748-8>
- Rutty, J., Biggs, M., Dowsett, D., Kitchener, A., Coltman, N., et al. (2019). Post mortem computed tomography: An innovative tool for teaching anatomy within pre-registration nursing curricula. *Nurse Education Today*, 76, 154-164. <https://doi.org/10.1016/j.nedt.2019.02.001>
- Saxena, V., Natarajan, P., O'Sullivan, P. S., & Jain, S. (2008). Effect of the use of instructional anatomy videos on student performance. *Anatomical sciences education*, 1(4), 159-165. <https://doi.org/10.1002/ase.38>
- Shaffer, J. F. (2016). Student performance in and perceptions of a high structure undergraduate human anatomy course. *Anatomical sciences education*, 9(6), 516-528. <https://doi.org/10.1002/ase.1608>
- Schnotz, W. (2002). Commentary: Towards an integrated view of learning from text and visual displays. *Educational psychology review*, 14, 101-120. <https://doi.org/10.1023/A:1013136727916>
- Skinder-Meredith, A. E. (2010). Innovative activities for teaching anatomy of speech production. *Anatomical Sciences Education*, 3(5), 234-243. <https://doi.org/10.1002/ase.173>
- So, S., Patel, R. M., & Orebaugh, S. L. (2017). Ultrasound imaging in medical student education: Impact on learning anatomy and physical diagnosis. *Anatomical sciences education*, 10(2), 176-189. <https://doi.org/10.1002/ase.1630>

Souza, H. C., Neto, J. L. T., & Bravo, D. S. (2009). The importance of anatomy practice using cadavers and new technologies in undergraduate biological science and nursing courses. La importancia de la práctica anatómica, el uso del cadáver y nuevas tecnologías en los cursos de biología y de enfermería. *Revista Argentina de Anatomía Clínica*, 8(2), 80-86. <https://doi.org/10.31051/1852.8023.v8.n2.14555>

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and instruction*, 4(4), 295-312. [https://doi.org/10.1016/0959-4752\(94\)90003-5](https://doi.org/10.1016/0959-4752(94)90003-5)

Vorstenbosch, M. A., Klaassen, T. P., Kooloos, J. G., Bolhuis, S. M., & Laan, R. F. (2013). Do images influence assessment in anatomy? Exploring the effect of images on item difficulty and item discrimination. *Anatomical Sciences Education*, 6(1), 29-41. <https://doi.org/10.1002/ase.1290>

Winn, B. (1987). Charts, graphs, and diagrams in educational materials. *The psychology of illustration*, 152-198. https://doi.org/10.1007/978-1-4612-4674-9_5

Young, J. Q., van Dijk, S. M., O'Sullivan, P. S., Custers, E. J., Irby, D. M., & Ten Cate, O. (2016). Influence of learner knowledge and case complexity on handover accuracy and cognitive load: results from a simulation study. *Medical Education*, 50(9), 969-978. <https://doi.org/10.1111/medu.13107>

Zilverschoon, M., Vincken, K. L., & Bleys, R. L. (2017). The virtual dissecting room: Creating highly detailed anatomy models for educational purposes. *Journal of biomedical informatics*, 65, 58-75. <https://doi.org/10.1016/j.jbi.2016.11.005>



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Anatomy Outreach Days: One Approach to Large-Scale Anatomy Outreach Events

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Abstract

The Anatomy Outreach Program (AOP) at The Ohio State University aspires to enhance anatomical knowledge and appreciation of the human body through interactive laboratory experiences. In May 2022, the AOP held a 3-day outreach event called Anatomy Outreach Days (AOD). AOD exposed more than 300 high school students across Ohio to various human anatomical donor materials, a facilitator panel, and an anatomy-themed game room. Anatomy Outreach Team (AOT) members were recruited to facilitate the different activities with student participants. AOT facilitators guided students through nineteen anatomy stations across five laboratory spaces, spending roughly ten minutes per station. At these stations, students were taught using human anatomical donor materials such as hearts, lungs, and joint prostheses or participated in activities like listening to heart sounds. Post-event Likert-based surveys evaluating student and teacher experiences of the event were distributed following the event; 48 student responses and 7 teacher responses were received. Participant satisfaction with their experience at AOD was rated as 'excellent' with a score of 4.56 for students and 4.86 for teachers. The survey results also showed that students and teachers would highly recommend AOD to their peers. It was concluded that the logistical format of AOD at The Ohio State University was conducive to a positive experience for student and teacher participants.

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Key words: anatomy education, outreach, educational outreach, high school students, outreach events

Introduction

Anatomy educational outreach programs (AEOPs), such as the Division of Anatomy's Anatomy Outreach Program (AOP) at The Ohio State University, act as a mechanism for university scientists to engage educators, students, and the public in a more rigorous scientific dialogue. These programs benefit participants by providing supplemental science learning experiences for students, granting teachers access to new methods of exploring and building knowledge, and fostering positive teaching and communication skills for scientists, graduate students, and other facilitators (Tanner et al., 2003). Outreach programs in STEM (Science, Technology, Engineering, and Mathematics) have been found to share some common goals, including increasing overall student participation in STEM, promoting science, supporting science teaching, and encouraging interest in education and career aspirations (Husher, 2010). More specifically, AEOPs cited within the literature shared common goals of increasing interest and participation in the anatomical sciences by familiarizing students at all levels with anatomical concepts, improving awareness of the links they share with everyday

life, and introducing anatomy as a possible career option (Cook et al., 2020; Houtz & Quinn, 2006). The AOP works to uphold these goals and positively impact the community while embracing its mission to enhance anatomical knowledge and appreciation of the human body.

Much of the existing literature surrounding STEM outreach programs (AEOPs included) focuses on program descriptions and anecdotes from program leaders and, while these references are essential and valuable, there is very little quantifiable information for comparison with new programs or studies (Bogue et al., 2012; Laursen et al., 2007). Millar et al. (2019) stated: "Although this approach has led to some understanding of outreach programs it underplays the level of complexity in running outreach programs and leaves a gap in understanding how student identity and aspirations toward science are supported in science outreach." Examples of anatomy-specific programs from the literature highlight the use of short-duration, small-scale (e.g., 1-2 hours and small groups of 50 or less at one time) events held across several months that are often successful and, like the AOP's

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traditional session, they represent only one modality (Adams et al., 2020; Cale et al., 2023; Diaz et al., 2019; Hubbard et al., 2005; Ruth et al., 2023). This study aims to fill a gap in the literature focusing on a large-scale anatomy educational outreach event, a modality that is relatively absent from the literature. An emphasis will be placed on program planning, logistics, and participant satisfaction. Through this project, we hope to create a reference point for future events and research specific to the interests and attitudes of participants concerning participation in large-scale outreach events.

The Anatomy Outreach Program (AOP) at The Ohio State University serves hundreds of high school students across Ohio year-round, offering human anatomical donor lab visits and opportunities to discuss education and career paths within healthcare and science. During the 2021-2022 academic year, the AOP hosted in-person, hands-on anatomy outreach sessions for over 400 students enrolled in anatomy or other high school science courses. A typical anatomy outreach session lasted 1–2 hours, including an introduction to the lab and safety practices plus 4 interactive stations (central nervous, cardiopulmonary, musculoskeletal, and gastrointestinal systems; see Table 1 for station descriptions). Each station had specimen trays, probes, and a myriad of anatomic specimens. During the session, all students were given gloves and were encouraged to be hands-on with the various anatomic materials. This allowed students to explore the anatomy of different organs and systems on healthy specimens that could

subsequently be compared to specimens with pathologic or surgical changes that alter the organ’s appearance, structure, or function. Facilitators were instructed to introduce themselves and their station topic to the participants and to choose a starting place for the station (e.g., the anatomic features of the healthy human heart). From that starting point, we encouraged facilitators to allow student questions to guide the topics of discussion while maintaining relevance to anatomy, medicine, and education.

Table 1. Descriptions of topics and materials used for AOP outreach session stations prior to AOD 2022.

Station	Station Topic	Anatomic Specimens/Materials Used
		Description of Station
1	Anatomy of the Brain and Eyes	Brain with good Gyri and Sulci, Brain in Midsagittal Section, 2 set of eyes.
		Identify and describe anatomic features & functions of brain, cerebellum, and brainstem, including lobes, fissures, major gyri & sulci, blood supply, & cranial nerves. Describe the anatomy of the eye.
	Anatomy of the Lungs and Lung Pathologies	Respiratory system en bloc (Hyoid bone, larynx, trachea, bronchi, & lungs), mature adult healthy lungs, lungs from young adult. Healthy, smoker, and cancerous lungs. Pleural effusion/pericarditis. Lungs with adenocarcinoma.
		Describe the anatomy of the lungs and bronchial tree. Compare and contrast mature and young adult lungs. Compare and contrast healthy lung with lung pathologies.
2	Liver Anatomy and Pathologies	Healthy liver and gallbladder. Pathology specimens (early-stage liver cancer, late-stage liver cancer, liver with alcoholic cirrhosis, pigmented gall stones).
		Discuss the anatomy and functions of the liver and gall bladder. Discuss differences between healthy liver and liver pathologies. Describe the formation of gall stones and the different types.
	Anatomy of the Kidney	Healthy mature kidney, healthy kidney from young adult, horseshoe kidney.
		Demonstrate the anatomy of the healthy kidney. Compare adult kidney to young adult and cystic kidneys. Describe the formation of a horseshoe kidney.
Female Reproductive Anatomy	3 isolated uteruses.	
	Discuss parts and functions of uterus, fallopian tubes, and ovaries.	
3	Full prosected donor	Fully prosected donor, emphasis on musculoskeletal system and neurovasculature in the limbs. Face and external genitalia always covered.
		Discuss the anatomy of the anterior thigh, including muscles and neurovasculature. Use femoral triangle to show difference between artery, nerve, and vein. Station often used to discuss and answer questions about body donation and donor preservation.
	Joints & Joint Replacements	Joint prosections: Shoulder, elbow, hip, & knee..Hip & knee replacement prosections.
		Explore various joints, describing associated bones, ligaments, and special relationships. Compare and contrast healthy, arthritic, and replacement joints.
4	Anatomy of the Heart	3 healthy hearts with varying levels of dissection.
		Demonstrate the internal and external features including coronary vasculature of the heart. Discuss size and orientation within thorax.
	Cardiovascular Pathology	1 healthy heart. Hearts with various pathologies/surgical interventions: enlarged heart, LVAD, LVAD with mitral valve replacement, pacemaker, stent, double CABG, & sternum with scar tissue from open heart surgery. Isolated abdominal aortic aneurysm & abdominal aorta with plaque buildup.
		Compare and contrast healthy heart with heart pathologies and surgical interventions. Discuss purpose of surgical interventions, and implications of vascular disease/conditions.

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Over the past few years, discussions with teachers and student participants highlighted areas for improvement and expansion of the existing outreach session that would allow the program to evolve into something larger and more robust. To create a more dynamic and meaningful anatomy outreach event for participants, the AOP redesigned the existing Anatomy Outreach Days (AOD) held for many years at the beginning of May. In previous years, AOD was limited to a 1-hour laboratory session with anatomy graduate student facilitators for each participating school group. The new AODs were scheduled for early May of 2022, hoping that students nearing the end of their anatomy coursework could have one final experience to solidify their knowledge and interest in anatomy and healthcare. AOD was expanded from 1 one laboratory space with 4 system-based stations to 5 laboratory spaces with 19 unique stations, consisting of hands-on human anatomical donor material stations, panels, and skill-based activities (Table 2). Through this expanded outreach event, the AOP could cover more anatomical regions with more human anatomical donor materials and activities than any other outreach event hosted by the group previously.

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Room Number & Topic	Station Topic	Anatomic Specimens/Materials Used
		Description of Station
1: Central Nervous System (CNS)	Protection of the CNS	Skull models, Vertebral Column model, Brain with Meninges, Brain & Spinal Cord with Meninges, CSF Ventricular Model
		Describe the anatomic structures that surround and protect the components of the CNS. Discuss CSF production, flow, reabsorption, and functions.
	Anatomy of the Brain	Brain with good Gyri and Sulci, Brain in Midsagittal Section
		Identify and describe anatomic features & functions of brain, cerebellum, and brainstem, including lobes, fissures, major gyri & sulci, blood supply, & cranial nerves.
Anatomy of the Spinal Cord	Laminectomy prosection, isolated spinal cords.	
	Explore the gross anatomy of the spinal cord.	
2a: Game Room	Category is... Anatomy!	AOT prepared trivia questions to quiz students on anatomy & physiology topics.
		Participants form two groups and compete to win prizes.
	Mystery Bone Boxes	10 boxes with 1 bone model in each, e.g., sacrum, ulna, & tibia.
		Participants place hands into boxes through a small slit and try to determine the bone by touch only.
Skelly Says	Articulated Skeleton Model, notecards with actions.	
	Student work together to perform muscle actions and determine which muscle(s) are responsible.	
2b: Facilitator Panel	College & Beyond	--
		3-4 facilitators answer participant questions. Topics could include life in college, picking a major, gap years, pre-programs, clubs & activities, etc.
3: Musculoskeletal System (MSK)	MSK Anatomy: Anterior Thigh	Donor with dissected lower limb.
		Discuss the anatomy of the anterior thigh, including muscles and neurovasculature.
	MSK Anatomy: Anterior Arm & Pectoral Region	Donor with dissected upper limb.
		Discuss the anatomy of the anterior arm and pectoral region, including muscles, major branches of brachial plexus, and axillary artery.
Joints & Joint Replacements	Joint prosections: Shoulder, elbow, hip, & knee. Hip & knee replacement prosections.	
	Explore various joints, describing associated bones, ligaments, and special relationships. Compare and contrast healthy, arthritic, and replacement joints.	
4a: Cardiovascular System	Anatomy of the Heart	3 healthy hearts with varying levels of dissection.
		Demonstrate the internal and external features including coronary vasculature of the heart. Discuss size and orientation within thorax.
	Cardiovascular Pathology	1 healthy heart. Hearts with various pathologies/surgical interventions: enlarged heart, LVAD, LVAD with mitral valve replacement, pacemaker, stent, double CABG, & sternum with scar tissue from open heart surgery. Isolated abdominal aortic aneurysm & abdominal aorta with plaque buildup.
		Compare and contrast healthy heart with heart pathologies and surgical interventions. Discuss purpose of surgical interventions, and implications of vascular disease/conditions.
Heart & Lung Sounds	10 stethoscopes, diagrams for pulse points and heart/lung sounds. Heart model. Sanitizing wipes and hand sanitizer.	
	Go over proper use of stethoscope. Demonstrate the four auscultation areas for the aortic, pulmonic, tricuspid, and mitral valves, and the common respiratory auscultation areas.	
4b: Respiratory System	Lungs In-Situ	Mediastinum/thorax prosection.
		Demonstrate the boundaries of the pleural spaces and relationships to other structures. Explore the locations/functions of the esophagus, aorta, sympathetic chain, phrenic and vagus nerves.
	Anatomy of the Lungs	Respiratory system enbloc (Hyoid bone, larynx, trachea, bronchi, & lungs), mature adult healthy lungs, lungs from young adult. Bronchial tree model.
		Describe the anatomy of the lungs and bronchial tree. Compare and contrast mature and young adult lungs.
Lung Pathologies	Healthy, smoker, and cancerous lungs. Pleural effusion/pericarditis. Lungs with adenocarcinoma.	
	Compare and contrast healthy lung with lung pathologies.	
5: Digestive & Urogenital Systems	Anatomy of the Digestive System	Isolated digestive system prosection (Distal esophagus to anus, includes accessory organs, abdominal aorta, IVC, and kidneys.) Pathology specimens (early-stage liver cancer, late-stage liver cancer, liver with alcoholic cirrhosis, pigmented gall stones).
		Discuss the anatomy and functions of the digestive tract and accessory organs. Discuss differences between healthy liver and liver pathologies. Describe the formation of gall stones and the different types.
	Anatomy of the Urinary System	Healthy mature kidney, urinary system enbloc (isolated kidneys, ureters, and bladder), healthy kidney from young adult, horseshoe kidney, cystic kidney.
		Demonstrate the anatomy of the healthy kidney, ureter, and bladder., Compare adult kidney to young adult and cystic kidneys. Describe the formation of a horseshoe kidney.
Anatomy of the Reproductive Systems	Bisected female and male pelvis (external genitalia covered), 3 isolated uteruses.	
	Identify the components of the internal reproductive organs, showing relationships to urinary and digestive system structures. Discuss parts and functions of uterus, fallopian tubes, and ovaries.	
Hallway	Photo Booth	Backdrop, tripod with cellphone attachment, articulate skeleton in lab coat.

Table 2. AOD 2022 activity station descriptions

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Important goals of AOD 2022 were to determine student and teacher satisfaction with the event, identify areas of improvement, and gather data surrounding participant characteristics and academic/career goals. Based on prior experience of running AOD, it was expected that teachers and students would have high satisfaction with the event and would be very likely to recommend it to a peer. The authors made no predictions regarding participant characteristics and academic/career goals, as this data was being collected from AOD participants for the first time.

AOD 2022 was designed to allow participants to be hands-on with healthy and pathological human anatomical donor materials and to explore healthcare with our dedicated and insightful facilitators. As discussed by Clark and colleagues (2016), hands-on outreach sessions are a more effective way to facilitate student understanding of physiology than didactic-style learning. Additionally, the hands-on experience that AOD provided for the students enabled us to highlight the human body's complexity, which can be challenging for the students to appreciate from textbooks and 2D images. We hoped that the AOD provided a memorable experience for students that could elicit or solidify their interest in science and anatomy or confirm their future academic/career goals. With our goal in mind, we developed and distributed a post-event survey for students and teachers after the hands-on graduate/professional student-led outreach event.

Methods

Research Approval

This project was approved by the Institutional Review Board (Approval #2022B0140) of The Ohio State University, and informed consent was obtained from all respondents.

Volunteer Facilitators

Each AOD station was led by one or more facilitators of the Anatomy Outreach Team (AOT). The AOT consists of over 100 dedicated health professional students (e.g., medical, dental, etc.), undergraduate students, and anatomy graduate students at The Ohio State University who volunteer their time to teach and inspire others through their love and passion for human anatomy.

Outreach (Student) Participants

AOD had more than 300 high school student attendees from 13 schools across Ohio, with an average round trip of 92.7 miles to participate in this enriching event.

Planning & Pre-event Timeline

The planning for this outreach event started months before AOD to ensure we had adequate time to solidify the details, identify needs, and assign tasks. In January and February, the AOP administrative team met on several occasions to discuss the specific times and dates when the event was to be held, which laboratory spaces the event would utilize, what groups

would be invited to participate, and a simple description of what activities would be included. The AOD was scheduled for May 4 and 5, 9:00 AM-3:00 PM, and May 6, 9:00 AM-12:00 PM, during which 5 laboratory spaces able to hold up to 50 participants were set up with activity stations.

At the beginning of March, the event details were emailed to teachers and program directors with whom the AOP had previously worked but who had yet to attend a traditional session in the same academic year. This email also included directions for scheduling, which was handled via email by asking teachers to provide a rank order list of preferred dates and times and the number of students anticipated to attend. The administration team worked to assign sessions to each school group, taking careful consideration of their submitted preferences. Emails confirming these details were sent out by the middle of March along with information for preparing students for the event, parking and arrival instructions, and waiver of liability and photo release forms required for all event participants.

At the beginning of April, recruitment of facilitators to lead the stations began via email, and a handful of AOT members volunteered their time to plan the specifics of the activities, create and post signage, and help set up and tear down for the event. The activities and stations were designed to provide a varied experience for participants that incorporated the central themes of science and medicine throughout the event. In addition to learning about the human body through healthy and pathologic anatomic specimens, students had the chance to learn more about the anatomy outreach and body donation programs at The Ohio State University. The week before the event, each participating high school teacher received final details and instructions, a short orientation video, and a reminder to submit all necessary forms. To accommodate the large number of students during AOD, each high school teacher was given a unique schedule that allowed them to cover all stations without overlapping with other student groups.

Event Content

Lab spaces dedicated to the body systems were arranged with 3 stations administered by 1 or 2 facilitators. The tools needed to work with human anatomical donor materials were provided at laboratory tables, including specimen trays, probes, wetting solution, and paper towels. Within each lab space, boxes of gloves and trash cans were arranged near the entrance and exit, and chairs/stools were placed near each lab table. To simplify the material and topics for facilitators, a digital anatomic atlas of the AOD specimens with photos, descriptions, diagrams, and links to more information was provided before the event. Additionally, labels were affixed to each specimen container with a brief description of what to describe and what anatomic features were most prominent on that specimen.

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Each high school class had 30 minutes per lab space, or roughly 10 minutes per station, where they were encouraged to ask questions, interact with the facilitators, and, if they felt comfortable, handle the human anatomical donor materials (Figure 1). The game room and facilitator panel were designed to give the students a break from the sights and smells of the donor labs while providing an engaging activity. Activities and material are described in Table 2; for more detailed descriptions, please contact TR (corresponding author).



Figure 1. (a) Students attempting to identify the bone in the mystery boxes. (b) Students learn how to use stethoscopes to listen to sounds of the heart and lungs. (c) High school students are engaged in learning about the respiratory system at three different stations. (d) Dental student teaching about the anatomy of the brain.

Post-event Survey

Student and teacher perspectives of AOD 2022 were assessed using a post-event survey administered via Qualtrics XM (Qualtrics International Inc., Provo, UT). The student post-event survey consisted of 20 questions of which half focused on student demographics and academic/career goals and the remaining ten questions related to event satisfaction, suggestions, and student perception of the experience (Appendix 1). The teacher post-event survey consisted of

16 questions related to event satisfaction, suggestions, scheduling, communications, and perceived benefits for students (Appendix 2). Details regarding consent to participate in the research study and completion of the post-event survey were sent to teachers by email the Monday following AOD 2022 for distribution to students (and their parents/guardians).

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Data Collection and Analysis

The post-event survey was closed two weeks after it was distributed, and the data collected was then exported from Qualtrics XM. Survey data were de-identified, cleaned, and organized using Microsoft Excel (version 16, Microsoft Corp., Redmond, WA) before being exported to SPSS for statistical analysis (version 27, IBM Corp., Armonk, NY). Qualitative data was organized and assigned to categories based on the whole of the responses, and then codes were assigned for categories to allow for frequency calculations.

Data Security

All data were de-identified and maintained on an external hard drive in a locked file cabinet within the Division of Anatomy.

Results

The survey used to evaluate AOD 2022 received 48 valid student responses and 7 teacher responses from the 332 individuals who attended the event giving a total response rate of 16.6%. The average age for students was 17.2 years, and the majority were in the 11th (37.5%) or 12th (50%) grades. Student ethnicity was primarily reported as Caucasian (75.0%), with other responses including African American (10.4%), Asian (6.3%), and other (8.3%). In terms of academic coursework, 42 out of 48 student respondents (87.5%) reported taking an anatomy and physiology course during their high school career; other popular science courses included chemistry (66.7%) and biology (41.7%; Table 3).

Science Course	Number of students who reported taking course <i>n</i>	Percent of Cases (out of 48) %
Anatomy & Physiology	42	87.5
Chemistry	32	66.7
Earth Science	11	22.9
Biology	20	41.7
Environmental Sciences	2	4.2
Physics	1	2.1
Astronomy	4	8.3
Other	10	20.8

Table 3. Self-reported science courses taken in high school by study participants; the question was designed as 'select all that apply'

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A portion of the survey focused on academic and professional school plans to gauge where students' interests lay with regard to higher education. Most students (77.1%) wanted to earn a bachelor's degree. In comparison, fewer chose to pursue an associate degree (4.2%) or technical school (2.1%), and some students (16.7%) had no academic plans following high school (Figure 2). When asked about

attending professional school (e.g., medical or dental school), respondents were split down the middle, with 24 stating a desire to attend a professional program and 24 who did not. Of those planning to attend a professional program, medical school was the most popular, with 11 responses, followed by physical therapy (6) and other degrees (6; Figure 3).

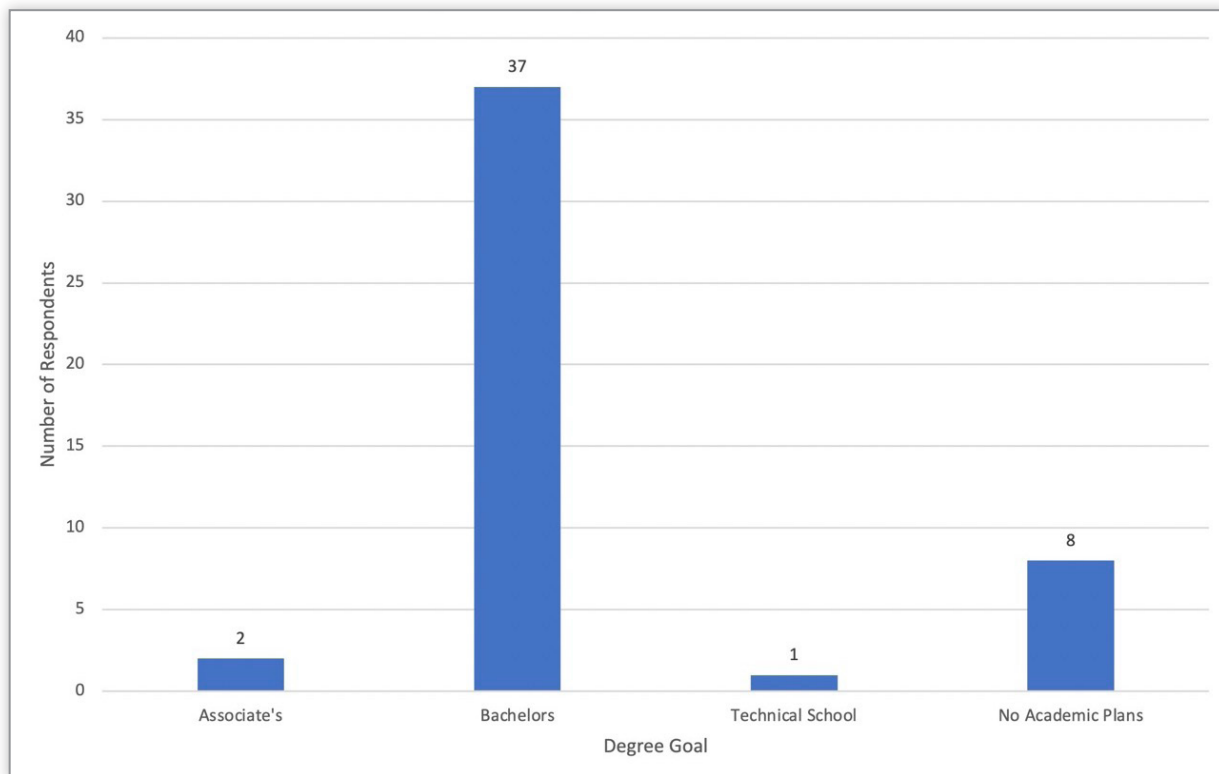


Figure 2. Student participant responses to "What are your academic plans following high school?"

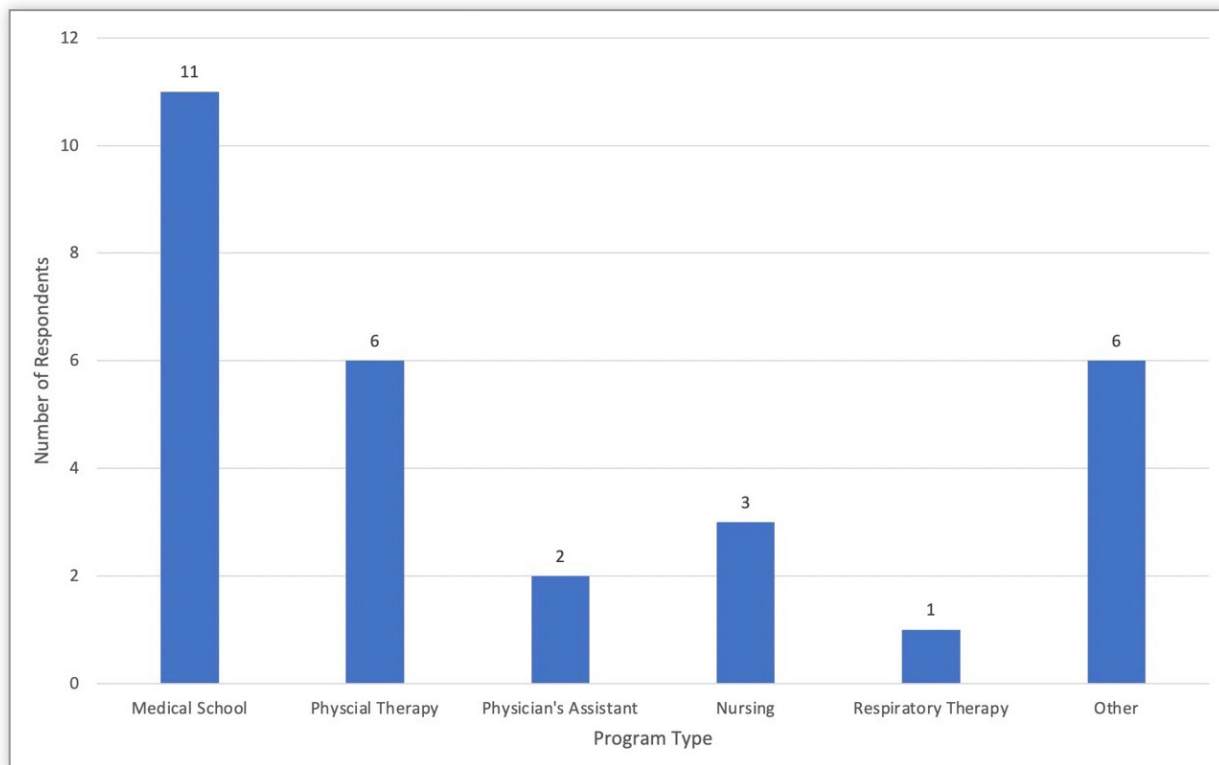


Figure 3. Student participant responses to "Which type of [professional] program/school do you intend to attend?"

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We asked both students and teachers to rate the experience at AOD 2022 and if they would recommend the experience to a fellow student/teacher in the future. On a scale of 1 (poor) to 5 (excellent), students rated the event at 4.56, and teachers rated the event at 4.86. When asked about recommending the event to others, students averaged 4.65, and teachers averaged 5.00, with 1 being very unlikely and 5 being very likely.

The post-event survey had several open-ended questions to gauge the rationale for responses and to collect suggestions and general comments about programming. These questions also explored respondents' perceptions of the most and least

educational activities. Student and teacher responses are summarized in Tables 4, 5 and 6.

Most teacher respondents (71.4%) reported that all activities were educational, while 27 students (56.3%) found the organ stations to be the most educational. Both groups had a large proportion that reported the game room (or a component of the game room) as the least educational activity, with 4 teacher responses (57.1%) and 14 student responses (29.2%). Students suggested changes to activities (11), changes to timing (8), and adding a break to the day's schedule (2). Teachers followed suit, suggesting station changes, length of activities, and adding a break to the schedule.

Response Theme	Number of Responses	Selected open-ended responses
Student (n = 41)		
All Activities	8	"All of them, I think I learned something new in every room"
Facilitator panel	3	"I thought that the student panel was very helpful for me"
Organ Systems	27	"I found the pathology of the organs most educational because it allowed me to compare abnormal organs to healthy ones, as well as what caused them to be abnormal."
Anatomy Trivia	3	"My favorite part of the activities was playing the Jeopardy game of the different systems."
Teacher (n=7)		
All Activities	5	"Really all of it. Most of my students have not been exposed to high level science and most won't go to college so the experience could have a huge influence in their lives."
Facilitator panel	1	"Even the diversity of the team of students was appreciated. The Q and A section was really informative. Every person was on top of their game and so approachable."
Organ Systems	1	"The hands-on lab experiences were most educational."

Table 4. Which activity did AOD participants perceive to be the most educational?

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Response Theme	Number of Responses	Selected open-ended responses
Student (n = 44)		
Urinary & Reproductive Systems	4	"If I had to choose my least favorite part, it would have been the urinary system just because it doesn't interest me."
Games	14	"the game room... I enjoyed having a break but was not able to participate in the activities, therefore I was happy to move out of this room and on to new labs."
Brain	2	"The entire nervous system because it was repetitive at each station and I had already learned all of it."
Heart	1	"I feel like they were all equally educational i just knew more about some of them then others so probably the heart."
None	23	
Teacher (n=7)		
Urinary & Reproductive Systems	1	"Reproductive was good but i think it lacked detail and reality to the topics that they would want to learn more about."
Games	4	"The games were great but of all the things we did that day, they were the least helpful as I could have done them in my classroom."
Heart & Lungs Sounds	1	"The blood pressure station was a little hard to do/hear."
None	1	

Table 5. Which activity did AOD participants perceive to be the least educational?

Response Theme	Number of Responses	Selected open-ended responses
Student (n = 44)		
Timing	8	"Timing, there were a few stations that did not get finished with the section they were teaching."
More facilitator availability	1	"Allow for more openness fore students"
More activities	11	"Something I would like to have done is go to the morgue."
Add a break	2	"I would make it a little less repetitive and maybe provide some sort of snack because I know my entire class was very hungry"
Event Logistics	1	"Maybe go from the third floor to the second, work your way down so it's easier for teachers to get students where they're going without confusion"
No Changes	21	
Teacher (n=7)		
More Time	1	"Longer sessions. Maybe closer to 45 minutes?"
More Specimens/ Content	3	"Increase exploration of reproductive system" "More specimens that deal with smoking and illegal substances"
Add a Break	1	"The three hours was great, but kids need a reboot. Some sort of snack (which I know is difficult in the anatomy building) would have given them a boost."
No Changes	2	

Table 6. What changes to AOD were suggested by participants?

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Discussion

Examples of anatomy outreach programs that have benefitted student participants, teachers, and facilitators can be found in literature. These programs provide unique opportunities to interact and learn about the human body and medicine using various methods, such as small group hands-on anatomy lab experiences, summer camps, and workshops (Cook et al., 2020; Houtz & Quinn, 2006; Meyer et al., 2018). Benefits include enhanced interest and student engagement in science, providing teachers with new methods of navigating and building knowledge on complex topics, and supporting facilitators' positive communication and teaching skills (Laursen et al., 2007; Tanner et al., 2003). It is important to recognize that outreach programs focused on anatomy, science, and STEM can potentially transform students' understanding and interaction with these subjects (Clarke et al., 2019; Ruth et al., 2023). Therefore, it is crucial to continue researching and exploring new approaches and methods, such as AOD 2022, to advance this field further. By learning from these experiences and improving our outreach strategies, we can generate greater student engagement in pursuing education and careers related to anatomy, science, and healthcare.

The AOD event was unlike other anatomy outreach events put on by the AOP, given that it accommodated so many students in a short time and provided more learning opportunities. By sharing this event's details and outcomes, we provide a framework for other programs to build similar experiences for anatomy students in their spheres of influence. Further work is needed to understand how large-scale events such as AOD 2022 impact students' interests in anatomy and the medical field and how much educational utility they hold for participants. Now that we understand the logistics and management of this event, we can shift our focus in this direction.

Part of the post-event survey focused on participants' academic plans following high school, and a surprising number stated a desire to pursue a bachelor's degree and a professional degree. The most common professional degree program selected by students was medical school, while other programs included physical therapy, physician assistant, and respiratory therapy. This information is helpful in several ways. It highlights the interests of our participants and identifies where we can improve programming to meet these interests. Additionally, this aids us in our facilitator recruitment process, identifying areas where we can improve the diversity of professional students we have present at our large-scale events.

A limitation of this study is that a survey was not conducted to look at these same questions from students before AOD. A pre-event survey may have allowed us to determine if there was a change in the academic goals or perceptions of anatomy content following the event. Post-event

evaluations often show high participant satisfaction with outreach activities and positive attitudes toward STEM; this may indicate that only using post-event surveys may lead to misinterpretation of data that could be mitigated with a counterpart pre-event survey (Vennix et al., 2018). However, it should be noted that most respondents were in their third or fourth year of high school. As a result, the impact of the three-hour anatomy-themed event may have been less significant for these students compared to younger participants.

Additionally, the study is limited by the low response rate, with only 16.6% of participants providing feedback. This raises the concern that the data collected may only partially represent the population. While most responses and comments were positive, it is important to consider that those who chose to participate in the study may have been more motivated and engaged. To gain a more comprehensive understanding of the event's impact, future evaluations should aim to increase the response rate and gather feedback from a broader range of participants.

A byproduct of the anatomy lab experiences is an environment where participants can meet and interact with facilitators with similar backgrounds and aspirations. On multiple occasions, students expressed that they enjoyed and appreciated having the opportunity to interact with the facilitators. One student said, "the students working the stations were very upbeat which made the overall experience that much better and I didn't dread going to the next station in fact was excited to continue learning." Another stated: "I loved to see how much knowledge the staff and students had about anatomy and how inviting they were to my class." Teachers also noted the positives of having their students interact with our facilitators: "The student panel was very informative. The team was very down-to-earth and relatable to us. Not pretentious in any way. Fun and approachable."

Open-ended questions measured the activities participants found the most and least educational. In most areas, students and teachers agreed that the organ system stations, or all activities, were the most educational. These stations were designed to be the event's focal point, so these results support our intentions. A few students and teachers discussed how the facilitator panel allowed students to interact with professional students and ask questions about their path to medical school, undergraduate majors and tips, and how to be successful in college, among other topics.

Surprisingly, the game room was the least educational activity reported by students and teachers, though this space often had the highest level of engagement and positive energy relayed from facilitators. The game room was designed to add a buffer to the AOD schedule and to give students a break from the anatomy labs for one of their rotations. The authors recognize that participants prefer the hands-on activities in terms of educational value but having the game room allowed us to adjust group schedules when groups arrived

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late for the start of the event or when groups needed to leave earlier than planned. The game room could easily be omitted or used to fill a gap, so it will likely have a place in future events regardless of feedback. However, the game room will be modified to try new games and activities to increase its educational nature.

The survey asked for changes that students and teachers may like to see in the future; outside of some changes to specific organ stations (e.g., urinary and reproductive stations). Given that most responses focused on logistics and timing of the event schedule, the AOP will work in the future to extend the time per activity and introduce a break (potentially for lunch) into the overall schedule. This will be done by extending the total time of the event from 3 hours to somewhere in the 4–5-hour range. Since there was no previous event of a similar scale to reference, the organizers had little guidance pertaining to the appropriate duration for the AOD. However, they aimed to make it longer and more intensive than the AOP's typical outreach sessions. Participant responses in this area helped corroborate the organizers' observations during the event and created a clear path for improvement for future AODs.

Planning for AOD 2022 presented several challenges, including when to plan the event and being considerate of the time of all groups. Because AOD was traditionally held at the end of the academic year, it conflicts with student, facilitator, and facilities schedules. Many high school students take end-of-year examinations, participate in sports activities, or participate in other end-of-year activities during May. We asked teachers if they could offer an alternative date for AOD, but few had suggestions, stating that they liked having this event at the end of the year when students could get the most out of it and that other times of year were equally hard to schedule. Lastly, accommodating time considerations for all groups was an inherent challenge. With more groups, more opportunities for late arrival or early dismissal impacted the overall event schedule. Because of this, buffer activities and flexibility were required on the part of the organizers and supervisors. Some groups mentioned that the time spent on each station was perfect, whereas others wished more/less time was spent on each station. In this regard, it can be challenging to address the needs of all attendees; we will continue to communicate with our partners to ensure all participants can get the most out of this experience.

Conclusion

Overall, AOD 2022 was a success as it was enjoyable and a great learning experience for our participants, facilitators, and organizers. Meyer and colleagues (2018) discussed the inherent benefit of an outreach day and 'hands-on' experience, relating it to higher scores in anatomy and physiology and helping solidify science understanding in schools without access to cadavers and dissection

opportunities. Similarly, we agree that outreach events help supplement the average high-school anatomy classroom, as these students can interact with human anatomic donors and ask questions related to human anatomy, pathologies, and medical interventions. In addition to the benefits participants see, the outreach days' benefits extend to facilitators lending the opportunity to practice teaching anatomy and engaging with younger people across various backgrounds (Clarke et al., 2019).

The AOD event was not without faults, nor will it be run in the future without making improvements, but for the first time running a large-scale outreach event, the AOP has no complaints. Both students and teachers have expressed their satisfaction with their experience in the anatomy labs, emphasizing their recommendation of it to others. This further supports the point being made. One teacher said, *"Tyler, Dr. Quinn, and every student that participated was very approachable and valuable. It really is an experience like no other and I cannot say enough good things! Thank you for EVERYTHING! It really gives my students an idea if this is an area of education they are interested in pursuing."* A student had this to say about their participation in the event, *"The [donors] were also incredible to see, it made the experience more humane, and it truly helped me reflect on my passion to pursue medicine. Overall, I found all of the organs we looked at incredibly educational, especially when we compared a healthy lung to a smoker's lung."*

The above are just a couple of glowing reviews the event received; numerous teachers and students expressed how much they learned, how surprised they were when viewing a specific specimen, or how much they enjoyed interacting with our facilitators. These words reinforce why we organize and host events such as this, so we may spark interest and solidify participants' desire to continue education in anatomy, science, or healthcare. The authors hope that the data and results reported here help other institutions find a scaffold to plan their anatomy outreach events so that we, as a field, may continue to give back to our communities.

Acknowledgments

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Literature Cited

- Adams, J. S., Nelson, H.M., Strong, E., Wisco, J., & Klappa, S.G. (2020). Mentors' experience in teaching basic science concepts in the community outreach program, Anatomy Academy: A phenomenological study. *HAPS Educator* 24(2), 27-35. <https://doi.org/10.21692/haps.2020.017>
- Bogue, B., Shanahan, B., Marra, R. M., & Cady, E. T. (2012). Outcomes-based assessment: Driving outreach program effectiveness. *Leadership and Management in Engineering* 13(1), 27-34. [https://doi.org/10.1061/\(ASCE\)LM.1943-5630.0000209](https://doi.org/10.1061/(ASCE)LM.1943-5630.0000209)
- Cale, A. S., Byram, J. N., Organ, J. M., & Schmalz, N. A. (2023). "A whole new perspective on how the body fits together" – An evaluation of a cadaver laboratory experience for high school students. *Anatomical Sciences Education*, 16(2), 291-304. <https://doi.org/10.1002/ase.2229>
- Clark, G., Russell, J., Enyeart, P., Gracia, B., Wessel, A., Jarmoskaite, I. et al. (2016). Science educational outreach programs that benefit students and scientists. *PLOS Biology*, 14(2), Article e1002368. <https://doi.org/10.1371/journal.pbio.1002368>
- Clarke, M. A., Sharma, N. M., & Schiller, A. M. (2019). An outreach program with hands-on, physiology-based exercises generates questions about STEM career expectations. *Advances in Physiology Education* 43(2), 175-179. <https://doi.org/10.1152/advan.00013.2019>
- Cook, D. P., Steed, K., Read, C., Baysarowich, R., Redway, T., Robineau-Charette, P., & Carnegie, J. (2020). Science outreach: Six examples of programs that enrich the learning environments of students and educators. *HAPS Educator, Special Conference Edition*, 16-25. <https://doi.org/10.21692/haps.2020.107>
- Diaz, M. M., Ojukwu, K., Padilla, J., Steed, K., Schmalz, N., Tullis, A. et al. (2019). Who is the teacher and who is the student? The dual service- and engaged-learning pedagogical model of anatomy academy. *Journal of Medical Education and Curricular Development*, 6, Article e2382120519883271. <https://doi.org/10.1177/2382120519883271>
- Houtz, L. E., & Quinn, T. H. (2006). Build a human project: Improving attitude and increasing anatomy content knowledge and skills for middle-level students. *Journal of Higher Education Outreach and Engagement*, 11(2), 21-32.
- Hubbard, C. J., Miller, J. S., & Olson, D. (2005). A new way to teach an old topic: The cadaver-based anatomy short course for high school students. *The Anatomical Record Part B: The New Anatomist*, 284B(1), 6-11. <https://doi.org/10.1002/ar.b.20059>
- Husher, K. (2010). Building an evaluation framework for Australian science and maths outreach programs in schools. [Doctoral thesis, University of Newcastle].
- Laursen, S., Liston, C., Thiry, H., & Graf, J. (2007). What good is a scientist in the classroom? Participant outcomes and program design features for a short-duration science outreach intervention in K-12 classrooms. *CBE Life Sciences Education*, 6(1), 49-64. <https://doi.org/10.1187/cbe.06-05-0165>
- Meyer, E. R., Williams, S., Conway, M., & Notebaert, A. (2018). Kids in the gross anatomy lab: How an outreach program in anatomy educates high school and undergraduate students about health care. *HAPS Educator*, 22(3), 262-267. <https://doi.org/10.21692/haps.2018.031>
- Millar, V., Toscano, M., van Driel, J., Stevenson, E., Nelson, C., & Kenyon, C. (2019). University run science outreach programs as a community of practice and site for identity development. *International Journal of Science Education*, 41(18), 2579-2601. <https://doi.org/10.1080/09500693.2019.1689587>
- Ruth, A. A., Nesbitt, A., & Johnson, L. E. (2023). Flexible, short-duration outreach sessions in the human anatomy laboratory provide authentic, humanistic experiences. *Anatomical Sciences Education*, 16(2), 280-290. <https://doi.org/10.1002/ase.2209>
- Tanner, K. D., Chatman, L., & Allen, D. (2003). Approaches to biology teaching and learning: Science teaching and learning across the school-university divide – Cultivating conversations through scientist-teacher partnerships. *Cell Biology Education*, 2(4), 195-201. <https://doi.org/10.1187/cbe.03-10-0044>
- Vennix, J., den Brok, P., & Taconis, R. (2018). Do outreach activities in secondary STEM education motivate students and improve their attitudes towards STEM? *International Journal of Science Education*, 40(11), 1263-1283. <https://doi.org/10.1080/09500693.2018.1473659>

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Appendix 1: Student Post-Event Survey

Item	Response Format
Student Information and Academic/Career Goals	
1. What was your age on your last birthday?	[Drop Down]
2. Please select the gender with which you most identify:	Select all that apply: <input type="checkbox"/> Male <input type="checkbox"/> Female <input type="checkbox"/> Nonbinary/third gender <input type="checkbox"/> Other (please explain) [Text box] <input type="checkbox"/> I would prefer not to answer
3. Please select your grade level:	[Drop Down] 9 th grade 10 th grade 11 th grade 12 th grade
4. Please select the ethnicity(ies) with which you most identify:	Select all that apply: <input type="checkbox"/> Black or African American <input type="checkbox"/> American Indian or Alaskan Native <input type="checkbox"/> Asian <input type="checkbox"/> Native Hawaiian or another Pacific Islander <input type="checkbox"/> White <input type="checkbox"/> Other (please explain) [Text box]
5. What courses have you taken or are taking currently (in high school) that are related to science?	Select all that apply: <input type="checkbox"/> Anatomy (and Physiology) <input type="checkbox"/> (AP) Biology <input type="checkbox"/> Physics <input type="checkbox"/> Earth Science <input type="checkbox"/> Chemistry <input type="checkbox"/> Forensics <input type="checkbox"/> Astronomy <input type="checkbox"/> Environmental Science <input type="checkbox"/> Other (please list any other science course you have taken in high school) [Text box]
6. What are your academic plans following high school?	Multiple choice: <ul style="list-style-type: none"> • Associate's degree (2 year) • Bachelor's degree (4 year) • Technical school • No academic plans • Other (please explain) [Text box]

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Item	Response Format
7. If you plan to enroll in a degree-seeking program of any kind, what is your intended major/topic of study? (if not applicable, please respond "N/A")	[Text box] –
8. Do you plan to attend a professional school/program following a traditional four-year degree? (eg. Medical or Dental school, Physical Therapy, Occupational Therapy, Physician Assistant, etc.)	Multiple choice: <ul style="list-style-type: none"> • Yes • No
9. If you answered "Yes," to above question which type of program/school do you intend to attend?	Multiple choice: <ul style="list-style-type: none"> • Medical school • Dental school • Physical therapy • Occupational therapy • Physician Assistant (PA) • Nursing • Respiratory Therapy • Other (please explain) [Text box]
10. In a few sentences or less, what do you see yourself doing for a career?	[Text box]
Program Satisfaction	
11. On a scale of 1 – 5, with 1 being poor and 5 being excellent, how would you rate your experience with the Anatomy Outreach Day 2022?	Multiple choice: <ul style="list-style-type: none"> • 1 • 2 • 3 • 4 • 5
12. In a few sentences or less please explain the rating you gave in the question above.	[Text box]
13. On a scale of 1 – 5, with 1 being very unlikely and 5 being very likely, how likely would you be to recommend the Anatomy Outreach Days to a classmate or friend that has not participated?	Multiple choice: <ul style="list-style-type: none"> • 1 • 2 • 3 • 4 • 5
14. In a few sentences or less please explain the rating you gave in the question above.	[Text box]
15. What activity or activities did you find the MOST educational?	[Text box]
16. What activity or activities did you find the LEAST educational?	[Text box]

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Item	Response Format
17. What are 2 to 3 aspects of the event that you think were most beneficial to yourself as a student?	[Text box]
18. What is something that you would change about Anatomy Outreach Day?	[Text box]
19. Is there any activity or topic that you would like to see covered in future events that was not included in Anatomy Outreach Day 2022?	[Text box]
20. Do you have any other suggestions or comments relating to the Anatomy Outreach Day as a whole?	[Text box]

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Appendix 2: Teacher Post-Event Survey

Item	Response Format
Program Satisfaction/Suggestions/Comments	
1. On a scale of 1 – 5, with 1 being poor and 5 being excellent, how would you rate your experience with Anatomy Outreach Day 2022?	Multiple choice: <ul style="list-style-type: none"> • 1 • 2 • 3 • 4 • 5
2. In a few sentences or less please explain the rating you gave in the question above.	[Text box]
3. On a scale of 1 – 5, with 1 being very unlikely and 5 being very likely, how likely would you be to recommend future Anatomy Outreach Days to a teacher/school that has not participated?	Multiple choice: <ul style="list-style-type: none"> • 1 • 2 • 3 • 4 • 5
4. In a few sentences or less please explain the rating you gave in the question above.	[Text box]
5. On a scale of 1 – 5, with 1 being very easy and 5 being very difficult, how would you rate the scheduling process for Anatomy Outreach Day 2022?	Multiple choice: <ul style="list-style-type: none"> • 1 • 2 • 3 • 4 • 5
6. In a few sentences or less please explain the rating you gave in the question above.	[Text box]
7. On a scale of 1 – 5, with 1 being very easy to understand and 5 being very difficult to understand, how would you rate the communications distributed by the Anatomy Outreach Program in preparation for Anatomy Outreach Day 2022?	Multiple choice: <ul style="list-style-type: none"> • 1 • 2 • 3 • 4 • 5
8. In a few sentences or less please explain the rating you gave in the question above.	[Text box]
9. Is there any information that you would have found helpful to have received prior to the event that you did not receive as a part of Anatomy Outreach Day 2022 advance communications? Please explain.	[Text box]

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Item	Response Format
10. From your perspective as a teacher, what activity or activities did you find the MOST educational for your students?	[Text box]
11. From your perspective as a teacher, what activity or activities did you find the LEAST educational for your students?	[Text box]
12. What are 2 to 3 aspects of the event that you think were most beneficial to students?	[Text box]
13. Is there a time of year (other than the 1st week of May) that would better accommodate your student group attending an event like Anatomy Outreach Day 2022? Please explain.	[Text box]
14. What is something that you would change about Anatomy Outreach Day?	[Text box]
15. Is there any activity or topic that you would like to see covered in future events that was not included in Anatomy Outreach Day 2022?	[Text box]
16. Do you have any other suggestions or comments relating to the Anatomy Outreach Day as a whole?	[Text box]



HAPS Curriculum & Instruction 2022 Laboratory Survey: Demographics of Respondents, Institutions, and Students

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Abstract

In 2022, a subset of the Human Anatomy and Physiology Society (HAPS) Curriculum & Instruction Committee administered the third offering of the HAPS lab survey. This survey included a three-part framework of (1) demographics, (2) lab activities and learning outcomes, and, (3) the impact of a global pandemic on instruction. Here we report on demographics of respondents, their institutions, and students. Survey results related to lab activities and outcomes, and COVID-19 impacts, will be addressed in subsequent manuscripts. The duration of teaching service has been stable with 54.3% to 58.3% of respondents serving at least ten years in their current position, and 88% of respondents working at a single institution. Job responsibilities focused on teaching (98.9%) as well as multiple other commitments including service and lab and/or course coordination. The number of respondents with a terminal degree increased and there has been a decrease in the percentage of respondents working at 2-year institutions, with 50% of respondents working at 4-year institutions, of which a slight majority had graduate programs. Career goals of enrolled students remained focused on allied-health and instructors indicated nursing as the most common student career goal, with a range of other careers also mentioned. Overall, the results affirmed the importance of anatomy and physiology (A&P) instruction and the multiple roles that

A&P instructors serve at their institutions. <https://doi.org/10.21692/haps.2023.013>

Key words: anatomy, physiology, education, survey, instruction, faculty, institutions, demographics, fees

Introduction

The laboratory component is an essential element of introductory undergraduate anatomy & physiology (A&P) instruction, as it confers crucial critical thinking and clinical skill sets, complements and applies important lecture concepts, and provides opportunities for “hands-on” collaborative learning opportunities. In an effort to characterize this A&P laboratory experience for students, the Human Anatomy & Physiology Society (HAPS) sponsored

two previous surveys of A&P instructors in 2013 (Brashinger, 2014a; 2014b) and 2017 (Brashinger, 2017). These initial surveys investigated the foundational learning outcomes for A&P laboratory instruction and the best practices for achieving these goals. The 2013 survey provided a baseline of opinions and common practices for the undergraduate A&P laboratory, while the 2017 survey expanded upon this foundation.

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A majority of respondents in both surveys indicated that they used specific laboratory learning outcomes and that having students meet learning outcomes was a high priority. Participants in the 2017 survey responded that their most important laboratory experience priorities were meeting program objectives, teaching three-dimensional and structure/function relationships, and reinforcing lecture content. An intriguing observation in both surveys was the finding that a significant number of instructional A&P laboratory goals were not directly related to laboratory knowledge, as evidenced by the relatively low rankings of clinical knowledge, scientific inquiry, and science laboratory knowledge skills. Future studies suggested by these collective results included determining whether A&P instructional priorities align with entry-level expectations of nursing and allied health programs and investigating how learning outcomes align with laboratory learning experience priorities (Brashinger, 2014a; 2014b; 2017).

With regard to lab activities, the 2017 survey indicated that optical microscopy was the main instructional approach for histology, although digital and print imagery were common (Brashinger, 2017). Also revealed by this survey was the prevalent use of whole preserved animals and preserved organ dissection for anatomy instruction and human subjects for physiology experimentation. Although human anatomical donor dissection and the use of live animals for physiology experimentation were limited, a significant number of 2017 survey respondents reported using prosected human anatomical donor specimens and computer modeling for human dissection instruction. These ranked frequencies of methodologies in histology, dissection and physiology experimentation provided a useful framework for further delineation of best practices in A&P laboratory instruction (Brashinger, 2017).

The Curriculum and Instruction Committee of HAPS was preparing to revise and administer the survey in 2020 following the planned annual conference in Ottawa, ON, Canada. These preparations, like much of 2020, were disturbed by the COVID-19 pandemic, and put on hold while attention was diverted to shifting A&P instruction to a fully remote, online experience. After the HAPS 2021 virtual annual conference, preparations resumed to deliver the survey with added questions about experiences teaching A&P labs during the pandemic.

The lab survey most recently administered in 2022 built upon the foundation of the prior surveys, within an overarching three-part framework (Part I focusing on demographics of respondents and their institutions; Part II addressing lab activities and HAPS learning outcomes/goals, and Part III investigating the impact of a global pandemic on A&P teaching and science instruction in higher education). The current article presents Part I, the demographics data from the 2022 survey, which shared many similar questions with

the previous surveys, while providing an updated profile of the survey participants, the courses they instruct, and the institutions at which they teach.

The objective of Part I was to further delineate aspects of undergraduate A&P instruction in order to provide an appropriately structured context and framework for Parts II and III of the survey, which investigated commonly implemented A&P laboratory activities, the learning goals/outcomes for laboratory pedagogy, and the impact of a global pandemic on this instruction. In addition, select data from Part I will also serve as independent variables for statistical analysis of results from Parts II and III of this survey. Collectively, these three sections of the 2022 survey provide a comprehensive, nuanced, and multilayered portrait of undergraduate A&P laboratory instruction while identifying emerging trends in instruction across a diverse scope of institutions, courses, and educators.

Materials and Methods

During the 2021 HAPS virtual annual conference, the lab survey subcommittee of the Curriculum and Instruction Committee was formed and met to plan for the third administration of the HAPS lab survey. Within the subcommittee, members represented a diversity of institutional types, geographical regions, courses taught, and teaching format. The subcommittee met twice per month from June to October of 2021 to assess the utility of the questions from the first (Brashinger, 2014b) and second (Brashinger, 2017) lab surveys, respectively. We developed the present survey around three categories: demographics of instructors and institutions, laboratory activities and outcomes, and the impact of the COVID-19 pandemic on A&P instruction. Questions from the first and second HAPS lab surveys were seeded into the first two categories allowing for evaluation of temporal changes in A&P lab instruction.

Common questions in the 2013, 2017 and 2022 surveys included professional memberships (with "American Association of Clinical Anatomists" as a new option), highest degree/licensure, duration and employment contract ("full time", "part time", "permanent", etc.) of current position, type of institution (with "graduate program" included for 4-year institutions), student career goals, and lecture and lab instructional format (with "in-person", "hybrid", "synchronous" and "asynchronous" as revised options). Questions on prior surveys regarding position status and job title were reformatted with revised position categories for "job level" and a new question asking what "job duties" the respondents' position included. Likewise, the previously administered question on A&P course sequence duration was presented in our current survey based on course numbering and whether the lecture and laboratory were taken concurrently by students.

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In addition to the common questions detailed above, the 2022 survey also employed several newly written questions, which included the number of institutions at which respondents had taught, undergraduate enrollment at their current institution, the enrollment and number of sections offered per academic year for A&P as well as anatomy-only and physiology-only courses, the use of HAPS exams by respondents in their classes, the laboratory fees students were required to purchase each semester, and external laboratory resources students were required to purchase ("lab manual", "digital lab resource", "lab equipment", etc.). These novel questions provided a layered and multidimensional perspective of the A&P students, instructors and their undergraduate institutions.

To further develop the 2022 survey, subcommittee members volunteered to focus their efforts within one of the three survey categories. Within each category, members represented a diverse range of teaching experiences, teaching challenges, and individual perspectives. The first iteration of the survey was reviewed by the HAPS Board of Directors in 2021. Comments were used to refine the survey in October 2021. In November 2021 the revised survey was sent to four volunteers, who were not involved in the survey subcommittee, to obtain feedback on question clarity and survey length. These naive reviewers stated that the questions were concise and that the survey took 15–25 minutes to complete depending on how many questions applied to their role at their institution. After receiving approval from the HAPS Board of Directors to proceed with the revised survey, Institutional Review Board EXEMPT status was obtained under 45 CFR 46.101(b) (#2) by The University of Mississippi's Institutional Review Board (IRB, Protocol #22x-129). Respondents were required to verify that they were 18 years of age or older before beginning the survey.

The survey was delivered and publicized through HAPS membership emails, the HAPS listserv communication board, a HAPS Blog (Britson, 2022), and HAPS social media during February and March of 2022. While the survey was anonymous, respondents could choose to enter a gift card raffle by entering their name and email address after submitting their lab survey responses. ADInstruments, Inc. sponsored gift card incentives for respondents completing the survey. One winner of a \$100 gift card, and four winners of \$50 gift cards, were chosen at random at the end of March 2022. At that time, 141 responses had been received. To encourage additional participation, the subcommittee presented a poster (Britson et al., 2022) at the 2022 annual HAPS conference to communicate preliminary findings and offer additional incentives in the form of a door prize raffle. The survey remained open for submissions through August 15, 2022.

For the development of the demographic portion of the 2022 survey, questions asking for information job levels, duties, and type of employment contract, sizes of the respondents' institutions and classes (both lecture and laboratory), variety of anatomy and physiology courses offered and enrollment requirements, lecture and laboratory instruction formats, and amount of required lab fees were added to the questions seeded from the two earlier surveys. Specific development of the laboratory activities and outcomes, and the impact of the COVID-19 pandemic on A&P instruction survey sections, will be presented in subsequent manuscripts. Linking of demographic data to responses will allow comparisons across institutions and courses regarding how laboratories are taught, how students are assessed, and how anatomy and physiology instruction continued during the COVID-19 pandemic. Frequency data and descriptive statistics were calculated for all survey questions. All statistical tests were conducted using SPSSV27 software licensed to the University of Mississippi.

Results

There were 176 responses to the survey. For respondents who disclosed their location, 29.9% were from the southern region of HAPS, 23.0% from the eastern region, 20.9% from the western region, and 25.1% from the central region (Human Anatomy & Physiology Society, 2023a). A demographic profile of the typical survey respondent showed membership in HAPS and at least one other professional society, a terminal degree, working in a faculty position at a single institution, and employment in their current position for more than ten years. Nearly 70% of survey respondents indicated membership in HAPS (Figure 1). Additional memberships in the American Association for Anatomy and the American Association of Clinical Anatomists were the next most common at 10.8% and 10.2% of survey respondents, respectively. From 2013 to 2022, the proportion of respondents holding a terminal degree increased from 48.6% to 56.9% while the number of respondents with a master's degree decreased from 44.8% to 31.3% (Figure 2). Length of time in their current positions has been relatively constant across the three surveys with 54.3% to 58.3% (2013 to 2022) of respondents with ten plus years in their current position (Figure 3). Eighty-eight percent of respondents worked at a single institution with 9.71% at 2 institutions, 1.14% at 3 institutions, and 1.14% at more than 3 institutions. Respondents indicated that their positions were considered faculty (91.0%), staff (6.78%), retired/emeritus (1.13%), student (0.56%), or another status (0.56%). No respondent indicated that they were in a post-doctoral position.

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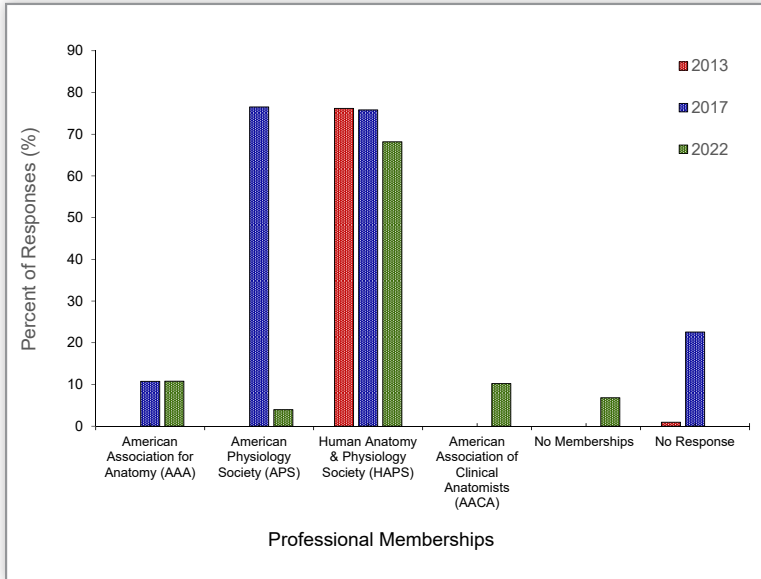


Figure 1. Professional society memberships held by respondents (n=176) to the HAPS 2022 Curriculum and Instruction survey. Respondents were directed to select all answers that apply. Where applicable data from the 2013 and 2017 surveys were also included.

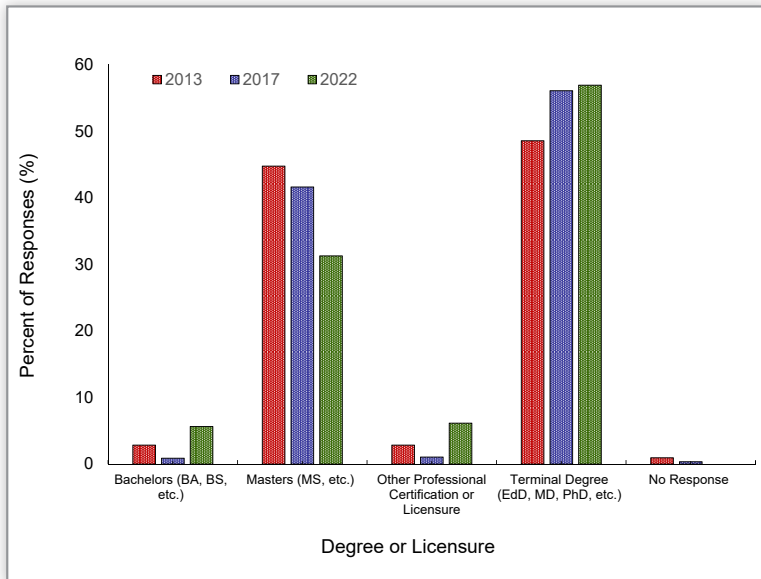


Figure 2. Highest degree and/or licenses held by respondents (n=176) to the HAPS 2022 Curriculum and Instruction survey. Respondents were directed to select all answers that apply. Where applicable data from the 2013 and 2017 surveys were also included.

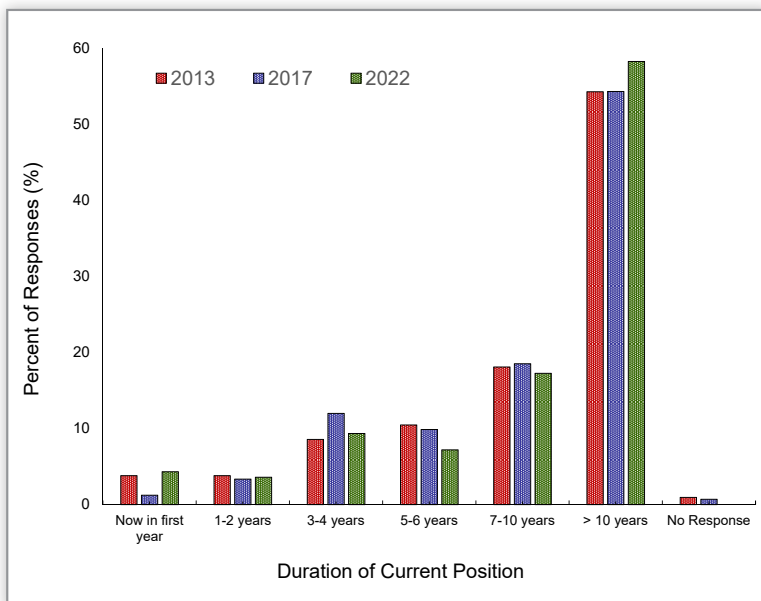


Figure 3. Duration of time spent in current position by respondents (n=176) to the HAPS 2022 Curriculum and Instruction survey. Where applicable data from the 2013 and 2017 surveys were also included.

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Job responsibilities of respondents focused on teaching (98.9%) as well as multiple other commitments (Figure 4). More than 50% of respondents indicated that they also were responsible for service expectations, lab coordination, and/or course coordination. Approximately 20% of respondents indicated that their jobs also included research expectations or administrative duties. More than 90% of respondents were employed full-time (Figure 5). Most of the respondents to this question did not fully answer the question by also indicating if their contract had (n=44), or did not have (n=7), an expectation of renewal. When the question was answered completely, there were an equal number of responses for full versus part-time and renewable versus non-renewable.

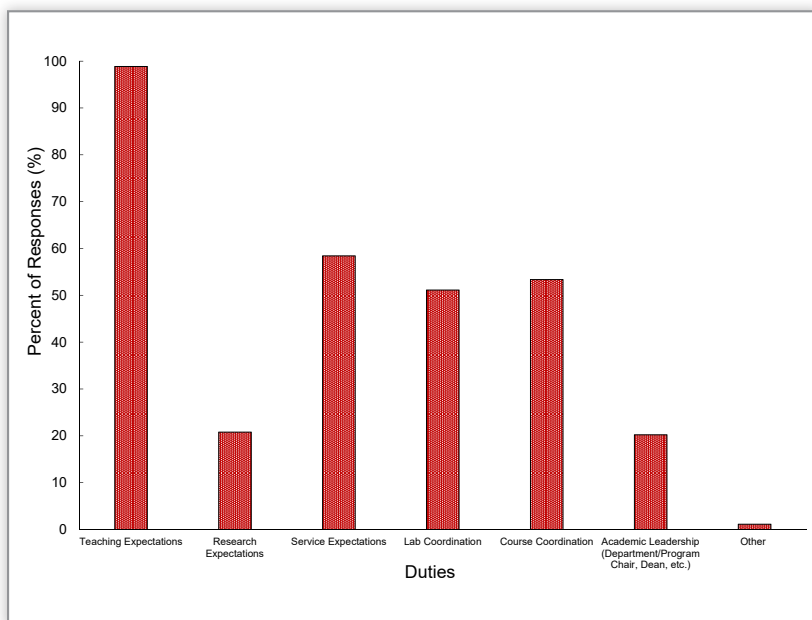


Figure 4. Job duties of respondents (n=176) to the HAPS 2022 Curriculum and Instruction survey. Respondents were directed to select all answers that apply.

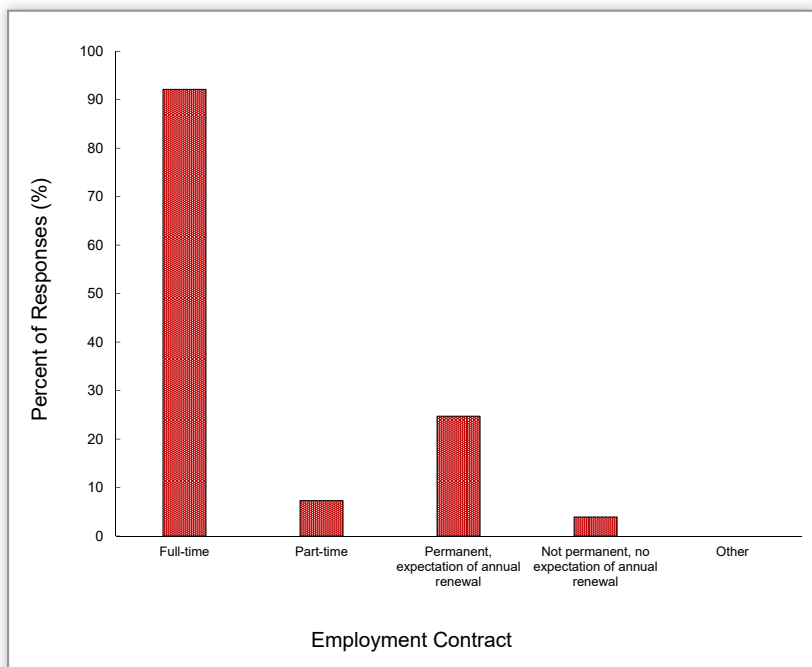


Figure 5. Position and contract characteristics of respondents (n=176) to the HAPS 2022 Curriculum and Instruction survey. Respondents were directed to select all answers that apply.

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From the previous surveys to the current survey, there has been a decrease in the percentage of respondents working at 2-year institutions while the percentage at 4-year institutions increased (Figure 6). Of the 50% of current respondents working at 4-year institutions, slightly more than half were at institutions with a graduate degree program. Enrollment across all institutions from the current survey ranged from less than 1,000 students (11.9%), 1,000 to 5,000 students (38.1%), 5,000 to 15,000 students (27.3%), and more than 15,000 (22.7%). Enrollment in lecture and laboratory sections for A&P I and II, anatomy-only, physiology-only, and 1-semester A&P essentials courses for individual respondents and institutions varied extensively and reflected the diversity of institutions represented (Table 1).

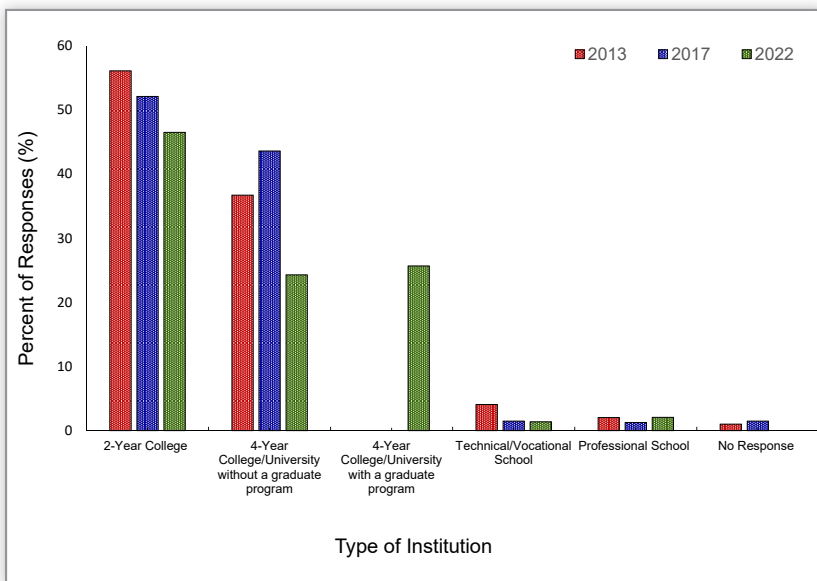


Figure 6. Type of institution employing survey respondents (n=176) to the HAPS 2022 Curriculum and Instruction survey. Respondents employed at more than 1 institution were directed to answer for their primary institution. Where applicable data from the 2013 and 2017 surveys were also included. In the 2013 and 2017 surveys 4-year institutions were not separated into those with a graduate program and those without a graduate program.

	Your average section size	Your number of sections	Your institution's number of sections
A&P I lecture	53.3	2.34	13.6
A&P I lab	32.6	2.68	16.5
A&P II lecture	52.1	2.23	9.42
A&P II lab	31.5	2.58	12.3
Anatomy lecture	93.3	1.93	6.22
Anatomy lab	28.7	3.43	10.5
Physiology lecture	64.3	1.36	3.66
Physiology lab	27.0	2.34	6.53
1 semester, A&P essentials lecture	25.7	0.88	10.2
1 semester, A&P essentials lab	18.9	0.80	16.9

Table 1. Average student enrollment, number of sections per respondent, and number of sections per respondent institution for anatomy and physiology lectures and labs. (n=176; HAPS 2022 Curriculum and Instruction lab survey)

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Combined lecture and laboratory courses with a single course number were the most common for respondents' institutions for A&P I and II, anatomy-only, and physiology-only courses (Figure 7). Less frequently, respondents indicated that lecture and laboratory portions of a course were numbered separately at their institutions, though concurrent enrollment was required. Less than 4% of respondents indicated that lecture and laboratory portions of a course were numbered separately and that there was no requirement for concurrent enrollment. Preparation to enter nursing continued, as compared to the previous surveys, to be the most common reason for students enrolling in A&P courses (Figure 8). Other fields indicated by respondents included kinesiology, allied health, professional adjacent, and professional school programs. Respondents were directed to select all options that apply, and all options except for "other" were selected by more than 60% of respondents from all three surveys.

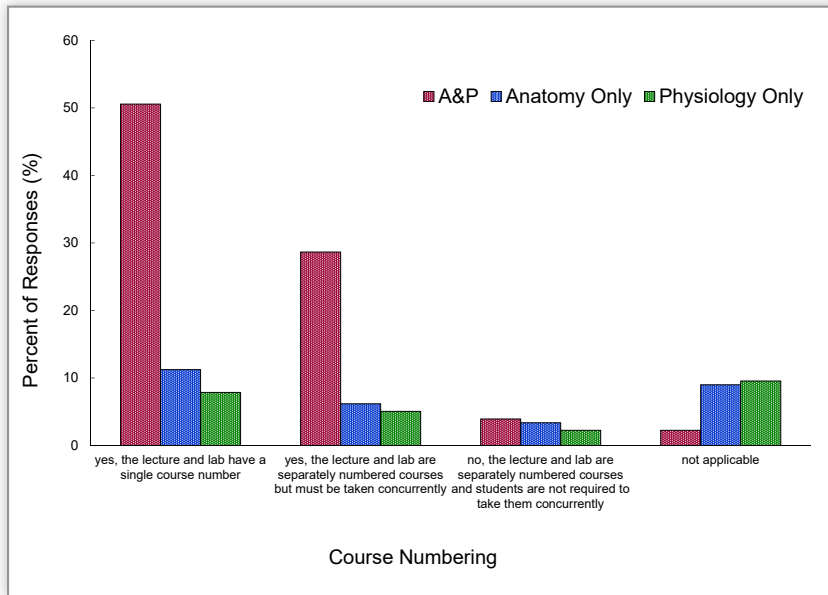


Figure 7. Course numbering and concurrent enrollment specifications for anatomy and physiology lecture and lab courses for respondents (n=176; HAPS 2022 Curriculum and Instruction survey) institutions.

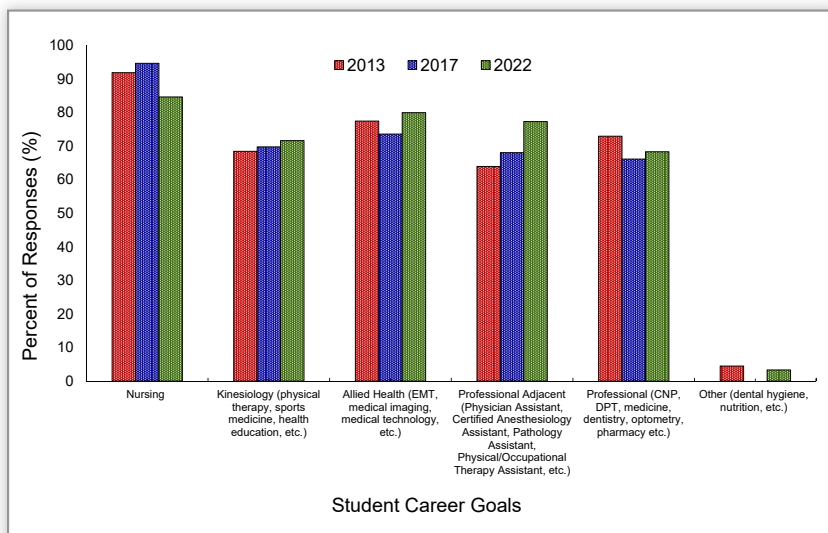


Figure 8. Career goals for students enrolled in the courses most often taught by survey respondents (n=176) to the HAPS 2022 Curriculum and Instruction survey. Respondents were directed to select all answers that apply. Where applicable data from the 2013 and 2017 surveys were also included.

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Respondents were asked to indicate the format of their courses prior to the COVID-19 pandemic. This specification was highlighted in the survey in order to ask questions on pandemic-related changes in instruction in the third portion of the survey. In-person instruction was the most common format for both lecture (Figure 9a) and laboratory (Figure 9b) in A&P I and II, anatomy-only, physiology-only and 1-semester A&P essentials courses. Hybrid instruction was more common for lecture components of courses compared to the laboratories. The only course category where synchronous or asynchronous instruction was prevalent was in the “essentials” courses. Routine use of a HAPS Exam (Human Anatomy & Physiology Society, 2023b) by respondents was uncommon with 3.93% indicating use of the HAPS comprehensive A&P exam while 1.12% used the HAPS comprehensive anatomy only exam, 23.3% had considered using a HAPS exam but did not adopt one, and 65.7% did not use a HAPS exam. No respondent indicated routine use of the HAPS A&P I or A&P II exams.

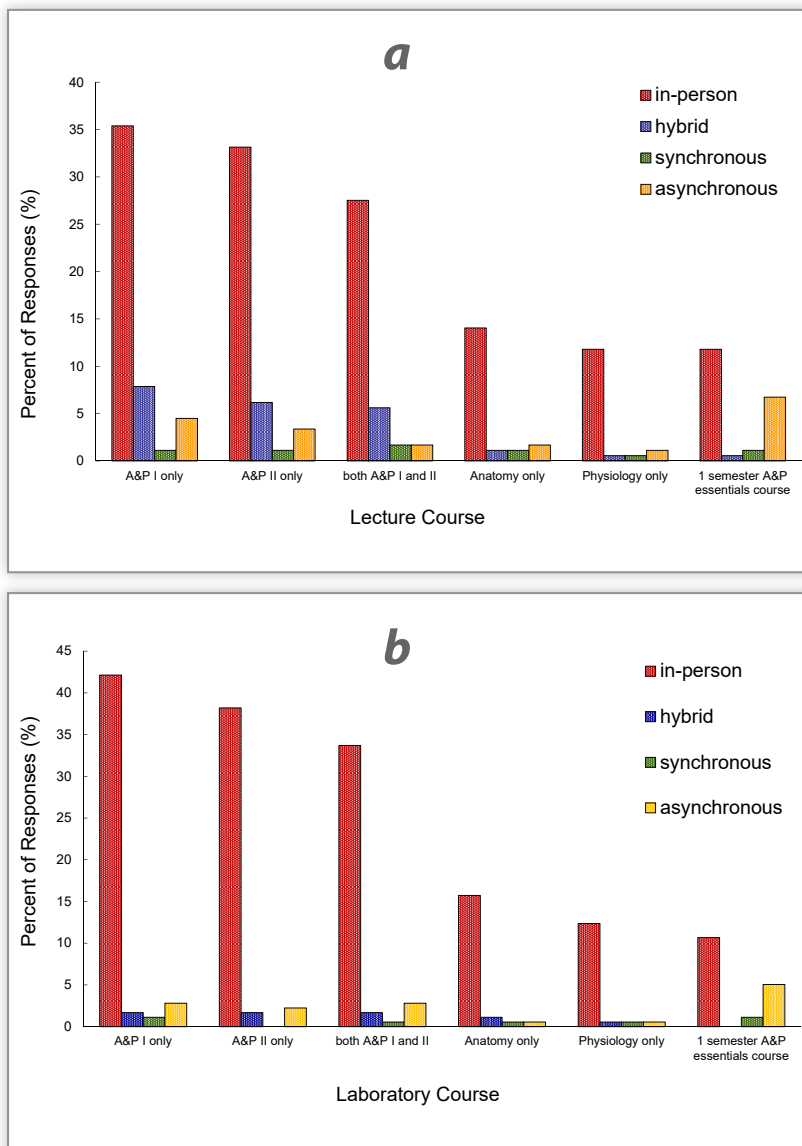


Figure 9. Course instruction formats (pre-COVID) for anatomy and physiology lectures (a) and labs (b) taught by respondents (n=176) to the HAPS 2022 Curriculum and Instruction survey. Respondents were directed to select all answers that apply.

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Sixty-six respondents indicated that their institutions charged lab fees for students enrolling in an A&P I, A&P II, anatomy-only, physiology-only, or a 1-semester A&P essentials course. The average lab fee charged was \$65.62 (USD) with a median charge of \$40 (USD). The minimum lab fee charged was \$5 (USD) with a maximum of \$450 (USD). Lab manuals and lecture textbooks were the most common course resources required by students (and not covered by lab fees) for 52.8% and 42.7% of respondents, respectively (Figure 10). Digital resources and personal lab equipment were less frequently required.

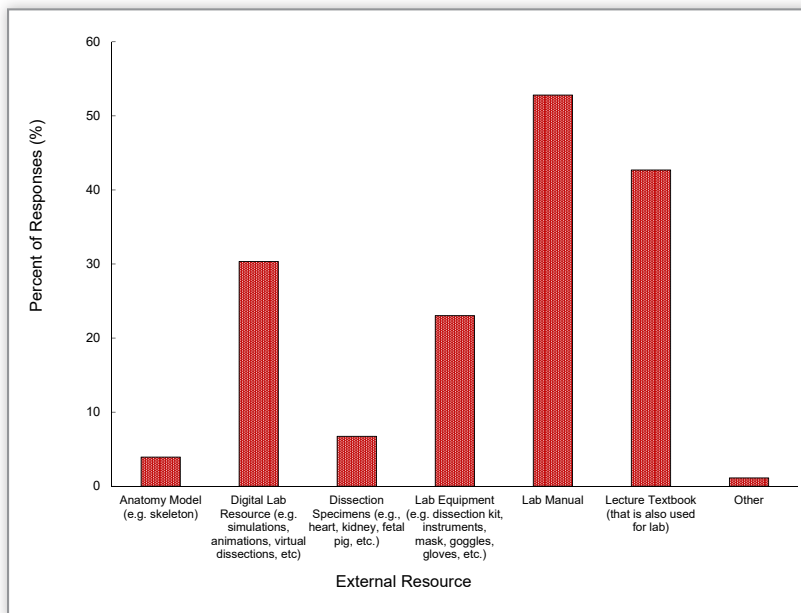


Figure 10. External resources (e.g., not covered by tuition or lab fees) required to be purchased or rented by students for lab activities taught by survey respondents ($n=176$) to the HAPS 2022 Curriculum and Instruction survey. Respondents were directed to select all answers that apply.

Discussion

In comparing the respondent demographics from our current survey with those of 2017 and 2013, there are clear trends that are discernible in addition to several noteworthy differences, both in the responses given and with certain questions included within the previous surveys (Brashinger, 2014a; 2014b; 2017). Although the number of participants was less than in 2017 ($n=567$), there was still a sizable increase of respondents in comparison to the initial survey of 2013 ($n=105$), and a relatively even geographical distribution.

A majority of respondents from all surveys indicated membership in HAPS and at least one other professional society; however, there has been a substantial decrease in American Physiology Society (APS) membership. Anecdotally, one of the subcommittee members (Schmitz) stated that the decrease in educational outreach opportunities by APS was their reason for APS membership non-renewal. The percentage of respondents having earned a terminal degree (e.g., Doctor of Education, PhD, or MD) continued to reveal an upward trend, mirrored by a diminishing number

of respondents with a master's and a considerably smaller percentage of those having a bachelor's or other professional certification as their highest degree or licensure.

Over half of survey participants had taught at their current institution for at least 10 years and nearly one-fifth of respondents had been at their institution for 7-10 years, with a modest increase in those with 10 plus years for the current survey. This is a consistent response across all surveys that signifies the considerable teaching experience of participants, the vast majority of whom (~90%) are presently working at a single institution and considered to be of full-time faculty status. Interestingly, previous surveys suggested that about 80% of respondents had permanent positions. If the question of position renewability had been completely answered on the current survey, there would have been equal numbers of renewable versus non-renewable responses. Future iterations of this question will be revised to clarify the information requested on both employment status (full versus part time) and contract type (renewable vs. non-renewable).

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Responses to a novel question in the 2022 survey regarding job responsibilities indicated that almost 99% of participants focus on teaching for their job duty, but over half also indicated the inclusion of other responsibilities such as service, lab and/or course coordination, academic leadership and research expectations. These results affirm the multiple roles that A&P instructors serve at their respective institutions, both inside and outside the classroom.

There have been several previously published surveys of A&P instruction in recent years (Hopp et al., 2019; Keiner et al., 2014) that revealed important characteristics of instructors; however, their overall respondent demographics were less comprehensive than the HAPS lab surveys of 2013, 2017 and 2022. A number of surveys have been conducted to investigate skeletal muscle coverage in undergraduate anatomy and A&P courses. The Saladin survey (2008) provided informative data on specific skeletal muscles covered in these classes, but without details for respondent demographics. A subsequent skeletal muscle survey by O'Loughlin et al. (2022) and Reynolds et al. (2022) did analyze characteristics of the courses and institutions of respondents, such as geographic location and the type of institution, but focused more on the course demographics and muscle coverage in human anatomy and A&P courses. This survey revealed that the vast majority of respondents taught at institutions within the United States, with 62% of them at a 4-year college or university. This contrasts with the results of each HAPS lab survey, which indicated that the largest single category of responses was from 2-year colleges, although the 2022 survey revealed that collectively 4-year colleges/universities with or without a graduate program comprised nearly one-half of all responses. Subsequent to the muscle survey, a similar study of skeletal system coverage has recently been developed by Aryal and O'Loughlin (2022). This survey will collect demographics on the course format and the type and geographic location of the respondent's institution, although the main focus of this survey pertains to the bones and bone features being taught in undergraduate A&P courses.

Like O'Loughlin and Reynold's muscle survey, a prior study by Hopp et al. (2019) that assessed aspects of teaching assistant use in A&P courses also indicated that the majority of participants were from the United States, most of whom were teaching at either a 2-year community college/technical school or a 4-year public, nonprofit institution. Additionally, Hsu and Halpin (2022) recently published a study exploring the coverage of core concepts by physiology instructors, revealing that a majority of instructors were at research-intensive (R1) or comprehensive (R2) universities, with approximately one-quarter of respondents teaching at small liberal arts or 2-year colleges. This physiology survey also indicated that nearly 60% of participants were full or associate professors, approximately 21% were assistant professors, and the remainder were lecturers, part-time faculty, or occupied other instructor positions. A significant

majority (84%) of respondents for this survey had 5 or more years of teaching experience, which corroborates the results from the HAPS 2022 lab survey that showed that a sizable majority of participants have taught at least 5 years at their current institution, attesting to the considerable teaching experience accrued for many of the respondents.

Relative to previous surveys (Brashner 2014a; 2014b; 2017), the largest change seen in this survey relative to previous surveys was a greater percentage of respondents coming from 4-year institutions both with and without graduate programs. The type of institution employing respondents may influence their responsibilities as well as differences in curricular focus. Even though there has been movement away from stratification of education (difference in expectations of student performance and capability at the 2-year relative to the 4-year college), there is still implicit or overt bias by some towards goals, expectations, and quality of instruction for students at a 2-year versus a 4-year institute. Biases favoring instruction at 4-year institutions can be nullified through appropriate training and implementation of principles of curriculum development [e.g., course blueprinting and backwards design or integration of core concepts as guiding instruction (Coderre et al., 2009; Emory, 2014; Hull et al., 2017; Ismail et al., 2020; McLaughlin et al., 2005; Michael & McFarland, 2020; Patil et al., 2015; Villarroel et al., 2018)]. Yet, those who might have the greatest impact on this bias, tend to have a reduced ability to achieve training using newer fundamentals of educational theories (Hyson 2021).

Institution size varied considerably for our respondents with some of them teaching lectures to classes numbering in the hundreds of students. Within the laboratory, however, there was relative consistency in the class size (~30 students/section). An enrollment cap for laboratory instruction can be seen as a benefit to ensure proper supervision of students for safety purposes (Human Anatomy & Physiology Society, 2018), allow for maximum active participation in laboratory exercises and within groups, and allow for an optimal educational environment for laboratory and experimental based learning (Hofstein & Lunetta, 1982; McComas, 2005).

Prior to March of 2020 (the onset of COVID-19 pandemic modifications), the majority of instruction occurred in-person for both lectures and labs. Yet, there was a greater variety of instructional formats in the presentation of lecture materials relative to laboratory instruction. Responses showed an emphasis on in-person laboratory instruction and the importance of hands-on instruction, regardless of the course, and mirrored what has been previously reported on the topic (Henige, 2011; Hofstein & Lunetta, 1982; McComas, 2005). This emphasis may have led to difficulty in establishing meaningful laboratory instruction in the online environment, something that many experienced at the beginning of the pandemic modifications of 2020-2022 (Davis & Pinedo, 2021; Stokes & Silverthorn, 2021). There

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was less variety in the mode of instruction in anatomy-only and physiology-only courses, relative to A&P (both I and II), along with a higher reliance on the asynchronous mode of instruction in the 1-semester A&P essentials course when delivery of instruction was not in-person. To the latter point, the use of online instruction in the 1-semester course could serve as a model for institutions or instructors seeking to add permanent online courses in A&P, anatomy-only and/or physiology-only, especially given current trends in increased use of distance and online learning in higher education (Harmon et al., 2021; Rowe, 2017; Seaman et al., 2018; Stokes & Silverthorn, 2021).

The current study shows that the primary reason students enrolled in A&P courses continues to be an attraction to a career in nursing. This is in line with the recent findings of the American Association of Colleges of Nursing (2022) that indicated interest in a nursing career as one of the best correlates for student enrollment in these programs. Notably, our survey data also shows an increase in the enrollment of students interested in other kinds of healthcare careers (including allied health, professionally-adjacent, and kinesiology-based careers). This increase in interest may be due (at least in part) to the monetary benefits of any career in healthcare. The US Bureau of Labor Statistics (2022) estimates that the median annual income of healthcare professionals is, on average, \$29,280 higher than the median annual income of all other surveyed professions. This, coupled with the projected 13% growth in jobs in the healthcare industry, seems to indicate that demand for A&P courses will only continue to grow in the coming years.

According to Zippia's Database of over 30 million profiles (2022), there are roughly 6,446 A&P instructors employed in the United States. About 65% of these instructors are over 40 years old while only 13% are under 30. This disparity in demographics highlights a potential challenge in future A&P education: as trained faculty members reach retirement age, the need for newly qualified instructors will increase. In the United States, there are currently only 21 active anatomy doctoral programs, and in recent years, the number of graduates from these programs has declined (Wilson et al., 2021). As the need for well qualified instructors continues to grow, high quality anatomy and physiology-specific training programs may not be able to meet this demand. Many institutions already rely on faculty members directly trained in other fields to teach their A&P courses. Physicians, chiropractors, physical therapists, and biologists with varied backgrounds already instruct these courses in many colleges and universities, and this trend will likely only increase in the coming years. To offset some of this concern and assist institutions in making decisions on qualifications of any individual instructor to teach Anatomy and Physiology, HAPS has provided guidance that can be followed through the accreditation position statement of 2020 (Human Anatomy & Physiology Society, 2020).

Aside from adding new faculty or increasing course sizes, one other possible method of meeting enrollment demands could be an increase in the use of virtual courses. For better or for worse, the COVID-19 pandemic showed that A&P lab courses can be delivered virtually. Studies into the effectiveness of this modality have had mixed results. With regard to first-year medical students, Harrell et al. (2021) found that online students significantly outperformed those who had taken a traditional onsite human anatomical donor-based anatomy lab and posit that their results may be due to increased use of narrated dissection videos, video conferencing, and lab practicums using video clips from multiple perspectives. However, Colthorpe and Ainscough's 2021 analysis of undergraduate student performance in a virtual physiology lab showed significant declines in performance compared to traditional onsite students. Almost half of the virtual undergraduate students in that study indicated that the lack of live sessions hindered their academic progress, although structured learning progressions (including materials that were arranged topically) were very helpful. Feedback about what is and is not effective in the virtual learning environment will be critical to finding ways to use this modality to meet course enrollment demands. Additional insights on teaching A&P during the pandemic will be discussed in the third manuscript to come from the 2022 survey.

Education has always been seen as an opportunity to breach the equality barriers of society, as it offers individuals an opportunity to gain skills and education that can propel their careers and increase their earning power regardless of their prior socioeconomic status. Yet, according to the US Department of Education, "Tuition increases are outpacing the rate of inflation, increases in family income and increases in financial aid" (Boehner & McKeon, 2003). Rising costs, socio-economic status, or first-generation college-student status, can by themselves, or potentially combine with lab and/or course fees, to raise the equality barrier.

The lab is an essential component of A&P curricula and is integral to the understanding of course content. The lab activities provide students with opportunities for hands-on learning, while promoting constructivist approaches to education and inquiry-based learning which strengthens analytical reasoning, critical thinking, and problem-solving skills. College institutions requiring extra lab fees for participation in science courses to offset expensive equipment and educational tools needed for the lab activities should review their practices to see if such fees may bar some students from successful completion of their curriculum. Institutions should be encouraged to re-evaluate and determine whether these added fees are essential to maintain the quality of lab instruction being offered. While this survey did not identify the resources funded by lab fees, such information is needed for institutional re-evaluation as well as future versions of this survey.

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Conclusions

With each iteration of the HAPS lab survey, the breadth and depth of the data obtained have increased. These improvements result from refinements in question presentation and clarification of data needed. Alternatively, the data obtained are negatively impacted when terminology (e.g., employment status) is not consistent across institutions and survey research instruments. Alleviating this impact will require careful question phrasing as well as regular, systematic collection of demographic data by professional societies (e.g., during membership renewal) and researchers.

The third offering of the HAPS Curriculum & Instruction lab survey was delayed by COVID-19 pandemic, but the delay also created the opportunity to characterize instructional practices across a diversity of courses, institutions, and instructors prior to, during, and after the main disruption in 2020 and 2021. These demographic variables are used as comparison factors for analysis and interpretation of data for Part II (lab activities and HAPS learning outcomes/goals) and Part III (impact of a global pandemic on A&P teaching and science instruction in higher education). Parts II and III will be presented in upcoming issues of the *HAPS Educator*.

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Literature Cited

- American Association of Colleges of Nursing. (2022, April 5). *Nursing schools see enrollment increases in entry level programs, signaling strong interest in nursing careers*. <https://www.aacnnursing.org/news-data/all-news/article/nursing-schools-see-enrollment-increases-in-entry-level-programs>
- Aryal, A. & O'Loughlin, V. D. (2022). "What bones and bony features are you teaching your students?" A survey of skeletal system coverage in undergraduate human anatomy and physiology courses. *FASEB Journal* 36(S1). <https://doi.org/10.1096/fasebj.2022.36.S1.R3025>
- Boehner, J.A. & McKeon H.P. (2003). The college cost crisis: A congressional analysis of college costs and implications for America's higher education system. <https://eric.ed.gov/?id=ED479752>
- Brashinger, D. P. (2014a, March 15). *The HAPS laboratory instructor survey: A discussion of the preliminary data* [Conference presentation abstract]. HAPS Eastern Regional Meeting, Springfield, MA, United States. <https://cdn.ymaws.com/www.hapsweb.org/resource/resmgr/Conference/2014EasternRegProgram.pdf>
- Brashinger, D. P. (2014b, May 24-29). *The HAPS laboratory instructor survey: Final results and implications for instruction* [Conference presentation abstract]. Twenty-eighth Annual Conference of the Human Anatomy and Physiology Society, Fort Lauderdale, FL, United States. https://cdn.ymaws.com/www.hapsweb.org/resource/resmgr/Conference/HAPS-2014_Conference_Program.pdf

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- Brashinger, D. P. (2017). Instructional goals and practices in the introductory undergraduate pre-health professions anatomy and physiology laboratory. *HAPS Educator Special Edition*, 4-23. <https://doi.org/10.21692/haps.2017.001>
- Britson, C. A. (2022, February 14). HAPS lab survey 2022. *The HAPS Blog*. <https://hapsblog.org/2022/02/14/haps-lab-survey-2022/>
- Britson, C. A., Hopp, R., Clark, J., Armbruster, H., Kule, C., Anako, C. et al. (2022, May 25-29). *HAPS 2022 Lab Survey* [Conference presentation abstract. Thirty-sixth Annual Conference of the Human Anatomy and Physiology Society, Fort Lauderdale, FL, United States. <https://cdn.ymaws.com/www.hapsweb.org/resource/resmgr/haps2022/haps-2022-fl-program-c.inddr.pdf>
- Coderre, S., Woloschuk, W., & McLaughlin, K. (2009). Twelve tips for blueprinting. *Medical Teacher*, 31(4), 322-324. <https://doi.org/10.1080/01421590802225770>
- Colthorpe, K. & Ainscough, L. (2021). Do-it-yourself physiology labs: Can hands-on laboratory classes be effectively replicated online? *Advances in Physiology Education*, 45(1), 95-102. <https://doi.org/10.1152/advan.00205.2020>
- Davis, C. P. & Pinedo, T. (2021). The challenges of teaching anatomy and physiology laboratory online in the time of COVID-19. *Journal of Microbiology & Biology Education*, 22(1), 1-4. <https://doi.org/10.1128/jmbe.v22i1.2605>
- Emory, J. (2014). Understanding backward design to strengthen curricular models. *Nurse Educator*, 39(3), 122-125. <https://doi.org/10.1097/nne.0000000000000034>
- Harmon, D. J., Attardi, S.M., Barremkala, M., Bentley, D.C., Brown, K.M., Dennis, J.F. et al. (2021). An analysis of anatomy education before and during Covid-19: May–August 2020. *Anatomical Sciences Education*, 14(2), 132–147. <https://doi.org/10.1002/ase.2051>
- Harrell, K. M., McGinn, M. J., Edwards, C. D., Warren Foster K., Meredith M. A. (2021). Crashing from cadaver to computer: Covid-driven crisis-mode pedagogy spawns active online substitute for teaching gross anatomy. *Anatomical Sciences Education*, 14(5), 536-551. <https://doi.org/10.1002/ase.2121>
- Henige, K. (2011). Undergraduate student attitudes and perceptions towards low- and high-level inquiry exercise physiology teaching laboratory experiences. *Advances in Physiology Education* 35(2), 197–205. <https://doi.org/10.1152/advan.00086.2010>
- Hofstein, A., & Lunetta, V. N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. *Review of Educational Research*, 52(2), 201-217. <https://doi.org/10.2307/1170311>
- Hopp, R., Britson, C., Mukhopadhyay, S., Goldina, A., Chapman, M., & Nielsen, M. (2019). Teaching assistants in human anatomy and physiology: Their prevalence, recruitment strategies, funding, retention, and training. *HAPS Educator*, 23(2), 367-384. <https://doi.org/10.21692/haps.2019.015>
- Hsu, J. L. & Halpin, P. A. (2022). Exploring physiology instructors' use of core concepts: Pedagogical factors that influence choice of course topics. *Advances in Physiology Education*, 46(4), 667-676. <https://doi.org/10.1152/advan.00114.2022>
- Hull, K., Jensen, M., Gerrits, R., & Ross, K. T. (2017). Core concepts for anatomy and physiology: A paradigm shift in course and curriculum design. *HAPS Educator*, 21(2), 73-79. <https://doi.org/10.21692/haps.2017.017>
- Human Anatomy & Physiology Society. (2018). *Spotlight on safety*. https://www.hapsweb.org/page/Safety_home
- Human Anatomy & Physiology Society. (2020). *Accreditation Position Statement*. https://www.hapsweb.org/page/Accreditation_2020
- Human Anatomy & Physiology Society. (2023a). *HAPS regions*. <https://www.hapsweb.org/page/MapofHAPSRegions>
- Human Anatomy & Physiology Society. (2023b). *A&P I and A&P II exams*. <https://www.hapsweb.org/page/AP1and2Exam>
- Hyson, A. R., Bonham, B., Hood, S., Deutschman, M. C., Seithers, L. C., Hull, K., & Jensen, M. (2021). Professional development, shifting perspectives, and instructional change among community college anatomy and physiology instructors. *CBE Life Sciences Education*, 20(3), ar49,1-ar49,13. <https://doi.org/10.1187/cbe.21-02-0037>
- Ismail, M. A-A., Mat Pa M. N., Mohammad, J. A-M., Yusoff M. S. B. (2020). Seven steps to construct an assessment blueprint: A practical guide. *Education in Medicine Journal*, 12(1), 71–80. <https://doi.org/10.21315/eimj2020.12.1.8>
- Keiner, Y. C., McMahon, K., Schmidt, N., Jones, W. K., Olubadewo, J., Stout, S. et al. (2014). Accidents and injuries in the human A&P laboratory: A survey by the HAPS safety committee. *HAPS Educator*, 18 (Summer), 26-28.
- McComas, W. (2005). Laboratory instruction in the service of science teaching and learning: reinventing and reinvigorating the laboratory experience. *The Science Teacher*, 72(7), 24-29.
- McLaughlin, K., Coderre, S., Woloschuk, W., Lim, T., Muruve, D., & Mandin, H. (2005). The influence of objectives, learning experiences and examination blueprint on medical students' exam preparation. *BMC Medical Education*, 5, Article e39. <https://doi.org/10.1186/1472-6920-5-39>

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- Michael, J. & McFarland, J. (2020). Another look at the core concepts of physiology: revisions and resources. *Advances in Physiology Education*, 44(4), 752–762. <https://doi.org/10.1152/advan.00114.2020>
- O'Loughlin, V. D., Reynolds, A. M., Goodwin, M. E. (2022). Skeletal muscle coverage in undergraduate courses: A comparison of stand-alone human anatomy and anatomy and physiology (A&P) courses. *Advances in Physiology Education*, 46(3), 400–415. <https://doi.org/10.1152/advan.00038.2022>
- Patil, S. Y., Gosavi, M., Bannur, H. B., & Ratnakar, A. (2015). Blueprinting in assessment: A tool to increase the validity of undergraduate written examinations in pathology. *International Journal of Applied Basic Medical Research*, 5(Suppl 1), S76–S79. <https://doi.org/10.4103/2229-516x.162286>
- Reynolds, A. M., Goodwin, M. E., O'Loughlin, V. D. (2022). General trends in skeletal muscle coverage in undergraduate human anatomy and anatomy & physiology courses. *Advances in Physiology Education*, 46(2), 309–318. <https://doi.org/10.1152/advan.00084.2021>
- Rowe, R. J, Koban, L., Davidoff, A. J., & Thompson, K. H. (2017). Efficacy of online laboratory science courses. *Journal of Formative Design in Learning*, 2, 56–67. <https://doi.org/10.1007/s41686-017-0014-0>
- Saladin, K. S. (2008). How many muscles do you teach? A survey of HAPS-L readers. *HAPS Educator*, 13 (Fall), 10–13.
- Seaman, J. E., Allen, I.E., & Seaman, J. (2018). Grade increase: Tracking distance education in the United States. Babson Survey Research Group, Released under a Creative Commons Attribution-ShareAlike 4.0 International license. <http://www.onlinelearningsurvey.com/highered.html>
- Stokes, J. A., & Silverthorn, D. U. (2021). Updating anatomy and physiology lab delivery: Shifting from a paper-based to an online lab instruction platform, just in time for a global pandemic. *Advances in Physiology Education*, 45(2), 290–298. <https://doi.org/10.1152/advan.00190.2020>
- US Bureau of Labor Statistics. 2022. Healthcare occupations. In U.S. Bureau of Labor Statistics (Eds.), *Occupational outlook handbook*. <https://www.bls.gov/ooh/healthcare/home.htm>
- Villarroel, V., Bloxham, S., Bruna, D., Bruna, C., Herrera-Seda, C. (2018). Authentic assessment: creating a blueprint for course design. *Assessment & Evaluation in Higher Education*, 43(5), 840–854. <https://doi.org/10.1080/02602938.2017.1412396>
- Wilson, A. B., Kaza, N., Singpurwalla, D.J., & Brooks, W. S. (2021). Are anatomy PhDs nearing extinction or adapting to change? United States graduate education trends in the anatomical sciences. *Anatomical Sciences Education*, 14(4), 432–439. <https://doi.org/10.1002/ase.2013>
- Zippia The Career Expert. (2022). Anatomy professor demographics and statistics in the US. <https://www.zippia.com/anatomy-and-physiology-instructor-jobs/demographics/>



HAPS Curriculum & Instruction 2022 Laboratory Survey: Laboratory Activities and Learning Outcomes

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Abstract

In early 2022, the Human Anatomy & Physiology Society (HAPS) Curriculum & Instruction Lab Survey subcommittee launched the third survey of instructors for introductory undergraduate-level courses in human anatomy and physiology. This manuscript presents analyses of questions regarding the laboratory activities and learning outcomes (LOs) section of the survey and compares results to the first (2014) and second (2017) offerings of the lab survey. Laboratory instruction continues to be a valued component of anatomy and physiology instruction, although a greater variety of resources are now being used. New questions on curriculum development revealed that respondents utilize many techniques and resources to develop their curricula, though respondents at 2-year institutions report significantly lower levels of influence on their A&P curricula compared to respondents at 4-year institutions. Identification of anatomical structure LOs appeared to be prioritized over LOs for each structure's physiological role. Dissections, plastic model manipulations, use of human subjects for physiological experiments, and use of computer simulations have remained stable across all three surveys, although use of anatomical donors and computer simulations have increased over time. Collectively, we observed respondents developing intentional, outcome-directed changes to laboratory instruction while also being limited by historical practices at their institutions. Results also indicated that the COVID-19 pandemic has increased the speed at which instructors are making long-term curricular changes. <https://doi.org/10.21692/haps.2023.018>

Key words: anatomy, physiology, education, survey, learning outcomes, laboratory activities, COVID-19

Introduction

Science courses, such as Anatomy and Physiology (A&P), are unique because they require the development of coordinated lecture and lab activities to meet a cohesive set of learning objectives or outcomes (LOs) and goals spanning the duality of lecture and lab components of the course (Beck & Roosa, 2020; Hurtt & Bryant, 2016; McComas,

2005; Peacock et al., 2020). Specifically, several papers have identified the significance of laboratory education for helping students meet expectations of their undergraduate education (Finn et al., 2019; Griff, 2016; Henige, 2011; Hofstein & Lunetta, 1982; McComas, 2005). This significance is coupled with the acknowledged importance of A&P in the curriculum

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of healthcare professionals (Brown et al., 2017; Cheung et al., 2021), and may be the key to building student interest in learning A&P content (Casotti et al., 2008; Griff, 2016; Peacock et al., 2020; Pollock, 2022).

Instructors and curriculum designers with appropriate training and professional development opportunities can easily develop a laboratory curriculum to meet learning goals and objectives at a single campus (Hyson et al., 2021). However, designing laboratory curricula to align across multiple campuses (e.g., within a state's community college system or branch campuses of a single institution) can be more challenging, particularly when there may be little support for professional development opportunities and instructional philosophies vary across institutions. The Human Anatomy and Physiology Society (HAPS) has previously reported on efforts to document alignment among faculty toward a select few common learning goals in A&P courses (Brashinger, 2017).

To further assist in the commonality of educational goals, members of the Curriculum and Instruction Committee of HAPS undertook efforts in 1992 to codify a set of learning goals and outcomes that would be regularly updated, and that instructors at any institute of higher education could use to develop curricula that promote student success in A&P (Human Anatomy & Physiology Society, 2019). This effort aligned with those from other educators and researchers developing commonalities for teaching topics related to anatomical structures, common themes across topics, and the overall role of the laboratory experience in A&P instruction (Griff, 2016; Hull et al., 2017; Michael & McFarland, 2020). Together, these efforts indicate a desire to have a generalized guide on the essential components of an undergraduate A&P laboratory course, curricular objectives, and key activities. The goals from a generalized guide, however, can only be achieved when an individual instructor's ability to teach and instill a desire for learning the content are coupled with the students' intrinsic desire to learn (Finn et al., 2019; Hurtt & Bryant, 2016; Hyson et al., 2021).

Student-focused and outcome-driven education requires that students are prioritized along with learning activities designed to reach the desired outcomes. According to Whetten (2007), we are in the midst of an unfolding paradigm shift in higher education, from focusing on teaching to focusing on learning. One form of the learner-centered method of curriculum design is backward design which requires that educators determine what outcomes they want students to achieve and then carefully design the curriculum to include evidence-based course activities that allow them to work toward meeting the predetermined goals. In the backward design approach, attention is focused on the learner in the instructional design process, with the end-goal being deep understanding and lasting change (Tornwall, 2017). For backward design to be effective, educators must identify desired results, analyze multiple

sources of data, and determine an appropriate action plan (McTighe & Thomas, 2003). Backward design also helps educators strategically plan activities that match learning outcomes to competency requirements and ensures that student knowledge reflects current practice (Maldonado, 2022). Additionally, backward design increases faculty accountability and relies on instructors to select assignments that measure student ability to meet learning objectives rather than solely assessing content knowledge (Martin et al., 2019).

The role of the educator within an institution can affect their academic freedom and ability to influence the curriculum. In a decentralized model of course design, the individual instructor is responsible for the design, update, and revision of the courses they teach whereas in a centralized course design model, a single set of course materials imposed at the college, department, or program level is used (Felber, 2021). In the centralized model, full-time faculty are responsible for determining course objectives, developing the curriculum and course materials, as well as updating the courses, while adjunct faculty members are limited to teaching the designed courses. Whereas full-time faculty members are usually salaried tenure or non-tenure track faculty hired by the institution, adjunct faculty members are employed on an as-needed basis and are expected to teach without the added responsibility of curriculum development, committee work, and scholarship. Part-time faculty might also be unable to participate in institutional activities, governance, student advising, curriculum development, and course content (Moorehead et al., 2015).

It is not always clear what should be used as the marker for a student's success, and this can even be more challenging in A&P courses where successful completion of the course(s) with a specific grade is required for entrance into multiple professional degree programs. In the past, a degree used to be indicative of a level of knowledge and intellectual ability as well as a passport to employment, but that may no longer be the case due to organizational changes and increased numbers of graduates (McPhee & D'Esposito, 2018). As such, success is now measured based on the ability of students to secure gainful employment *after* graduation. Assessments should therefore confirm students' learning **and** their ability to meet requirements necessary for employment. Increased administrative interest in assessments that compare student success rates across institutions has also resulted in increasing federal pressure on colleges to demonstrate their effectiveness (Braun, 2019). The individual A&P educator must weigh all these concerns and evaluate potential success by utilizing a combination of formative and summative assessments to determine student understanding of course content and achievement of learning objectives (Braun, 2019).

One way to achieve this goal is by careful selection and implementation of learning activities that will help students successfully master content knowledge and the skills

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necessary for excellence as healthcare professionals (Beck & Roosa, 2020; Brown et al., 2017; Casotti et al., 2008; McComas, 2005; McDaniel & Daday, 2017; Peacock et al., 2020; Zarifnejad et al., 2018). This effort starts by evaluating and including activities and techniques that seem ubiquitously used or have been shown to effectively build skills, foster student engagement, and improve mastery of A&P content (Beck & Roosa, 2020; Brashinger, 2017; Brown et al., 2017; Hurtt & Bryant, 2016; Peacock et al., 2020; Pollock, 2022; Price, 2020). Evaluation should also include the expectations for learning by the students, along with an examination of access to technologies within and outside the classroom (Cheung et al., 2021; Harrison et al., 2001; McDaniel & Daday, 2017; Persinger et al., 2021; Pollock, 2022; Stokes & Silverthorn, 2021). The latter point is essentially important given the implications of changing educational settings following the haphazard responses in public health to the COVID-19 pandemic of March 2020 through present day (Harmon et al., 2021; Stokes & Silverthorn, 2021).

Once activities have been identified, the next step is alignment of the lab curriculum with learning goals, objectives, and outcomes. This fundamental approach to course design is similar to what is seen in elementary and secondary education (Beck & Roosa, 2020; Griff, 2016; Hurtt & Bryant, 2016). This approach may be limited, however, without the professional development necessary to ensure proper alignment and control of curriculum development, or lack of student buy-in to the educational experience (Beck & Roosa, 2020; Finn et al., 2019; Hurtt & Bryant, 2016; Hyson et al., 2021; Peacock et al., 2020; Persinger et al., 2021; Pollock, 2022).

Alignment of learning outcomes, activities, and assessments is considered best practice in instructional design (Dick et al., 2001; Gronlund & Brookhart, 2009; Krathwohl, 2002). As such, we intend to evaluate what changes have occurred over the last decade in the development and alignment of undergraduate anatomy and physiology laboratory curricula. We will also assess how these changes have modified educational practices for the instructor and the institution, the selection of specific learning outcomes, and the choices of activities that students utilize to meet these goals within the laboratory portion of undergraduate anatomy, physiology, and A&P courses.

Materials and Methods

The second part of the HAPS 2022 lab survey contained 19 questions and focused on the learning outcomes, laboratory activities, and resources used by educators. Five of these questions were repeated from the 2013 (Brashinger, 2014a; 2014b) and 2017 (Brashinger, 2017) HAPS lab surveys, and one question new to the 2017 survey was repeated. The 2022 HAPS lab survey obtained Institutional Review Board EXEMPT status under 45 CFR 46.101(b) (#2) by The University of Mississippi's Institutional Review Board (IRB, Protocol

#22x-129) in January 2022, and was open for responses from February to August 2022, with the primary period of volunteer respondent recruitment occurring in February, March, and May (Britson et al., 2023). Full details of survey development and revisions are presented in Britson et al. (2023).

Specific courses of interest were expanded, as compared to the two previous surveys (Brashinger, 2014a; 2014b; 2017), to include laboratory instruction for human A&P essentials (1 semester); human A&P I and II (2 semester sequence); human anatomy only (1 semester); human physiology only (1 semester); and histology (1 semester). New questions were developed to focus not only on *what* activities and assessments are used in the laboratory but also *why* we use them. Questions exploring the identification, development, alignment, and selection of laboratory learning outcomes were asked as well as identification of how much influence individual educators have over the activities, assessments, and outcomes used in the courses they teach.

Questions asking about resources used in the laboratory were revised to remove reference to brand names or specific vendors and to add a description of the resource. This revision will benefit readers by removing the potential for bias for or against a brand or vendor and will enable the questions to be used in future surveys without the need for revision. New questions were also added to examine how the practical skill of identifying anatomical structures (Human Anatomy & Physiology Society, 2019) was assessed through the use of laboratory practical examinations. Since responses to part 1 (demographics) of the 2022 lab survey (Britson et al., 2023) are linked to parts 2 (activities and learning outcomes) and 3 (instruction during the COVID-19 pandemic) by respondent, we were also able to compare responses about lab activities and learning outcomes to demographic data. Frequency data and descriptive statistics were calculated for all survey questions. All statistical tests (e.g., t-tests, ANOVAs) were conducted using SPSSV27 software licensed to the University of Mississippi.

Results

There was a total of 176 responses to this survey (Britson et al., 2023), 105 responses to the 2013 survey (Brashinger 2014b), and 567 responses to the 2017 survey (Brashinger 2017).

Laboratory Priorities and Purposes

While there appeared to be a decrease in certainty about the stability of the future importance or prevalence of laboratory activities as compared to previous survey responses (Figure 1), there was no significant difference between the frequency of responses from 2017 and 2022 ($t = 4.9 \times 10^{-16}$; $df = 3$; $p = 3.182$). Frequency values for the 2022 response "unsure" were not entered into the paired, two-tailed t-test as it was not a response option in 2017. Respondents viewed

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laboratory curriculum and activities as essential to meet educational requirements for their program or degree (Table 1). Moreover, there was a general trend wherein laboratory activities and curriculum were seen by respondents as an essential avenue to allow for kinesthetic learning and to provide a means to excite students about topics related to anatomy and physiology. A majority of respondents saw laboratory activities as a means to expose students to a diversity of viewpoints and to new information as well as

an avenue to support the development of critical thinking skills, along with reinforcing information covered in the lecture component of the A&P course (Table 2), particularly the interrelationship of structure and function. There was limited agreement on laboratory activities being essential for developing other skills necessary for the future goals of many students (i.e., ability to work in groups, understanding the clinical application of information, developing skills for scientific investigation).

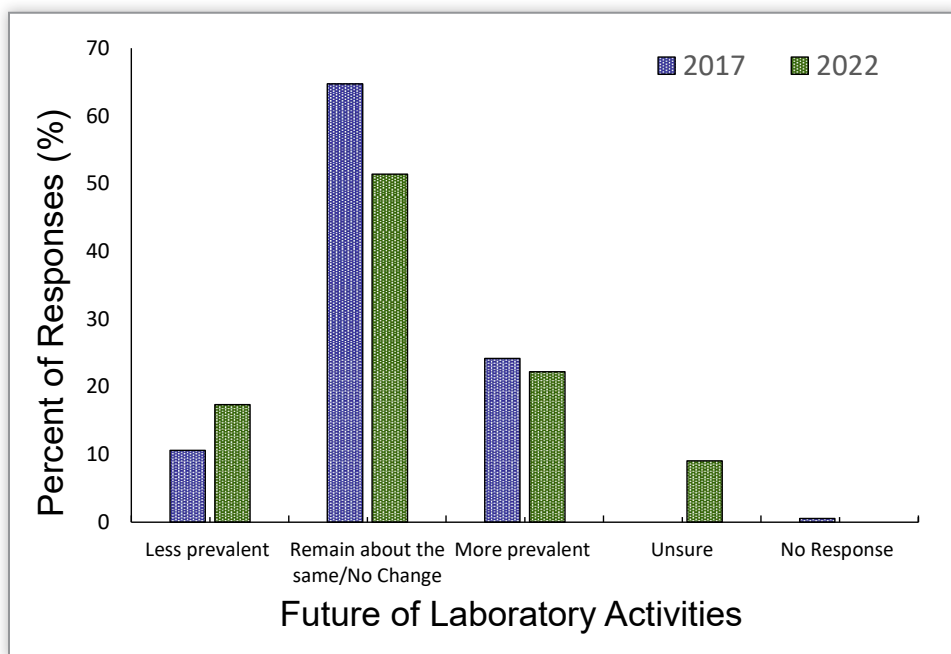


Figure 1. Percent of survey responses from 2017 and 2022 when asked to choose the option that best answers the following question: Given the financial, space, and other priorities at your institution, do you expect in-person anatomy and physiology laboratory activities to become more or less prevalent in the next ten years?

	Not a purpose of the lab experience	Has a purpose, but not essential to the lab experience	Absolutely essential to the lab experience
Meet program objectives/requirements	2 (1.12)	31 (17.4)	132 (74.2)
Meet degree objectives/requirements	7 (3.93)	47 (26.4)	111 (62.4)
Meet transfer objectives/requirements	29 (16.3)	48 (27.0)	85 (47.8)
Engage with students (e.g., student-instructor interactions)	4 (2.25)	33 (18.6)	127 (71.3)
Student engagement and student-student interactions	1 (0.56)	37 (20.8)	126 (70.8)
Excite students about A&P	4 (2.25)	56 (31.5)	102 (57.3)
Provide Tactile/kinesthetic learning opportunities	2 (1.12)	25 (14.0)	137 (77.0)
Expose students to new information or viewpoints	14 (7.87)	65 (36.5)	85 (47.8)

Table 1. Frequency and percent of total responses (in parentheses) to the following survey question: “Using the scale provided, please rate your impression of the following PURPOSES of the A&P Laboratory experience.”

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	Not a purpose of the lab experience	Has a purpose, but not essential to the lab experience	Absolutely essential to the lab experience
Develop critical thinking skills	1 (0.56)	42 (23.6)	123 (69.1)
Develop scientific inquiry skills	8 (4.49)	72 (40.5)	85 (47.8)
Develop scientific laboratory skills	15 (8.43)	65 (36.5)	84 (47.2)
Develop literature research skills	75 (42.1)	70 (39.3)	20 (11.2)
Learn new content prior to lecture	44 (24.7)	81 (45.5)	38 (21.4)
Reinforce understanding of lecture content	0 (0)	27 (15.2)	138 (77.5)
Understand the interaction of structure and function	1 (0.56)	25 (14.0)	138 (14.0)
Understand the clinical application of information	12 (6.74)	85 (47.8)	66 (37.1)
Develop "soft skills" and ability to work in groups	5 (2.80)	73 (41.0)	87 (48.9)

Table 2. Frequency and percent of total responses (in parentheses) to the following survey question: "Using the scale provided, please rate your impression of the following PRIORITIES of the A&P Laboratory experience."

Laboratory Curriculum Development

A majority of the respondents indicated they are using a more holistic approach to developing a laboratory curriculum based on learning objectives that focus on a combination of backward design and course blueprinting along with specification grading (Figure 2). Additionally, a majority of the respondents indicated having at least some influence on the development of the curriculum at their institution (Figure 3). At the same time, a minority of respondents (10%) indicated that the curriculum and learning outcomes/objectives are given to them to follow, while another subset of the respondents indicated that there are no curriculum learning outcomes for laboratory education around which they could plan a curriculum.

A majority of respondents indicated that learning objectives used for developing the laboratory curriculum came from within the department (25%) or the institution (32%; Figure 4). There was no significant difference in the level of influence on learning outcomes ($F = 2.059$; $df = 6,157$; $p = 0.061$) due to job status (e.g., full-time, part-time, permanent, etc.), but there was a significant difference in the level of influence on learning outcomes ($F = 4.852$; $df = 4,159$; $p < 0.001$) due to institution type (e.g., 2-year institution, 4-year institution, etc.). Respondents at 2-year institutions reported a significantly lower level of influence as compared to respondents at 4-year institutions with or without a graduate program.

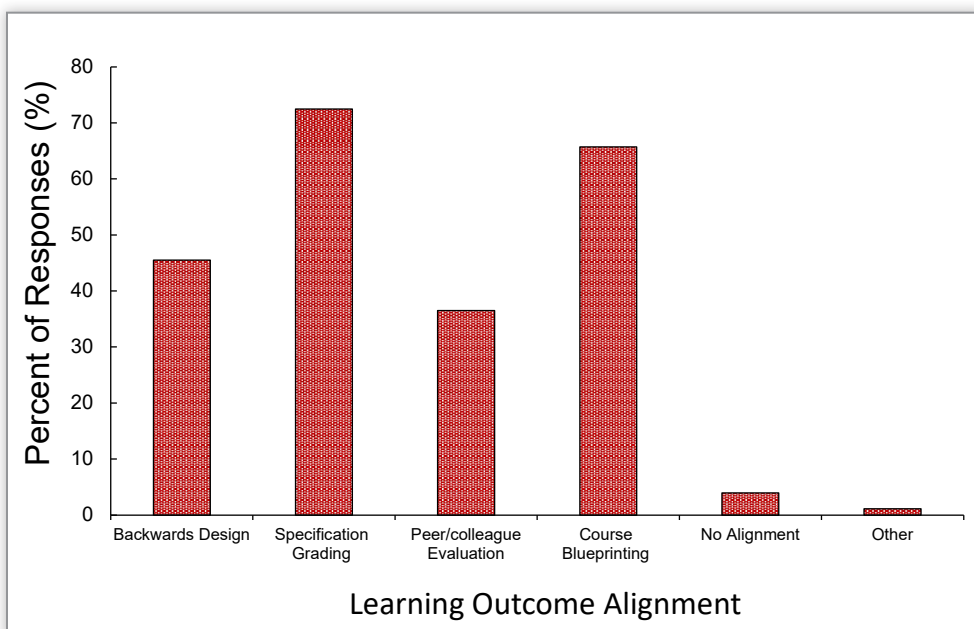


Figure 2. Percent responses to the question, "How do you align the purposes and priorities listed with your laboratory learning outcomes? SELECT ALL THAT APPLY." Backward Design refers to designing a curriculum by setting goals before choosing instructional methods and assessments. Specification Grading is when students are able to repeatedly attempt assignment/assessment until a recognized standard has been achieved. Course Blueprinting refers to holistic mapping of all aspects of teaching and learning for a course.

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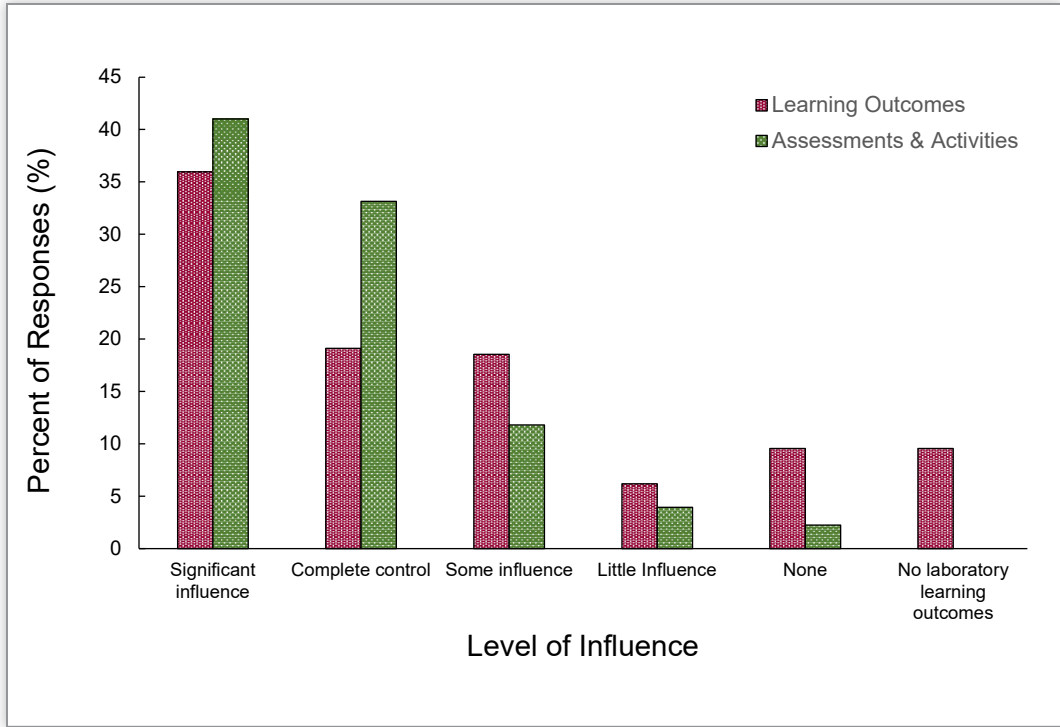


Figure 3. Percent of survey responses for how much influence respondents have over the learning outcomes and activities and assessments in their course. For Significant Influence, respondents generate the learning outcomes, activities, and assessments but receive assistance and contributions from others. Complete Control refers to respondents' control over the learning outcomes, activities, and assessments. In Some Influence, respondents contribute to the development of the learning outcomes, activities, and assessments. In Little Influence, respondents contribute at a minimal level to the development of the learning outcomes, activities, and assessments.

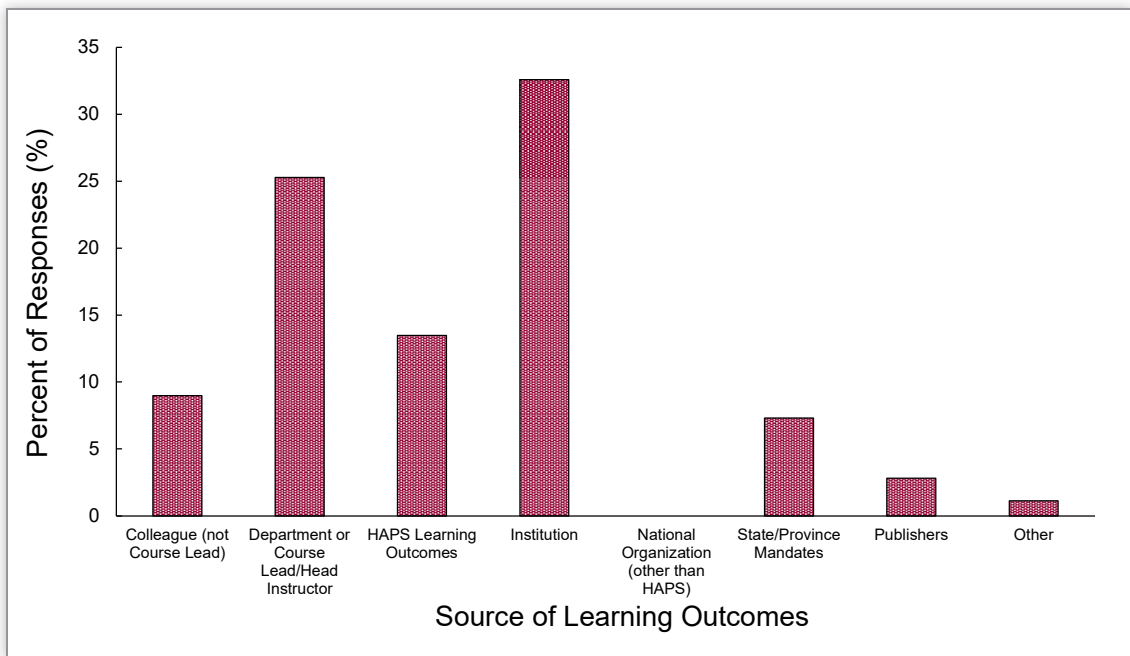


Figure 4. Percent of survey responses to the question, "If your course's laboratory learning outcomes are provided to you, where do they come from? SELECT ALL THAT APPLY." Institution may refer to a single institution or group under a single administrative structure.

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As seen in Table 3, the primary focus of the laboratory curriculum appears to be oriented toward HAPS learning goals 1 and 3, use of appropriate terminology, and identification of structures and functions, respectively. There is a lesser emphasis on explaining how systems maintain homeostasis, recognizing patterns of unification across

systems, and applying knowledge to real world situations, HAPS learning goals 4, 8 and 7, respectively, with the least important goal appearing to be the ability to apply literacy skills to evaluate peer-reviewed resources (HAPS learning goal 10).

	Not Important	Somewhat Important	Important	Very Important and Essential
Use appropriate terminology to discuss anatomy and physiology.	1 (0.56)	6 (3.37)	20 (11.2)	133 (74.7)
Use appropriate laboratory tools and techniques to examine anatomical structures or physiological functions.	9 (5.06)	33 (18.5)	54 (30.3)	68 (38.2)
Identify anatomical structures and describe the complex interrelationships between structure and function.	3 (1.68)	4 (2.25)	27 (15.2)	127 (71.3)
Explain how body systems work together to maintain homeostasis.	6 (3.37)	21 (11.8)	44 (24.7)	86 (48.3)
Explain how variability in the human population produces ranges of values considered "normal" for body parameters.	24 (13.48)	44 (24.7)	64 (36.0)	30 (16.9)
Propose evidence-based hypotheses to explain physiological responses or the functions of anatomical structures.	27 (15.2)	58 (32.6)	43 (24.157)	32 (18.0)
Apply knowledge of anatomy and physiology to real-world situations.	5 (2.81)	31 (17.4)	58 (32.6)	65 (36.5)
Recognize and apply patterns that unify, organize, and simplify the abundant detail of anatomy and physiology.	5 (2.81)	33 (18.5)	58 (32.6)	63 (35.4)
Interpret and draw appropriate conclusions from graphical and other representations of data.	18 (10.1)	44 (24.7)	55 (31.0)	41 (23.0)
Apply information literacy skills to access and evaluate peer-reviewed resources.	56 (31.5)	54 (30.3)	32 (18.0)	17 (9.55)
Approach and examine anatomy and physiology issues from an evidence-based perspective.	29 (16.3)	44 (24.7)	57 (32.0)	29 (16.3)
Adapt information to effectively communicate with different audiences.	38 (21.4)	45 (25.3)	39 (21.9)	37 (20.8)
Recognize that our individual differences (ethnicity, gender, culture, etc.) shape our understanding of anatomy and physiology.	27 (15.2)	51 (28.7)	48 (27.0)	34 (19.1)
Foster respect for individuals across differences within educational and professional settings.	19 (10.7)	32 (18.0)	48 (26.966)	63 (35.4)

Table 3. Frequency and percent of total responses (in parentheses) to the following survey question: "How important are each of the following HAPS Learning Goals to the development of your lab curriculum and learning outcomes?"

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Additionally, there are distinct differences in the incorporation of learning objectives between those focused on anatomy and structural identification (Table 4) and those focused on physiology and homeostatic regulation (Table 5). There appears to be a greater emphasis being placed on identification of structures over the physiological role or its association to homeostasis within the laboratory curriculum.

	Incorporated and summatively assessed in lab	Incorporated but only formatively assessed	Incorporated, but not assessed in lab	Not incorporated nor assessed in lab
Use of appropriate anatomical terminology (Module A)	124 (69.7)	13 (7.30)	7 (3.93)	12 (6.74)
Histology (Cytology) (Module C, 7, 10; Module D)	117 (65.7)	14 (7.87)	5 (2.81)	19 (10.7)
Integument (Module E. 2, 3, 4)	102 (57.3)	19 (10.7)	10 (5.62)	21 (11.8)
Skeletal (Module F. 2, 3, 6, 7, 8)	126 (70.8)	13 (7.30)	1 (0.56)	13 (7.30)
Skeletal Muscle (Module G. 3, 7, 8, 9, 10)	126 (70.8)	14 (7.30)	1 (0.56)	13 (7.30)
Nervous System (Module H. 2, 3, 10, 11, 12, 13, 15, 16; Module I. 3, 4, 5, 6, 7)	124 (69.7)	15 (8.43)	1 (0.56)	13 (0.56)
Cardiovascular (Module K. 2, 6, 12, 13)	127 (71.4)	11 (6.18)	1 (0.56)	13 (7.30)
Lymphatic (Module L. 3)	78 (43.8)	22 (12.4)	8 (4.49)	42 (23.6)
Respiratory (Module M. 2)	123 (69.1)	14 (7.87)	2 (1.12)	13 (7.30)
Digestive (Module N. 1, 2, 3, 4, 5, 6, 7, 8, 9,10)	121 (68.0)	15 (8.43)	2 (1.12)	14 (7.87)
Urinary (Module P. 2, 3)	125 (70.2)	11 (6.18)	2 (1.12)	14 (7.87)
Reproductive (Module R. 2, 3, 6)	110 (62.0)	22 (12.4)	5 (2.81)	14 (7.87)

Table 4. Frequency and percent of total responses (in parentheses) to the following survey question: "Indicate the incorporation and assessment of HAPS Learning Outcomes for anatomical identification of STRUCTURE AND FUNCTION that are generally associated with the development of laboratory curriculum that you are currently using."

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	Incorporated and summatively assessed in lab	Incorporated but only formatively assessed	Incorporated but not assessed in lab	Not incorporated nor assessed in lab
Osmosis & Tonicity (Module C, 8)	56 (31.5)	21 (11.8)	16 (8.99)	55 (30.9)
Muscle Contraction & Strength (Module G. 5, 6, 8, 9)	52 (29.2)	26 (14.6)	27 (15.2)	43 (15.2)
EMG activity of muscle contraction (Module G. 4, 6)	32 (18.0)	21 (11.8)	23 (12.9)	70 (39.3)
Nerve Conduction Velocity (Module H. 7)	20 (11.2)	16 (8.99)	26 (14.6)	81 (45.5)
Tendon Reflex Response (Module H. 14, 15)	39 (21.9)	34 (19.1)	25 (14.0)	49 (27.5)
Reaction to external stimulus (Module H. 14, 15, 16; Module I. 2)	34 (19.1)	35 (19.7)	25 (14.0)	50 (14.0)
Processing of sensory information (cranial nerve/ special sense tests) (Module I. 4, 5, 6, 8, 9)	59 (33.2)	28 (15.7)	26 (14.6)	33 (18.5)
Heart Rate responses & ECG (Module K. 9, 10, 11)	84 (47.2)	27 (15.2)	12 (6.74)	24 (13.5)
Blood Typing Results (Module K. 5)	97 (54.5)	17 (9.55)	6 (3.37)	26 (14.6)
Blood Pressure Measurements (Module K. 10, 15)	82 (46.1)	28 (15.7)	15 (8.43)	21 (11.8)
Spirometer Measurements (Module M. 4)	77 (11.8)	26 (14.6)	18 (10.1)	26 (14.6)
Digestive Enzyme Activity (Module M. 12)	48 (27.0)	20 (11.2)	16 (8.99)	59 (33.2)
Urinalysis Results (Module P. 4, 8; Module Q 2, 6)	71 (39.9)	24 (13.5)	15 (8.43)	33 (18.5)
Heredity and Reproduction (Module S. 2, 3)	33 (18.5)	16 (8.99)	23 (12.9)	73 (41.0)

Table 5. Frequency and percent of total responses (in parentheses) to the following survey question: "Indicate the incorporation and assessment of HAPS Learning Outcomes for interpretation of *PHYSIOLOGICAL PROCESSES* that are generally associated with the development of laboratory curriculum that you are currently using."

Laboratory Activities

In a question that was new to the 2022 survey, the most common resources used for laboratory instruction for courses that were offered online prior to the COVID-19 pandemic were computer simulations and lab kits (Figure 5). Kits were either designed by the institution or available commercially. Questions that were asked on all three iterations of the HAPS lab survey assessed the use of resources for laboratory instruction in histology, anatomy, and physiology. While there were no statistically significant

changes in the frequency of responses across the three surveys ($F = 0.155$; $df = 2,14$; $p = 0.857$), there were notable outcomes. For the first time in the 2022 survey, digital imagery was used more frequently than glass slides in optical microscopy (Figure 6). Computer-based microscopy simulations (e.g., virtual slide boxes) were used more frequently in the 2022 survey than in 2013 or 2017. Though decreasing in use, optical microscopy and print images continued to be common.

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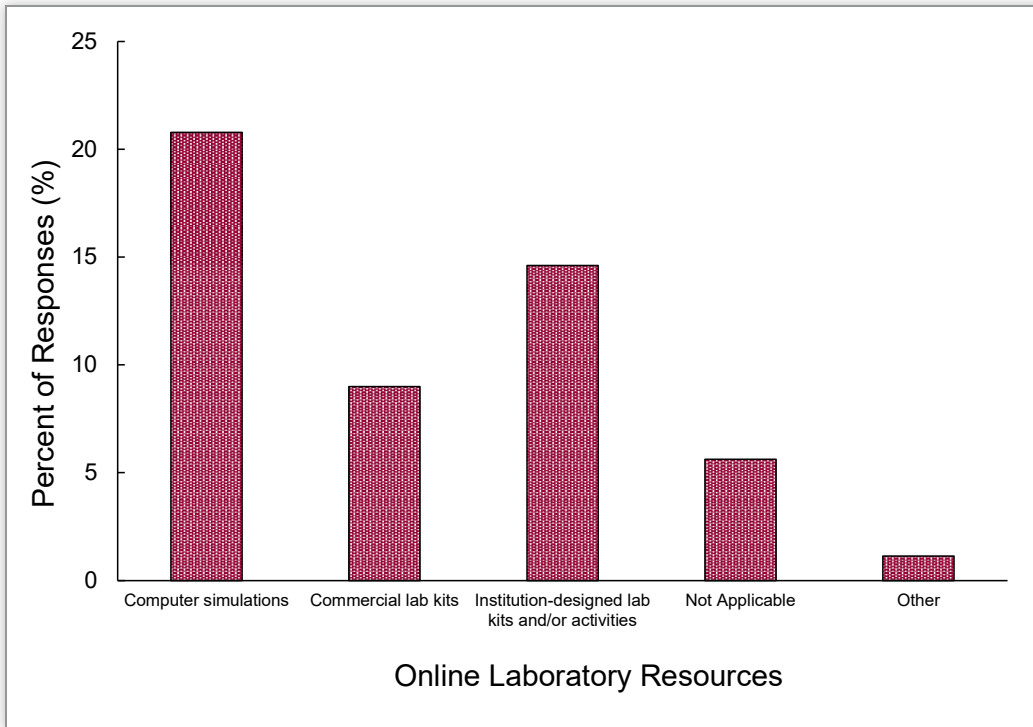


Figure 5. Resources used for online laboratory instruction for courses that were online before the COVID-19 pandemic.

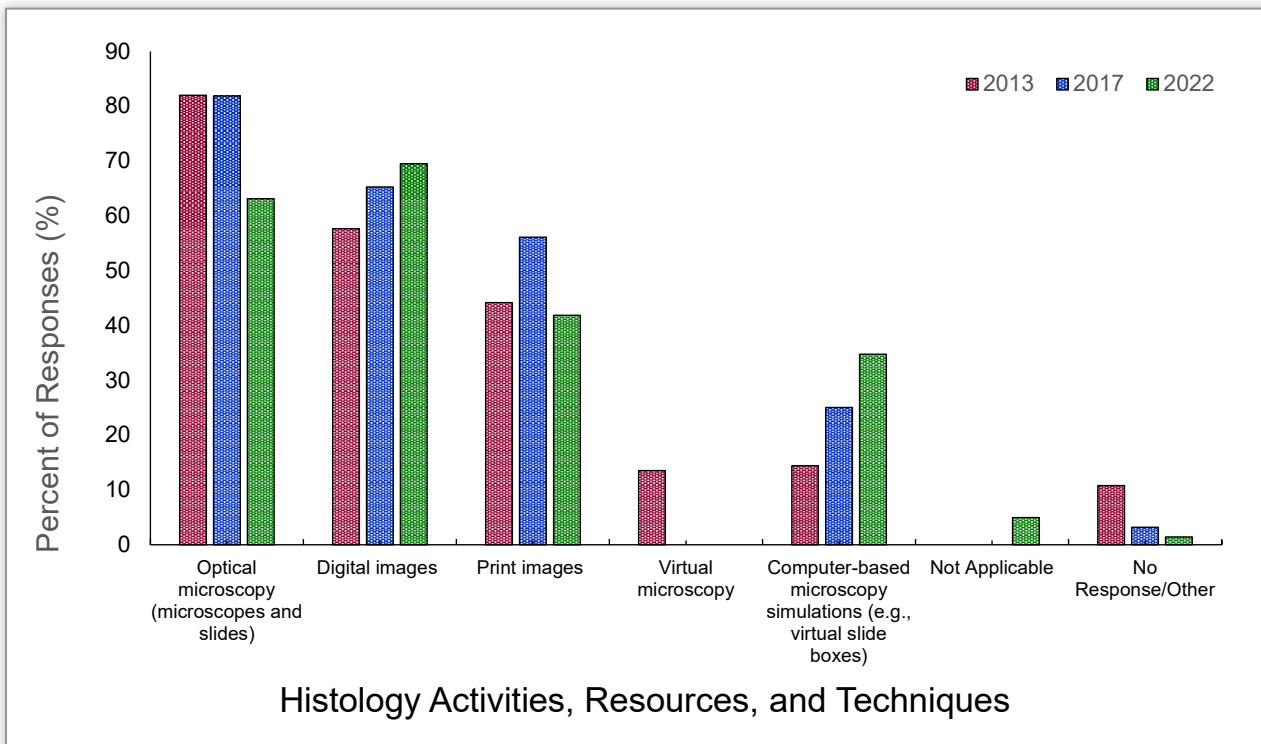


Figure 6. Activities, resources, and techniques used in the laboratory for the study of histology across three iterations of the HAPS laboratory survey (2013, 2017, and 2022).

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Preserved organ and preserved whole animal dissections continued to be the most common dissections performed in laboratories across all three surveys (Figure 7). There were no statistically significant changes in the frequency of responses across the three surveys ($F = 0.034$; $df = 2,15$; $p = 0.966$), but use of computer-based dissection has increased in each year the survey has been administered. Organs most commonly used for dissection included the brain, eye, heart, and kidney. Use of these four animal organs was the most frequent across all three surveys, and there were no statistically significant changes in the frequency of responses across the three surveys ($F = 0.457$; $df = 2,35$; $p = 0.636$; Figure 8).

Resources used for human dissection were variable across all three surveys, with anatomical donor dissection increasing from 7.2% and 7.4% in 2013 and 2017, respectively, and to 27.6% in 2022 (Figure 9), though there were no statistically significant changes in the frequency of responses across the three surveys ($F = 0.36$; $df = 2,13$; $p = 0.703$). Use of human subjects for blood pressure and cardiac function measurements and human tissue (e.g., cheek cells, blood) for physiological experiments decreased from 2013 to 2022, while use of computer simulations was at its highest level in the 2022 survey (Figure 10), but these changes were also not statistically significant ($F = 0.009$; $df = 2,20$; $p = 0.99$).

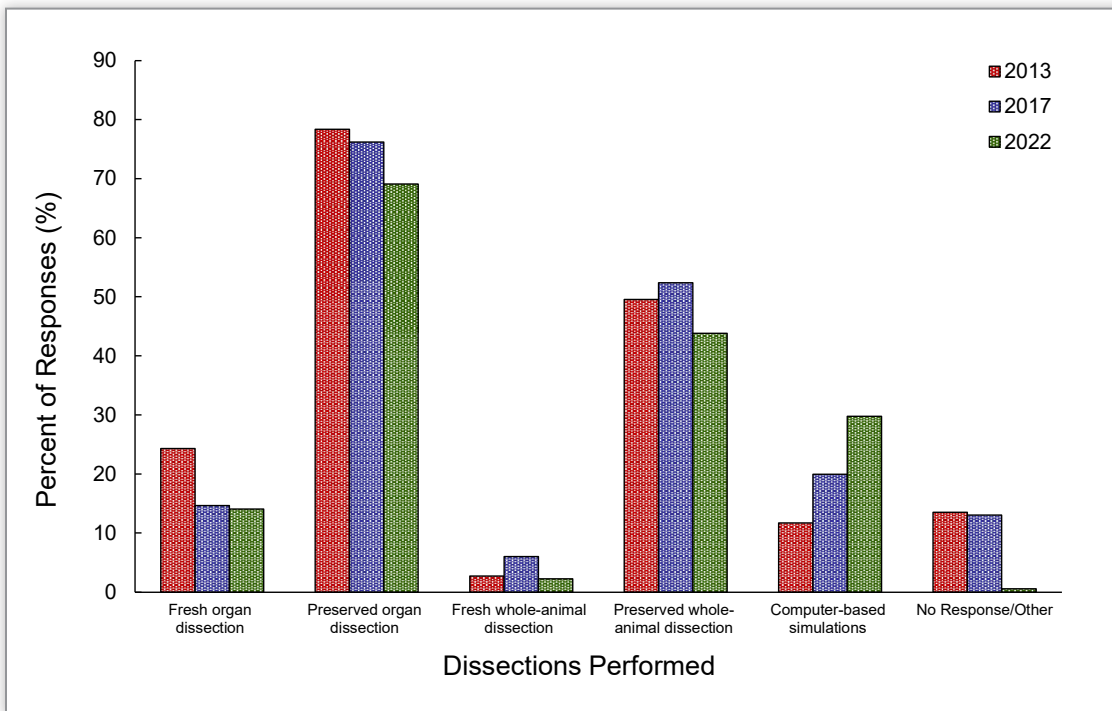


Figure 7. Type of dissections performed in the laboratory across three iterations of the HAPS laboratory survey (2013, 2017, and 2022).

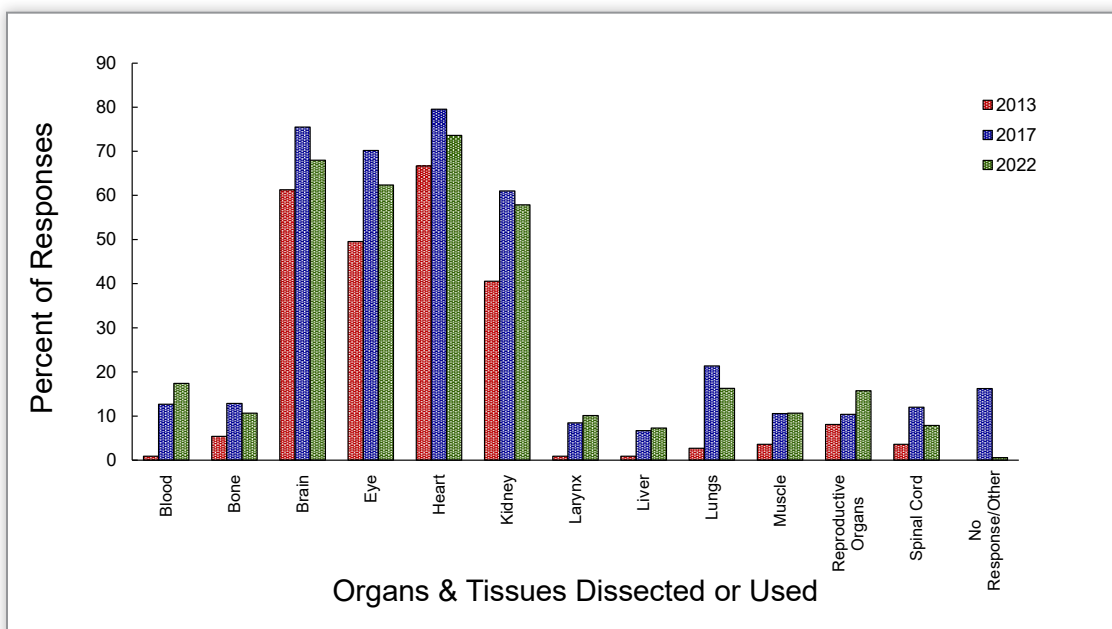


Figure 8. Organ dissection or tissue use in the laboratory across three iterations of the HAPS laboratory survey (2013, 2017, and 2022).

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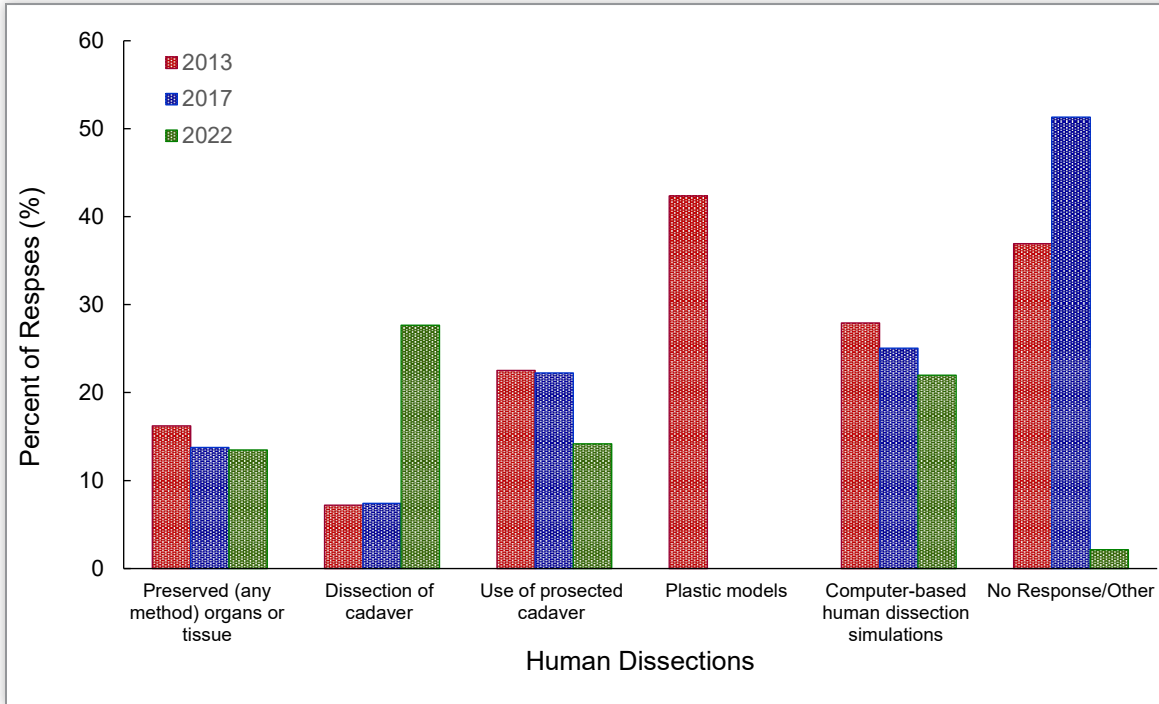


Figure 9. Resources used to study or conduct human dissection in the laboratory across three iterations of the HAPS laboratory survey (2013, 2017, and 2022).

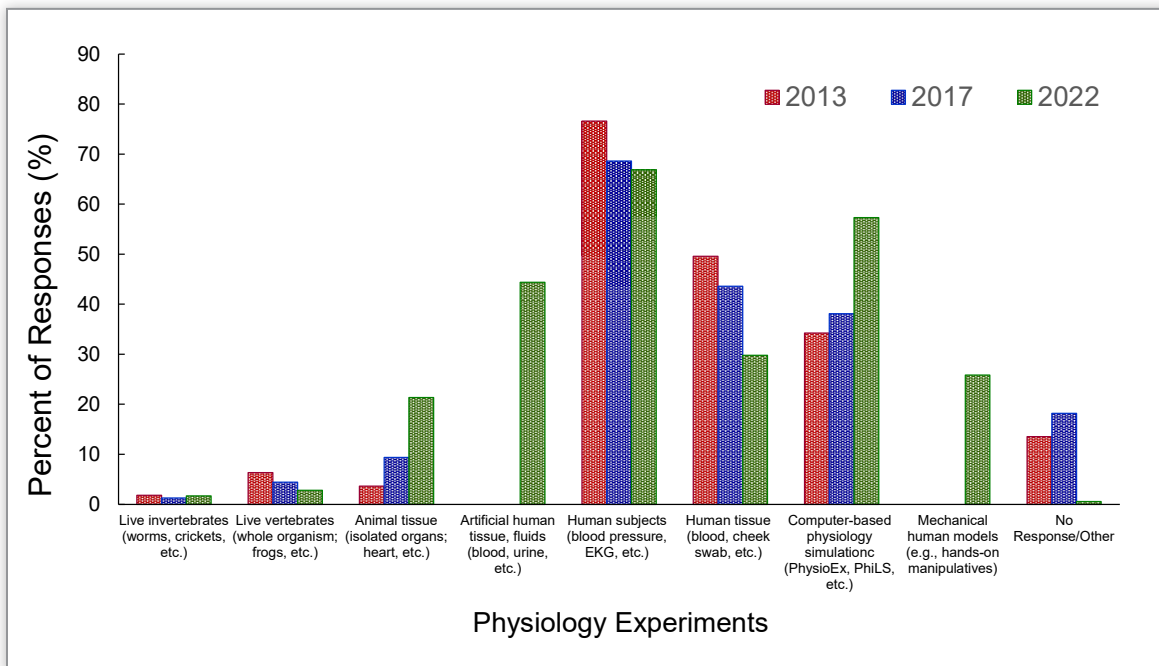


Figure 10. Resources used to study or conduct physiological experiments in the laboratory across three iterations of the HAPS laboratory survey (2013, 2017, and 2022).

Laboratory Assessments

Most respondents reported having complete (33.1%) or a significant level (41%) of control over the selection of assessments for laboratory activities (Figure 3). These values were similar to the frequency of respondents having significant or complete influence on the selection of learning outcomes for the laboratory as described earlier in the Results section. There was no significant difference in the level of influence for selecting lab activities and assessments

($F = 1.539$; $df = 6,156$; $p = 0.169$) due to job status (e.g., full-time, part-time, permanent, etc.), nor was there a significant difference in the level of influence for selecting laboratory activities and assessments ($F = 1.442$; $df = 4,158$; $p = 0.223$) due to institution type (e.g., 2-year institution, 4-year institution, etc.).

Publisher-provided content, use of Bloom’s taxonomy, and course blueprinting methods (holistic mapping of all aspects of teaching and learning for a course) were the

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most frequently used resources for developing laboratory assessments (Table 6). Laboratory practicals (74.7%), individual assessments (written quizzes or exams, 73.5%), and pre- and post-lab assessments (quizzes or exams; 57.3%) were those used most frequently by survey participants (Figure 11). A variety of resources were used for administering laboratory practicals, with plastic models and bones as the

most common (78.6%, Figure 12). Cumulative testing on multiple modules/body systems, where each assessment included questions on all content from the beginning of the course, and question stations, where students walked around the laboratory to complete the practical, were the most common methods for administering laboratory practicals at 85.9% and 79.7%, respectively (Figure 13).

Publisher-provided materials and reference Bloom’s taxonomy levels provided for assessment questions	61 (34.3)
Course Blueprinting methods (holistic mapping of all aspects of teaching and learning for a course) to develop assessments	37 (20.8)
Specification Grading (students are able to repeatedly attempt assignment/assessment until a recognized standard has been achieved) to develop assessments	28 (15.7)
Backward Design methods (designing a curriculum by setting goals before choosing instructional methods and assessments) to develop assessments	28 (15.7)
I don’t follow a specific method in developing lab assessments and primarily focus assessments on recall and identification	35 (19.7)
I don’t determine assessments; they are provided to me	13 (7.3)
Other	3 (1.69)

Table 6. Frequency and percent of total responses (in parentheses) to the following survey question: “Please complete the following sentence “I utilize _____.” to tell us how you DEVELOP ASSESSMENTS used in your anatomy and physiology lab curriculum. SELECT ALL THAT APPLY.”

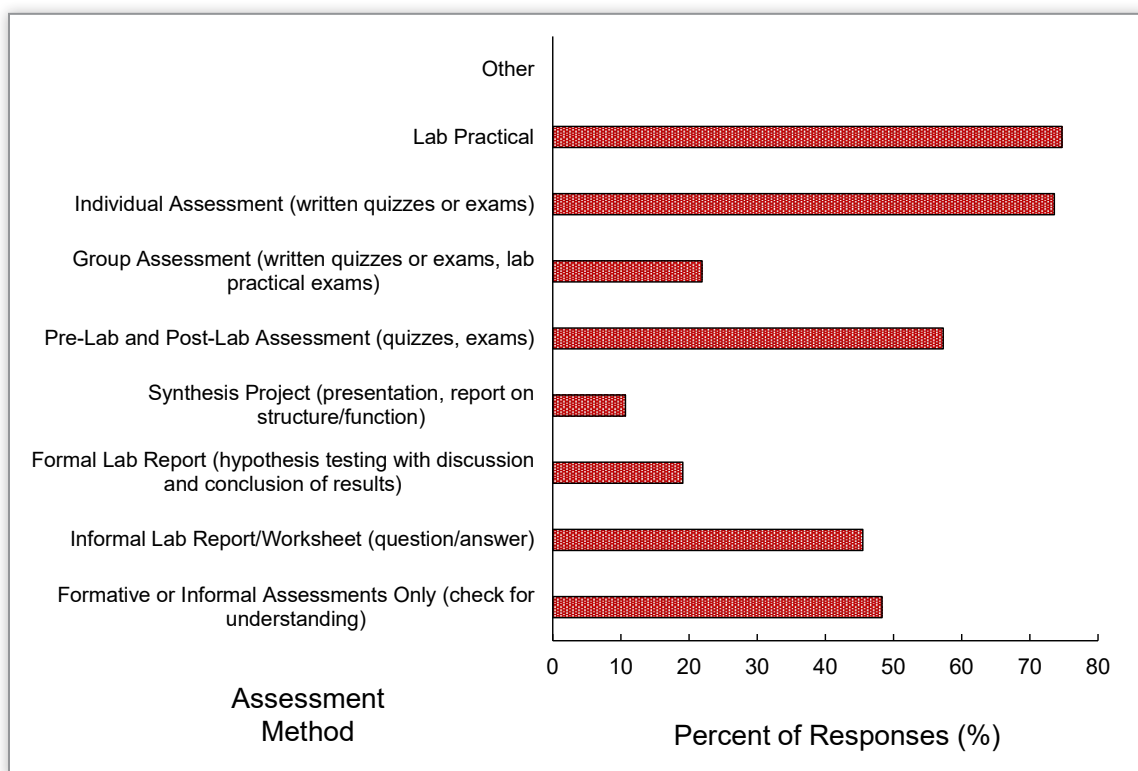


Figure 11. Types of assessments used in laboratory instruction of anatomy and physiology.

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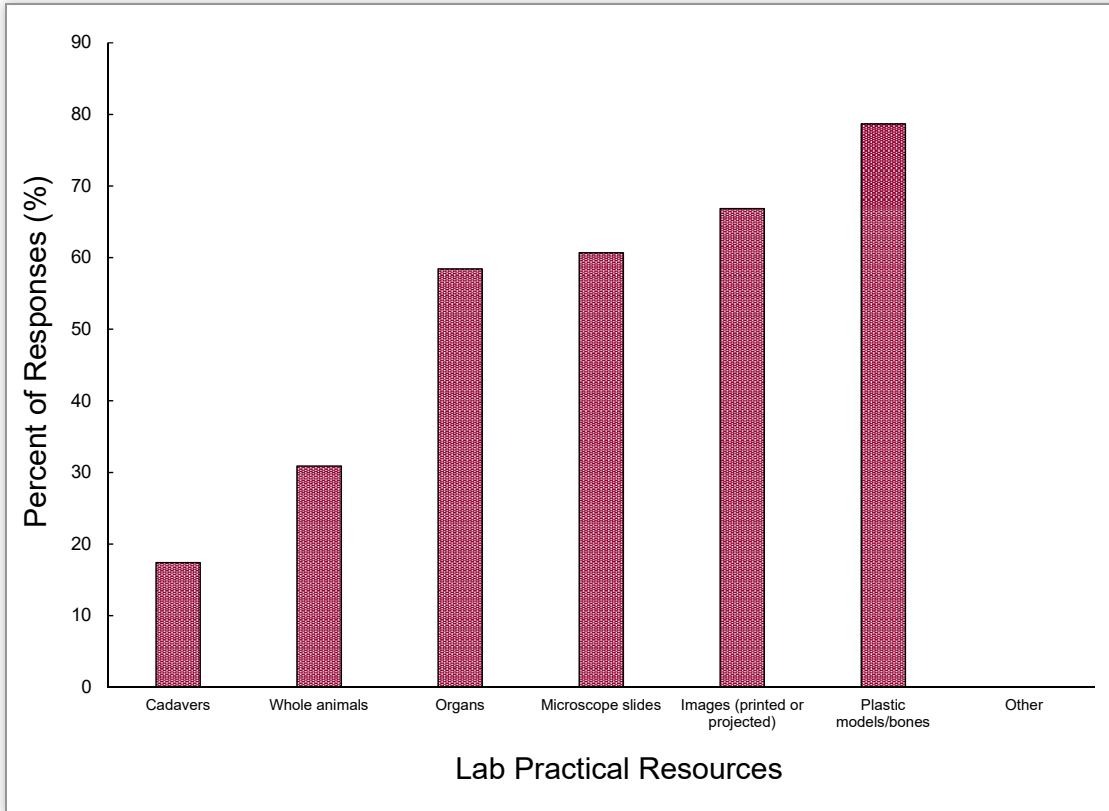


Figure 12. Resources used in the administration of laboratory practical examinations in anatomy and physiology.

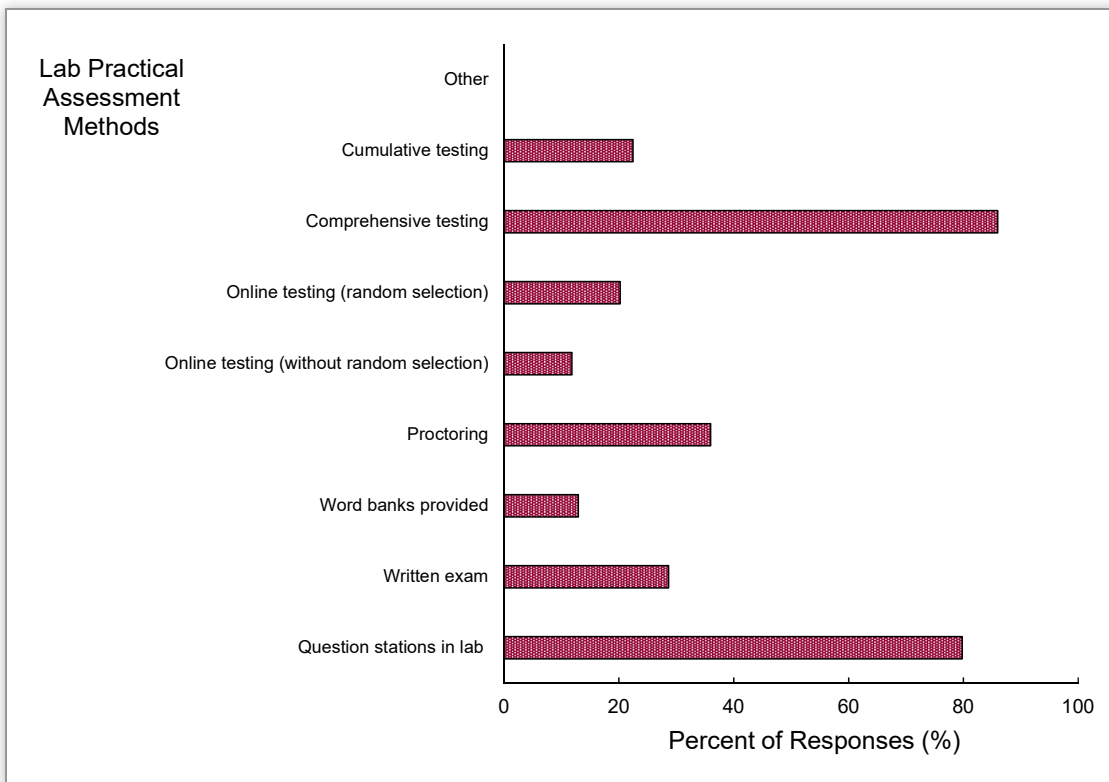


Figure 13. Methods of assessment for laboratory practical examinations in anatomy and physiology.

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Discussion

Recent trends in curriculum development have incorporated the educational approaches of backward design and course blueprinting (Coderre et al., 2009; McLaughlin et al., 2005; Patil et al., 2015). In backward design lessons are focused on the learning objectives of the course that in turn allow for course blueprinting [e.g., mapping each LO to a specific activity and assessment and incorporating the difficulty of the assessment for weighted calculation of a student's grade and improved student success (Beck & Roosa, 2020; Behrendt et al., 2020; Villarroel et al., 2018; Whetten, 2007)]. This trend is often partnered with an increased chance for students to experience authentic learning activities and assessments that provide multiple avenues for better retention of content (Behrendt et al., 2020; Casotti et al., 2008; Finn et al., 2019; Henige, 2011; Hurtt & Bryant 2016; Villarroel et al., 2018). As educators, including these authentic learning experiences is inherent to our laboratory curriculum, meaning that A&P education should provide students with the appropriate educational environment to meet this new trend in educational priorities (Beck & Roosa, 2020; Brashinger, 2017; McComas, 2005). Furthermore, when A&P instructors utilize clearly defined and explained expectations (e.g., goals and LOs) following a backward design or blueprinting (Coderre et al., 2009; McLaughlin et al., 2005; Patil et al., 2015) form of curriculum development, students are provided even greater opportunities to show growth and gain the success expected of them in both understanding content knowledge **and** applying that knowledge through measurable skill development (Beck & Roosa, 2020; Davis & Autin, 2020; Griff, 2011; White & Maguire, 2021).

To meet this desired outcome in curriculum development, either within an individual course or across aligned courses, instructors need some control over how they incorporate LOs and how they allow students to demonstrate they have met a particular LO (i.e., assessments). Most respondents indicated that they have this level of control solely for themselves, or by extension, through their institution or department. With this control over intended goals and LOs, instructors (individually or in collaboration with colleagues within their department) are able to develop a learning environment that allows students to master and apply content knowledge through skills development to meet the laboratory LOs appropriate for the course [i.e., A&P I, A&P II, anatomy-only, physiology-only, 1-semester A&P (Beck & Roosa, 2020; Davis & Autin, 2020; Emory, 2014, Griff, 2016; Ismail, 2020; Maldonado, 2022; Villarroel, 2018; White & Maguire, 2021)].

Survey responses indicated that this pattern of control is more common for instructors at 4-year colleges or universities versus 2-year institutions. One may be tempted to speculate that this difference is driven by the educational expectations of instructors and directives of the distinct institutions, or worse an implicit bias of tiered higher-educational experience (e.g., 4-year institutions

are perceived as higher quality than 2-year institutions, etc.). It is more likely, however, to be an artifact of the demographics of respondents (Britson et al., 2023) and the propensity to have multiple instructors, of varying backgrounds and pedagogical expertise, teaching multiple sections of common courses (i.e., A&P I, A&P II, anatomy-only, physiology-only, 1-semester A&P) at, and across, 2-year college campuses necessitating a more extensive and collaborative approach to overall curriculum development (Felber, 2021; Hyson et al., 2021; Whetten, 2007). Moreover, there can be requirements for curricular alignment enabling easy transfer of credit hours (Whinnery & Peisach, 2022) or a common course numbering system at 2-year colleges relative to the 4-year colleges or universities, leading to a greater acceptance for insight and input into LO and curriculum development in the higher-education environment. These requirements may necessitate utilization of common course LOs that individual A&P instructors must integrate within their curriculum to ensure each of the various sections of the common course offer similar learning opportunities. These requirements for alignment must be balanced with ensuring instructors are given the professional and academic freedom to teach the content they see as most appropriate. This balance appears to be viable because once LOs are selected for curriculum alignment, almost 75% of survey respondents have a significant or a complete level of freedom to select assessments for the laboratory activities used.

In formulating curricula, instructors strategically plan learning activities that develop competencies to ensure student knowledge reflects what is currently understood to be true (Maldonado, 2022). This approach allows for integration and utilization of identified content standards (i.e., core concepts and HAPS LOs) into the laboratory curricula for A&P courses (i.e., A&P I, A&P II, anatomy-only, physiology-only, 1-semester A&P) and guides individual lessons (Human Anatomy & Physiology Society, 2019; Hill et al., 2017; Hull et al., 2017; Michael & McFarland, 2020). This emphasis toward core concepts and standardized LOs can be coupled with a focus on meeting HAPS Learning Goals (Human Anatomy & Physiology Society, 2020). Within this line of thought, we saw a common perspective among respondents in which selection of goals and priorities for curricular development moved toward a more holistic approach to teaching both anatomy and physiology components within the laboratory curriculum. This perspective also allows instructors to maximize time and effort on conferring knowledge while simultaneously exciting students about human anatomy and physiology.

To excite students about human anatomy and physiology and their A&P courses, instructors must move from using the laboratory learning environment for reinforcing lecture content to other educational outcomes and skills that might stem from the laboratory environment in a science-based course (Casotti, 2008; McComas, 2005). Simply reinforcing

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content may create an implicit bias in students that lecture is more important to their learning than laboratory experiences. To counter this perception, instructors should overtly emphasize the value of laboratory experiences for providing students with alternative modes of learning such as kinesthetic activities, scientific experimentation, and increased interactions with peers and the instructor. Complementing traditional lecture modes of learning (e.g., think-pair-share) with these types of laboratory experiences and clear expectations and understanding of learning goals promotes more authentic learning which improves retention (Behrendt, 2020; Henige, 2011; Hurtt & Bryan, 2016; McComas, 2005), resilience, and internal motivation for continued education in students, particularly for those who have expressed a fear of failure (DeCastella et al., 2013; Finn et al., 2019; Vaughn et al., 2021).

Coupled with this desire to promote retention of terminology and understanding the interrelationship of structure and function, respondents expressed that the priorities and purposes of their laboratory curriculum placed a greater focus on providing students with more opportunities to meet the anatomy-focused LOs versus physiology-focused LOs and/or LOs based on problem-solving, critical thinking, or homeostatic regulation. This greater emphasis in the laboratory curriculum on identifying structures preferentially to physiological roles and the association of those roles to homeostasis should prompt us to reflect on whether the purposes of our laboratory curricula benefit the students by allowing them to maximize their potential for understanding the human body. A possible rationale for this discrepancy in the lab curricular focus may be related to the need to have students identify structures and build their vocabulary to explain their understanding, as shown in Table 3 and 4. This emphasis encourages students to acquire knowledge (when combined with the availability of anatomical models, dissectible materials and/or anatomical donors) by providing a dedicated space to reinforce the anatomical identification and understanding of anatomy and structural relationships (Chapman et al., 2017; Yamine & Violato, 2016). Additionally, some instructors might inadvertently reinforce this discrepancy by focusing more of their lecture curriculum on homeostasis, and how homeostasis operates across systems, rather than including homeostasis in a lab. In this scenario, instructors develop a lab curriculum focusing on anatomical resources to identify structures, with lecture sessions devoted to physiological concepts, the integration of systems, and the application of information to real-world scenarios.

Moreover, this focus may be an indirect byproduct from the perception that anatomy is an 'impossible', challenging, and content-heavy course for undergraduate students. When pre-loaded with this perception, students may be quickly overwhelmed by the number of structures, functions and terminology that must be mastered (Sparacino et al., 2019)

and fail to engage with activities focused on physiology LOs. Instructors may also inadvertently reinforce this perception by devoting the majority of laboratory time to the identification of structures and detrimentally limit coverage and exploration of many of the other concepts within the totality of the A&P curriculum. Even though there seems to be a greater emphasis on anatomical LOs, the general trend for incorporating LOs related to the ability to conduct basic cardiopulmonary testing and muscle physiology persists when compared to previous versions of this survey (Brashinger 2014a; 2014b; 2017).

It is speculation that the perception of difficulty in mastering anatomical information, as shown in tables 3-4, warrants devoting more time to identification skills in an already overloaded laboratory schedule. Decreased time in the lab curriculum focusing on physiology versus the anatomy concepts could also be due to the difficulty of performing some experiments, the accessibility of resources for others, or the lack of resources and time necessary to complete high quality lab activities to test physiological responses. Moreover, some instructors may more easily integrate publisher materials into the total curriculum in lieu of laboratory instruction with little impact on the educational outcomes. Additionally, student receptivity to and engagement with the activities used to teach physiology concepts might contribute to the inclusion or exclusion of physiology from the laboratory curriculum. These contributing factors, along with limited instructional resources, deserve additional investigation to determine if there are direct causes that can be addressed in future curriculum development and refinement.

Another aspect of A&P laboratory curriculum development is the selection of resources used to reinforce concepts. Of interest is the general consistency across the various resources being used by instructors, regardless of institution. This makes us wonder, 'why is resource use so consistent?' Is consistency linked to pedagogy and effectiveness for students learning and retention? Alternatively, is consistency linked to some form of convenience for selecting resources (i.e., excessive similarities across suppliers, repeating what has always been done, following suggestions from other instructors)? The approach of A&P lab instruction can differ amongst institutions, and even between instructors within an institution who have a common curricular focus. This difference may come from variations in the perceived importance of some topics over others (Tables 1 through 3), or from varying levels of institution demographics Britson et al., 2023) and expertise with specific topics where instructors may or may not have the pedagogical skills needed to apply information to a real-world situation. For instance, some might feel more confident teaching application of muscle physiology to real-world scenarios but less so for urinary functions. Compounding this difference is variability in the amount of content application and integration of systems

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existing between A&P lab textbooks and the possibility that instructors may not know where to obtain information to teach applications that are lacking in resources available to them (Margaris & Black, 2012).

To address these questions about consistent resource use, we must first stipulate that the general purpose of the lab classroom is to provide educational hands-on experiences to students (Casotti et al., 2008; McComas, 2005). These experiences are a foundation for increased engagement in education that leads to more authentic learning opportunities for the student (Hurtt & Bryant, 2016; Johnson & Gallagher, 2021). As such, the increased use of similar resources (Figures 6-8) might mean that instructors are attempting to create similar learning opportunities based on similar learning goals. Additionally, compared to previous versions of this survey, there is a shift towards a greater use of digital and virtual resources. This shift might reflect the openness of instructors to integrating technology into their A&P classroom, since students are becoming more reliant on these technologies in educational settings (Cheung et al., 2021; Harrison et al., 2001; McDaniel & Daday, 2017; Ostrin & Dushenkov, 2016; Persinger et al., 2021; Pollock, 2022; Stokes & Silverthorn, 2021).

The similarity in preference for laboratory materials (e.g., plastic models, microscope slides, digital histology, simulations) across instructors may also indicate a preference for laboratory resources supported by educational textbook publishers and supply companies. While anecdotal, a cursory review of various A&P textbooks and their respective digital platforms suggests that there is little variance across major publishers and their suggested resources. Though apparent standardization might limit instructor choice of resources, it may also decrease stress on laboratory support staff (e.g., lab coordinators, student TAs, laboratory student workers) when setting up and breaking-down the lab room between different sections of the course. Additionally, the increased use of models for anatomical investigation and digital resources, in lieu of wet labs, may provide financial benefit to the institution by reducing expenses that would otherwise be incurred to conduct dissections or wet labs across multiple sections of the A&P courses.

Also, a perception of limited options and the impression of having little control in curriculum development may inhibit some instructors from exploring secondary types of resources or developing individualized options for laboratory instruction (Felber, 2021; Moorehead et al., 2015). However, there are recent movements by some instructors to investigate less costly and simpler means to provide equivalent learning opportunities to students (Price, 2020). This movement indicates that the use of a similar resource might not be due to a pedagogical advantage but rather to a limited awareness of alternatives, a consideration that warrants further investigation.

Conclusions

A&P instructors manage many challenges while guiding students to successful outcomes in their coursework. Institutional limitations of funding, physical resources, standardized curricula, and enrollment demands must be balanced with implementing evidence-based pedagogical practices, maintaining expertise in current course content, and creating connections between students and learning outcomes. When these challenges are successfully met and balanced, the authentic learning experience created not only teaches but transforms the learners as students, citizens, and future healthcare professionals. It is our goal that A&P instructors can use the results from this survey to assess their own A&P courses in comparison to those of their colleagues. Reflecting on the similarities and differences in curricula should aid instructors in identifying pedagogical practices that are less effective versus those that may be more effective at meeting learning goals and outcomes of A&P curricula. These comparisons are even more important as we reflect on how we, as A&P instructors, responded to changes in the educational environment and the additional challenges of teaching stemming from the COVID-19 pandemic presented in the third manuscript of this series.

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Literature Cited

- Beck, E. & Roosa, K. (2020). Designing high structure courses to promote student engagement. *HAPS Educator*, 24(2), 58-63. <https://doi.org/10.21692/haps.2020.019>
- Behrendt, M., Foster, J., & Machtmes, K. (2020). Student perception of how to succeed in a pre-nursing anatomy and physiology course. *HAPS Educator*, 24(2), 5-20. <https://doi.org/10.21692/haps.2020.014>
- Brashinger, D. P. (2014a, March 15). *The HAPS laboratory instructor survey: A discussion of the preliminary data* [Conference presentation abstract]. HAPS Eastern Regional Meeting, Springfield, MA, United States. <https://cdn.ymaws.com/www.hapsweb.org/resource/resmgr/Conference/2014EasternRegProgram.pdf>
- Brashinger, D. P. (2014b, May 24-29). *The HAPS laboratory instructor survey: Final results and implications for instruction* [Conference presentation abstract]. Twenty-eighth Annual Conference of the Human Anatomy and Physiology Society, Fort Lauderdale, FL, United States. https://cdn.ymaws.com/www.hapsweb.org/resource/resmgr/Conference/HAPS-2014_Conference_Program.pdf
- Brashinger, D. P. (2017). Instructional goals and practices in the introductory undergraduate pre-health professions anatomy and physiology laboratory. *HAPS Educator Special Edition*, 4-23. <https://doi.org/10.21692/haps.2017.001>
- Braun, H. (2019). Performance assessment and standardization in higher education: A problematic conjunction? *British Journal of Educational Psychology*, 89(3), 429–440. <https://doi.org/10.1111/bjep.12274>
- Britson, C. A., Kule, C., Hopp, R., Clark, J., Armbruster, H., Anako, C. et al. (2023). HAPS curriculum & instruction 2022 laboratory survey: Demographics of respondents, institutions, and students. *HAPS Educator*, 27(2), 36-49. <https://doi.org/10.21692/haps.2023.013>
- Brown, S. J., White, S., & Power, N. (2017). Introductory anatomy and physiology in an undergraduate nursing curriculum. *Advances in Physiology Education*, 41(1), 56–61. <https://doi.org/10.1152/advan.00112.2016>
- Casotti, G., Rieser-Danner, L., & Knabb, M. T. (2008). Successful implementation of inquiry-based physiology laboratories in undergraduate major and nonmajor courses. *Advances in Physiology Education*, 32(4), 286-296. <https://doi.org/10.1152/advan.00100.2007>
- Chapman, A. M, Ward, H. C., Tiwari, A., Weimer, A., Duran, J. B., Guerra, F, & Sale, P. (2017). The role of language in anatomy and physiology instruction. *The American Biology Teacher*, 79(3), 184–190. <https://doi.org/10.1525/abt.2017.79.3.184>
- Cheung, C.C., Bridges, S. M., & Tipoe, G. L. (2021). Why is anatomy difficult to learn? The implications for undergraduate medical curricula. *Anatomical Sciences Education*, 14(6), 752-763. <https://doi.org/10.1002/ase.2071>
- Coderre, S., Woloschuk, W., & McLaughlin, K. (2009). Twelve tips for blueprinting. *Medical Teacher* 31(4), 322–324. <https://doi.org/10.1080/01421590802225770>
- Davis, T. C. & Autin, N. P. (2020). The cognitive trio: backwards design, formative assessment, and differentiated instruction. *Research Issues in Contemporary Education*, 5(2), 55-70.
- De Castella, K., Byrne, D., & Covington, M. (2013). Unmotivated or motivated to fail? A cross-cultural study of achievement motivation, fear of failure, and student disengagement. *Journal of Educational Psychology*, 105(3), 861–880. <https://psycnet.apa.org/doi/10.1037/a0032464>
- Dick, W., Carey, L., & Carey, J. O. (2001). *The systematic design of instruction*, 5th edition. Longman Publishing.
- Emory, J. (2014). Understanding backward design to strengthen curricular models. *Nurse Educator*, 39(3), 122-125. <https://doi.org/10.1097/nne.0000000000000034>
- Felber, S. (2021). Adjunct faculty participation in the centralized design of online courses. *Online Journal of Distance Learning Administration*, 23(1). <https://ojdla.com/articles/adjunct-faculty-participation-in-the-centralized-design-of-online-courses>
- Finn, K., Benes, S., FitzPatrick, K., & Hardway, C. (2019). Metacognition and motivation in anatomy and physiology students. *International Journal of Teaching and Learning in Higher Education*, 31(3), 476-490. https://scholarworks.merrimack.edu/health_facpubs/85

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- Griff, E. R. (2016). Changing undergraduate human anatomy and physiology laboratories: Perspectives from a large-enrollment course. *Advances in Physiology Education*, 40(3), 388-392. <https://doi.org/10.1152/advan.00057.2016>
- Gronlund, N. E. & Brookhart, S. M. (2009). *Writing instructional objectives, 8th edition*. Pearson Education Incorporated.
- Harmon, D. J., Attardi, S. M., Barremkala, M., Bentley, D. C., Brown, K. M., Dennis, J. F. et al. (2021). An analysis of anatomy education before and during Covid-19: May–August 2020. *Anatomical Sciences Education*, 14(2), 132–147. <https://doi.org/10.1002/ase.2051>
- Harrison, J. F., Nichols, J. S., & Whitmer, A. C. (2001). Evaluating the impact of physical renovation, computerization, and use of an inquiry approach in an undergraduate, allied health human anatomy and physiology lab. *Advances in Physiology Education*, 25(4), 202-210. <https://doi.org/10.1152/advances.2001.25.4.202>
- Henige, K. (2011). Undergraduate student attitudes and perceptions towards low- and high-level inquiry exercise physiology teaching laboratory experiences. *Advances in Physiology Education*, 35(2), 197–205. <https://doi.org/10.1152/advan.00086.2010>
- Hill, C. A., Britson, C. A., Elbatarny, H., Heimgartner, C., Waters, J. R., & Wayne, C. M. (2017). Managing large anatomy and physiology classrooms. *HAPS Educator*, 21(3), 45-47. <https://doi.org/10.21692/haps.2017.053>
- Hofstein, A. & Lunetta, V. N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. *Review of Educational Research*, 52(2), 201-217. <https://psycnet.apa.org/doi/10.2307/1170311>
- Hull, K., Jensen, M., Gerrits, R., & Ross, K. T. (2017). Core concepts for anatomy and physiology: A paradigm shift in course and curriculum design. *HAPS Educator*, 21(2), 73-79. <https://doi.org/10.21692/haps.2017.017>
- Human Anatomy and Physiology Society. (2019). *Anatomy and physiology learning outcomes, revised fall 2019*. https://www.hapsweb.org/page/Learning_Outcomes
- Human Anatomy and Physiology Society. (2020). *Learning goals, revised 2020*. https://www.hapsweb.org/page/learning_goals
- Hurt, B. & Bryant, J. (2016). Instructional design changes in an undergraduate A&P course to facilitate student engagement and interest. *Journal of College Science Teaching*, 46(2), 26-31.
- Hyson, A. R., Bonham, B., Hood, S., Deutschman, M. C., Seithers, L. C., Hull, K., & Jensen, M. (2021). Professional development, shifting perspectives, and instructional change among community college anatomy and physiology instructors. *CBE Life Sciences Education*, 20(3), Article e49. <https://doi.org/10.1187/cbe.21-02-0037>
- Ismail, M. A-A., Mat Pa, M. N., Mohammad, J. A-M., & Yusoff, M. S. B. (2020). Seven steps to construct an assessment blueprint: A practical guide. *Education in Medicine Journal*, 12(1), 71–80. <https://doi.org/10.21315/eimj2020.12.1.8>
- Johnson, S. N. & Gallagher, E. D. (2021). Learning processes in anatomy and physiology: A qualitative description of how undergraduate students link actions and outcomes in a two-semester course sequence. *Advances in Physiology Education*, 45(3), 486–500. <https://doi.org/10.1152/advan.00135.2020>
- Krathwohl, D. R. (2002). A revision of Bloom’s taxonomy overview. *Theory into Practice*, 41(4), 212-218. https://doi.org/10.1207/s15430421tip4104_2
- Maldonado, S. (2022). Moving forward in nursing education using the backward design. *Journal of Education*. <https://doi.org/10.1177/00220574211070220>
- Margaris, K. N. & Black, R. A. (2012). Modeling the lymphatic system: Challenges and opportunities. *Journal of the Royal Society Interface*, 9(69), 601–612. <https://doi.org/10.1098/rsif.2011.0751>
- Martin, E. M., Moorcroft, S. J., & Johnson, T.G. (2019). Backwards design and program level approaches to coach development in higher education. *International Sport Coaching Journal*, 6(3), 329–338. <https://doi.org/10.1123/iscj.2018-0071>
- McComas, W. (2005). Laboratory instruction in the service of science teaching and learning: reinventing and reinvigorating the laboratory experience. *The Science Teacher*, 72(7), 24-29.
- McDaniel, K. & Daday, J. (2017). An undergraduate anatomy lab revision success story. *HAPS Educator*, 21(2), 8-18. <https://doi.org/10.21692/haps.2017.010>
- McLaughlin, K., Coderre, S., Woloschuk, W., Lim, T., Muruve, D., & Mandin, H. (2005). The influence of objectives, learning experiences and examination blueprint on medical students’ exam preparation. *BMC Medical Education*, 5, Article e39. <https://doi.org/10.1186/1472-6920-5-39>
- McPhee, I. & D’Esposito, M. E. W. (2018). Student assessment in higher education: Embargo or empowerment? *Journal of Applied Research in Higher Education*, 10(2), 155–169. <https://doi.org/10.1108/JARHE-04-2017-0049>
- McTighe, J. & Thomas, R. S. (2003). Backward design for forward action. *Educational Leadership*, 60(5), 52-55.
- Michael, J. & McFarland, J. (2020). Another look at the core concepts of physiology: revisions and resources. *Advances in Physiology Education*, 44(4), 752–762. <https://doi.org/10.1152/advan.00114.2020>

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- Moorehead, D. L., Russell, T. J., & Pula, J.J. (2015). "Invisible faculty": 'Department chairs' perceptions of part-time faculty status in Maryland four-year public and private higher education institutions. *Delta Kappa Gamma Bulletin*, 81(4), 102-119.
- Ostrin, Z. & Dushenkov, V. (2016). The pedagogical value of mobile devices and content-specific application software in the A&P laboratory. *HAPS Educator*, 20(4), 97-103. <https://doi.org/10.21692/haps.2016.039>
- Patil, S. Y., Gosavi, M., Bannur, H. B., & Ratnakar, A. (2015). Blueprinting in assessment: A tool to increase the validity of undergraduate written examinations in pathology. *International Journal of Applied Basic Medical Research*, 5(Suppl 1), S76–S79. <https://doi.org/10.4103/2229-516X.162286>
- Peacock, J. L., FitzPatrick, K., & Finn, K.E. (2020). Integrating lecture and laboratory in anatomy and physiology: student perceptions and performance. *Journal on Excellence in College Teaching*, 31(1), 169-194.
- Persinger J. M., Dunham, S. M., & Husmann, P. R. (2021). To use or not to use: Supplemental technology in an undergraduate anatomy lab. *HAPS Educator*, 25(3), 36-44. <https://doi.org/10.21692/haps.2021.030>
- Pollock, N. B. (2022). Student performance and perceptions of anatomy and physiology across face-to-face, hybrid, and online teaching lab styles. *Advances in Physiology Education*, 46(3), 453-460. <https://doi.org/10.1152/advan.00074.2022>
- Price, T. (2020). A model for creating affordable educational resources for anatomy and physiology. *HAPS Educator*, 24(3), 61-73. <https://doi.org/10.21692/haps.2020.025>
- Sparacino, A. M., Gonzalez, V. H., Ball, S., Cielocha, J. J., Helm, K., & Mcleod, D. S. (2019). A quantitative analysis of four undergraduate human anatomy laboratory curricula: Approaches, identified structures, concepts, and thematic emphases. *Medical Science Educator* 29, 101-111. <https://doi.org/10.1007/s40670-018-00639-4>
- Stokes, J. A., & Silverthorn, D. U. (2021). Updating anatomy and physiology lab delivery: Shifting from a paper-based to an online lab instruction platform, just in time for a global pandemic. *Advances in Physiology Education*, 45(2), 290–298. <https://doi.org/10.1152/advan.00190.2020>
- Tornwall, J. (2017). Backward design toward a meaningful legacy. *Nurse Education Today*, 56, 13–15. <https://doi.org/10.1016/J.NEDT.2017.05.018>
- Vaughn, K. E., Srivatsa, N., & Graf, A. S. (2021). Effort praise improves resilience for college students with high fear of failure. *Journal of College Student Retention: Research, Theory & Practice*, 25(2), 378-397. <https://doi.org/10.1177/1521025120986517>
- Villarroel, V., Bloxham, S., Bruna, D., Bruna, C., Herrera-Seda, C. (2018). Authentic assessment: creating a blueprint for course design. *Assessment & Evaluation in Higher Education*, 43(5), 840-854. <https://doi.org/10.1080/02602938.2017.1412396>
- Whetten, D. A. (2007). Principles of effective course design: What I wish I had known about learning-centered teaching 30 years ago. *Journal of Management Education* 31(3), 339–357. <https://doi.org/10.1177/1052562906298445>
- Whinnery, E. & Peisach, L. (2022). 50-State comparison: Transfer and articulation policies. *Education commission of the states*. <https://www.ecs.org/50-state-comparison-transfer-and-articulation/>
- White, A. & Maguire, M. B. R. (2021). Using backward course design to create the next generation of nurse educator leaders. *The Journal of Continuing Education in Nursing*, 52(12), 554-557. <https://doi.org/10.3928/00220124-20211108-06>
- Yammine, K. & Violato, C. (2016). The effectiveness of physical models in teaching anatomy: A meta-analysis of comparative studies. *Advances in Health Sciences Education*, 21, 883–895. <https://doi.org/10.1007/s10459-015-9644-7>
- Zarifnejad, G., Mirhaghi, A., and Rajabpoor, M. (2018). Does peer education increase academic achievement in first year students? A mixed-method study. *Journal of Peer Learning*, 11(7), 89-98.



The Histo-Kitchen: Using Food Items to Teach Histology

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Abstract

Engaging students in active learning has proved to transform reflexive knowledge into true learning of material in medical education. Histology is one subject area that consistently presents as a challenge for medical and undergraduate students. The large amount of complex information needed to completely understand and interpret histological images is something that is many medical students do not fully grasp in the pre-clinical stages. Pedagogical studies that use physical objects and hands on learning have been shown to motivate and encourage students to self-learn such complex topics. This application of using physical objects and hands on learning, however, is not the easiest to translate to the cellular level. The Histo-Kitchen was designed to help students manage the vast amount of information and acquire knowledge in a meaningful and creative way. By incorporating food items into an active learning session, students were able to stretch their imagination and find representative items for common histological specimen representations. Based on post-session discussions, students found the activity to be beneficial to their learning and greatly enjoyed participating in the activity, often citing it as the most fun they have had learning histology. By providing students with opportunities to interact with complex material in creative and novel ways, students are able to learn in an environment that can be both engaging and enjoyable.

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Key words: food art, active learning, histology, PBL, medical education

Introduction

One of the great challenges in teaching histology is finding a way to make static, visually similar images have their own unique identities. Traditional histology didactics rely on lengthy lectures and the repetitive labelling of histological slides (Blake et al., 2003; Hightower et al., 1999). Although often presenting a concept in its entirety, these methods only provide the student with reflexive knowledge—often preventing true integration of the material into their knowledge base (Bergman et al., 2008). This problem is pervasive in medical education. In higher education, creative and simple activities from early education didactics are often overlooked in exchange for the more traditional lecture format (Balemans et al., 2016; Bloodgood, 2012; Burhanli & Bangir-Alpan, 2021; Felszeghy et al., 2017, 2019; Johnson et al., 2015; Ness, 2011; O'Malley, 2022). This format often stifles a student's ability to truly integrate new knowledge into their own schema, overwhelming the learner with information that is not easily understood from one session.

In early education, macaroni art is often regarded as a staple educational activity. This simple craft has stood the test of time and remained an effective modality to teach spatial reasoning, creativity, and appropriate use of materials.

From a broader perspective, this activity allows learners to explore how common, single shaped items, can be used to create a beautiful piece of art. In a similar manner as macaroni, cells are simple shapes that come together to form unique and multifunctional tissues. When isolated and stained, these tissues create beautiful works of art. Through observations and direct experience with students, as well as curriculum evaluation and review, we have found that students significantly reduce the time they spend using traditional learning modalities, such as lectures and textbook reading, in lieu of resources that approach scientific topics through images, mnemonics, and other creative or art-based modalities (Burhanli & Bangir-Alpan, 2021; El-Sayed et al., 2013; Felszeghy et al., 2019; Johnson et al., 2015; Miller et al., 2013; Walker et al., 2008).

One methodology implemented to bridge the gap between medical students' preferred modalities that also allows for appropriate coverage of the material is to integrate art into the learning sessions. Several studies have shown that using art to teach tough courses such as physiology, anatomy, or histology have increased student engagement, satisfaction, and retention of the material (Cracolici et al., 2019; Flôr et al.,

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2020; Housen, 2002; O'Malley et al., 2022). Studies have also found an improvement in students' clinical observational skills with the implementation of art into their studies (Bardes et al., 2001; Shapiro et al., 2006).

In a similar fashion to macaroni art, using food items to represent histological images is a way to integrate complex topics into a student's pre-existing schema. By expanding our concept of acceptable professional education didactic, we can greatly increase a learner's enthusiasm and understanding of complex topics. Furthermore, due to the fun and creative nature of this project, it also creates an environment in which students are actively excited to learn histology. This work complements any problem-based learning curriculum and can be used as a supplement to traditional lecture didactic.

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

1. Describe the epidemiology, pathology, and pathogenesis of the various types of renal cell carcinoma.
2. Describe the histological presentation and evaluation of the various types of renal cell carcinoma.
3. Apply critical thinking and problem-solving skills to the construction of a representative model.

Methods

Topic Selection

The Histo-Kitchen was initially designed for first-year medical students in the later stages of study of the renal system. Based on the current problem-based curriculum at the time of initial launch, the topic of renal cell carcinoma (RCC) histology was selected. RCC is the seventh most common type of cancer in the United States and has shown a sustained increase in its prevalence (Cairns, 2011). Considering the significant prognostic and therapeutic implications of its histological variants, understanding the microscopic appearance of RCC is of paramount importance to developing physicians. This lesson focused on the five most common subtypes of RCC: clear cell, papillary, chromophobe, oncocytic, and collecting duct carcinomas (Kay & Pedrosa, 2018).

Resource Collecting

Based on published histological reference slides of the various types of RCC, food items were selected for their ability to be modeled into shapes, represent cellular components, provide color contrast, and allow for variation across student work. Example items included: cereal, sour candy gel, pudding cups, licorice sticks, and chewing gum. Each item can be used to represent several different components. See Table 1 for a more detailed list of items and what they may symbolize. Prior to the session, large posters (24" x 36") of Figure 1 were printed for each team and partially laminated in order to create a food resistant working surface for the students. This allowed for easy clean-up and presentation of the final product. Additional office supplies such as scissors and tape may aid in the students' ability to manipulate the food objects, but are not required. Wearing gloves is advised as this can get messy!

Suggested Food Items and their Histological Representations	
Food Item	Suggested Histology*
Sour Candy Gel	Cytoplasm, Perinuclear Halos
Licorice Sticks	Microtubules, Collagen, Basal Lamina
Chewing Gum	Fibrous Stroma, Extracellular Matrix
Miniature Marshmallows	Cuboidal Epithelial Cells, Cell Membranes
Colorful Children's Cereal	Various Organelles
Hard Candy Pieces	Nucleus
Sour Candy Strips	Elastic Fibers, Collagen Fibril
Fruit Snacks	Polygonal Cells
*Food items may represent multiple components. There is no single correct answer.	

Table 1. Suggested food items and their histological representations.

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Project Implementation and Facilitation

The Histo-Kitchen was implemented on the third day of a problem-based learning session which utilized a student leader to run the session (Prasad and O'Malley, 2022). During the in-class portion of the activity, groups of two worked on using the provided food items to model the requested histology images. Groups also filled out a corresponding worksheet (Figure 1) summarizing the microscopic appearance and important pathophysiology of the most common subtypes of RCC. This activity was open resource, but students were encouraged to complete the written sections by memory first, before comparing to outside resources.

Students completed the activity in 20 minutes allowing for 10 minutes of discussion and sharing. Each team of two presented on one subtype of RCC explaining what each food item represented and any relevant physiology. Facilitators of this project are required to have some baseline knowledge of RCC, however the majority of the needed information can be readily found on online clinical based resources such as Amboss and UpToDate. A completed worksheet is shown. (Figure 2).

The Histo-Kitchen	Important Subtypes Types of Renal Cell Carcinoma				
	Clear Cell	Non-Clear Cell Renal Carcinoma			
		Papillary	Chromophobe	Oncocytic	Collecting Duct
Microscopic Appearance					
Relative Frequency					
Cell of Origin					
Etiology					
Prognosis					

Figure 1. Blank RCC Histo-Kitchen poster worksheet.

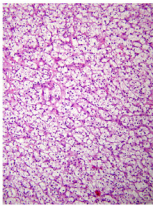
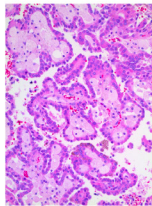
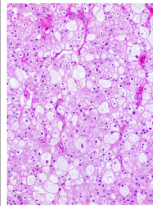
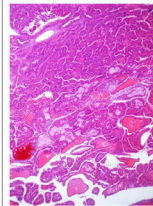
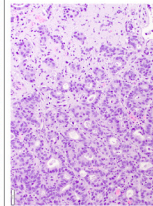
The Histo-Kitchen	Important Subtypes Types of Renal Cell Carcinoma				
	Clear Cell	Non-Clear Cell Renal Carcinoma			
		Papillary	Chromophobe	Oncocytic	Collecting Duct
Microscopic Appearance	 Clear, polygonal cells arranged as cords or tubules Clear, glycogen and/or lipid filled cytoplasm	 Cuboidal, low columnar cells growing in papillary formation	 Large polygonal cells with a prominent cell membrane Eosinophilic cytoplasm Perinuclear halo	 Similar to chromophobe RCC, but without perinuclear halo Cells occur as tumor nests	 Irregularly arranged glandular cells within a fibrous stroma
Relative Frequency	~ 70%	~ 10-15%	~ 5%	~ 1%	~ 1%
Cell of Origin	Proximal Convoluted Tubule	Proximal Convoluted Tubule	Intercalated cells of the cortical duct	Intercalated cells of the cortical duct	Medullary Collecting Duct
Etiology	Mutation of the VHL gene on chromosome 3p	Trisomy 7, Trisomy 17, or loss of Y chromosome	Hypodiploidy	Unknown	Unknown
Prognosis	Dependent on Tumor Stage	Type 1 is better than type 2 Type 2 is aggressive with a poor prognosis	Excellent Prognosis	Excellent Prognosis	Aggressive tumor with poor prognosis

Figure 2. Filled RCC Histo-Kitchen poster worksheet; facilitator version. Pictures sourced from PathologyOutlines.com.

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A Brief Facilitator Guide

The Histo-Kitchen active learning session can be completed within 30 minutes. The most technical aspect of this activity is the required set up and preparation. Fortunately, the creativity comes from the students and does not require too much advanced planning on the facilitator. Students will find a way to utilize any items they are given. Below is a summary of the steps taken to run this active learning session:

1. Collect food items and prepare the poster workspaces.
2. Introduce to the students the concept of using food items to mimic histological slides (in this case RCC).
3. Organize students into groups of 2-3 and give them 20 minutes to fill out the poster and create their images, they may use any study materials or references they have access to. During this step, music can be played to enrich the creative atmosphere.
4. Over the last 10 minutes, allow student groups to each present one histological image, explaining what each food item represents and how it fits into the overall histopathology. Time permitting, have other groups compare what they did differently to create their histological image.
5. Fold up the posters and dispose of them for easy clean-up. Don't forget to take pictures first!

Project Evaluation and Results

To identify how students perceived the activity, a post activity oral feedback session was held for all of the participants (n=6). Feedback questions included "what did you like about the activity?" and "how can this activity be improved for future topics?", as well as a request for any general feedback on the activity. Feedback for this educational session was overwhelmingly positive. Participants noted the importance of being able "...to use 3D models to learn histology...". They also acknowledged that constructing the image out of unique items allowed for an increase in retention of the information ("...This was a cool way to learn histo..."). Participants stated that by visualizing the histology with common food items, they thought they'd remember the histology better ("...we should do this for more histo classes..."). Additionally, they appreciated that the complex histology was easily broken down into manageable pieces through the activity. No formal assessment was done at this time.

Overall, the students presented quality work that allowed them to learn complex information and identify any corresponding gaps in knowledge. Representative student work of the microscopic appearance can be seen in figure 3.

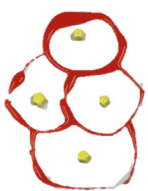




The Histo-Kitchen	Important Subtypes Types of Renal Cell Carcinoma				
	Clear Cell	Non-Clear Cell Renal Carcinoma			
		Papillary	Chromophobe	Oncocytic	Collecting Duct
Microscopic Appearance (Student Examples)					

Figure 3. Select student examples of RCC microscopic appearance.

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Discussion

This single 30-minute arts-based activity offers sustained educational benefits for student participants. In this presentation, renal cell carcinoma—a cancer well known for its varying histological presentations—can be easily understood when viewed through an artistic lens. Albeit nontraditional in the medical school setting, active learning sessions utilizing food items to construct the histology of RCC is a valuable method by which to instill a sense of the importance of RCC histopathology, while maintaining a fun and positive learning environment.

This perspective is among other works which have shown that integration of visual art into the teaching of histology is beneficial to students' understanding and retention of material (Balemans et al., 2016; Cracolici et al., 2019; Osório et al., 2013; Reid et al., 2019). However, this exercise does not focus on drawing to create the art, but rather the use of food as art, which is novel for the study of histology. Similar variations of this project can be completed using non-food items as well. The true benefit results not from the use of food, but from the manipulation of 3D elements in space to recreate a complex 2D image. As such, a wide array of household items can be used.

The Histo-Kitchen adds a unique yet familiar twist to the study of histology for various levels of learning. The activity could easily be adapted to be used for an introduction to histology and tissue types for high school or undergraduate college levels. We recommend keeping students in small groups to allow for each group member to actively participate in the activity as well as the debrief where students can reflect on their process as well as their peers' process.

Overall, students were receptive to the idea of recreating any histological image. One important note about the focus of this activity is that it is not focused on accuracy, but rather the cognitive process in which students decided what items serve as symbols and how they interact within the cell. Results may greatly vary across participants. One challenge for this exercise was that participants could see what other groups had created. In some cases, they would base their ideas off each other. While this has potential to lead to more accurate final products, it more often limits diversity and detracts from an otherwise robust discussion. In general, however, participants in this activity walked away with a greater understanding and appreciation for histology, as noted through their vocal feedback regarding the activity.

About the Authors

Andrew Stewart is a third-year medical student at Nova Southeastern University Dr. Kiran C. Patel College of Allopathic Medicine (NSU MD). He has 7 years of experience developing active learning projects for a wide range of learners. His research goals aim to improve the diversity of medical school didactic and facilitate student learning in non-traditional and creative ways. He is currently interested in pursuing a career in adolescent medicine with a focus on LGBTQ+ health.

Chasity O'Malley is an associate professor of medical education and physiology at Boonshoft School of Medicine at Wright State University. Her research goals aim to improve the learning experience for students by helping them learn to study and interact with the material in meaningful ways and for faculty by helping guide them on implementing active learning into their classrooms. Her NSF funded grant revolves around helping community college faculty implement evidence based instructional practices in their classroom, while adding to the evidence through their own classroom research projects. She also is actively involved in promoting diversity through her funded research projects centered around enhancing training for medical students related to the LGBTQ population.

Literature Cited

- Balemans, M. C. M., Kooloos, J. G. M., Donders, A. R. T., & Van der Zee, C. E. E. M. (2016). Actual drawing of histological images improves knowledge retention. *Anatomical Sciences Education*, 9(1), 60–70. <https://doi.org/10.1002/ASE.1545>
- Bardes, C. L., Gillers, D., & Herman, A. E. (2001). Learning to look: Developing clinical observational skills at an art museum. *Medical Education*, 35(12), 1157–1161. <https://doi.org/10.1046/J.1365-2923.2001.01088.X>
- Bergman, E. M., Prince, K. J. A. H., Drukker, J., Van der Vleuten, C. P. M., & Scherpbier, A. J. J. A. (2008). How much anatomy is enough? *Anatomical Sciences Education*, 1(4), 184–188. <https://doi.org/10.1002/ASE.35>
- Blake, C. A., Lavoie, H. A., & Millette, C. F. (2003). Teaching medical histology at the University of South Carolina School of Medicine: Transition to virtual slides and virtual microscopes. *Anatomical Record - Part B New Anatomist*, 275(1), 196–206. <https://doi.org/10.1002/AR.B.10037>
- Bloodgood, R. A. (2012). Active learning: A small group histology laboratory exercise in a whole class setting utilizing virtual slides and peer education. *Anatomical Sciences Education*, 5(6), 367–373. <https://doi.org/10.1002/ASE.1294>

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- Burhanlı, S., & Bangir-Alpan, G. (2021). Why do university students prefer YouTube to learn and study? *Educational Policy Analysis and Strategic Research*, 16(4), 164–177. <https://doi.org/10.29329/epasr.2021.383.9>
- Cairns, P. (2011). Renal cell carcinoma. *Cancer Biomarkers*, 9(1–6), 461. <https://doi.org/10.3233/CBM-2011-0176>
- Cracolici, V., Judd, R., Golden, D., & Cipriani, N. A. (2019). Art as a learning tool: Medical student perspectives on implementing visual art into histology education. *Cureus*, 11(7), e5207. <https://doi.org/10.7759/cureus.5207>
- El-Sayed, R., El-Hoseiny, S., & El-Sayed, E. (2013). Video-based lectures: An emerging paradigm for teaching human anatomy and physiology to student nurses. *Alexandria Journal of Medicine*, 49(1), 215–222. <https://doi.org/10.4314/bafm.v49i1>
- Felszeghy, S., Pasonen-Seppänen, S., Koskela, A., & Mahonen, A. (2017). Student-focused virtual histology education: Do new scenarios and digital technology matter? *MedEdPublish*, 6, 154. <https://doi.org/10.15694/MEP.2017.000154>
- Felszeghy, S., Pasonen-Seppänen, S., Koskela, A., Nieminen, P., Härkönen, K., Paldanius, K. M. A., et al. (2019). Using online game-based platforms to improve student performance and engagement in histology teaching. *BMC Medical Education*, 19(1). <https://doi.org/10.1186/S12909-019-1701-0>
- Flôr, A. F. L., Fernandes Costa, F., Lima Garcia, J. M., Braga, V. A., & Cruz, J. C. (2020). PhysioArt: a teaching tool to motivate students to learn physiology *Advances in Physiology Education*, 44(4), 564–569. <https://doi.org/10.1152/advan.00025.2020>
- Hightower, J. A., Boockfor, F. R., Blake, C. A., & Millette, C. F. (1999). The standard medical microscopic anatomy course: Histology circa 1998 *The Anatomical Record: An Official Publication of the American Association of Anatomists*, 257(2), 96–101. [https://doi.org/10.1002/\(SICI\)1097-0185\(19990615\)257:3](https://doi.org/10.1002/(SICI)1097-0185(19990615)257:3)
- Housen, A. C. (2002). Aesthetic Thought, Critical thinking and transfer. *Arts and Learning Research*, 18(1), 2001–2002. <https://vtshome.org/wp-content/uploads/2016/08/5%C3%86sthetic-Thought-Critical-Thinking-and-Transfer.pdf>
- Johnson, S., Purkiss, J., Holaday, L., Selvig, D., & Hortsch, M. (2015). Learning histology - Dental and medical students' study strategies. *European Journal of Dental Education*, 19(2), 65–73. <https://doi.org/10.1111/EJE.12104>
- Kay, F. U., & Pedrosa, I. (2018). Imaging of solid renal masses. *Urologic Clinics of North America*, 45(3), 311–330. <https://doi.org/10.1016/J.UCL.2018.03.013>
- Miller, C. J., McNear, J., & Metz, M. J. (2013). A comparison of traditional and engaging lecture methods in a large, professional-level course. *American Journal of Physiology - Advances in Physiology Education*, 37(4), 347–355. <https://doi.org/10.1152/ADVAN.00050.2013>
- Ness, R. B. (2011). Commentary: Teaching creativity and innovative thinking in medicine and the health sciences. *Academic Medicine*, 86(10), 1201–1203. <https://doi.org/10.1097/ACM.0B013E31822BBB9F>
- O'Malley, C. (2022). What the flip? A pilot study perspective on the flipped classroom for medical school physiology. *HAPS Educator*, 26(2), 14–18. <https://doi.org/10.21692/haps.2022.006>
- O'Malley, C., Levy, A., & Griffin, D. (2022). The hormone project: Application of art to engage critical thinking for undergraduate medical education. *HAPS Educator*, 26(3), 43–51. <https://doi.org/10.21692/HAPS.2022.015>
- Osório, N. S., Rodrigues, F., Garcia, E. A., & Costa, M. J. (2013). Drawings as snapshots of student cellular anatomy understanding. *Medical Education*, 47(11), 1120–1121. <https://doi.org/10.1111/MEDU.12320>
- Prasad, S., & O'Malley, C. (2022). An introductory framework of problem-based learning (PBL) and perspectives on enhancing facilitation approaches. *HAPS Educator*, 26(3), 52–58. <https://doi.org/10.21692/HAPS.2022.016>
- Reid, S., Shapiro, L., & Louw, G. (2019). How haptics and drawing enhance the learning of anatomy. *Anatomical Sciences Education*, 12(2), 164–172. <https://doi.org/10.1002/ASE.1807>
- Shapiro, J., Rucker, L., & Beck, J. (2006). Training the clinical eye and mind: Using the arts to develop medical students' observational and pattern recognition skills. *Medical Education*, 40(3), 263–268. <https://doi.org/10.1111/J.1365-2929.2006.02389.X>
- Walker, J. D., Cotner, S. H., Baepler, P. M., & Decker, M. D. (2008). A delicate balance: Integrating active learning into a large lecture course. *CBE Life Sciences Education*, 7(4), 361–367. <https://doi.org/10.1187/CBE.08-02-0004>



The Power of 4 Questions During a 5-minute Meeting

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Abstract

A challenge that exists in higher education is the lack of relatability between students and teachers. This disconnect likely prevents students from asking for help before, during, and/or after class. One way to increase relatability between students and teachers is by having a simple 5-minute conversation during an individual meeting, where I asked four questions and listened to the answers. The purpose of these meetings was to foster a relationship between myself and my students, in the hopes that students would feel more comfortable asking for help during and outside of class.

Students were offered a small amount of extra credit to meet with their human physiology professor during the first three weeks of the semester. To earn extra credit, students had to 1) Sign up for a five-minute meeting using a link posted on Canvas, 2) Find the office of the professor, and 3) Answer four questions. Students did not know the questions before hand which were- 1) Where are you from? 2) What is your career goal? 3) What is something unique about yourself? 4) What was the highlight of your break?

During the 2022-23 academic year, I had ~350 individual meetings with students where I asked these four questions. In a follow-up, anonymous survey, a common theme from students was these meetings were beneficial because they became more comfortable, and it made them more likely to ask questions in the future. These meetings appeared to be effective at increasing student engagement during and outside of class. <https://doi.org/10.21692/haps.2023.016>

Key words: relatability, education

Introduction

The perceived lack of relatability between students and teachers can be a stumbling block to student success (Cooper et al., 2018; Miller & Mills, 2019). Students often think of teachers as the “sage on the stage,” which can prevent them from voicing questions or concerns, because they don’t want to look dumb (O’Shea, 2020; Paciulli et al., 2022). However, there are many different strategies that can be employed to combat this disconnect and allow teachers to become relatable to students. Teachers can become more relatable by incorporating simple strategies such as talking about their lives outside of the class, keeping up on pop culture, incorporating analogies from everyday life into their teaching, and/or using humor (Cooper et al., 2018; Hsu & Goldsmith, 2021). The strategy I have found most effective is having a short, 5-minute, individual meeting with students.

I teach a large-enrollment (~350 students) introductory physiology class. During the first two weeks of class, students are afforded an opportunity to earn a small amount of extra credit by meeting with me in my office during the first two weeks of the semester, where they will answer four questions. Students are frequently reminded about this opportunity via daily Canvas announcements and

in-class assignments. Additionally, I ask students who have completed this activity to encourage their classmates to complete it. While I don’t share the questions with them, I assure them they know the answers. These questions are all “getting to know you questions.”

1. Where are you from?
2. What is your major?
3. What are your career goals?
4. What was the highlight of your winter/summer break?

This requires students to find my office and have a face-to-face conversation with me. Often, answers to these questions have led to meaningful discussions, where we learn about each other, and find that relatability that was seemingly missing. Ultimately this puts students at ease, which increases the likelihood they will ask and answer questions during class or office hours. After the two weeks has passed, I share with the class some general information I have learned to show the class that I do care about them as people.

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While this is a relatively easy strategy to employ, some considerations need to be made. Instructors must block time off in their schedule when students can come visit. Originally, I told students they could come by office anytime I was on campus. This led to frustration because of the constant interruptions, which made it nearly impossible to complete other tasks since students were dropping in every 10-minutes throughout the entire day. I now block off specific times for students to come (i.e., 12:00 pm – 3:00 pm), and students can schedule 5-minute appointments using a direct link provided in Canvas LMS to the Bookings app available through Microsoft OneDrive®. During the first two weeks of the Fall 2022 and Spring 2023 semesters, I met with ~360 students (~50% of total enrollment over two semesters).

For this strategy to be most effective, instructors must be genuinely interested in learning about students. While it can get tiresome to continually ask the same questions, it helps to have a mindset that we are about to meet an incredible person and their unique story. For example, holding these meetings has allowed me to learn about students who-

- were excited because they had just been certified to drive forklift at their job.
- paid for college by being a surrogate.
- fear physiology more than anatomy.
- recently lost a child or spouse.
- felt like they had no support system.
- were first generation students with huge family support because they were going to be the first college graduate in their family.
- have plans of going to MD/PA/PT/OT/AT school.

As teachers we need to remember these experiences have shaped that student. These conversations often lead to more valuable, future discussions that likely improve student success. The individual relationship with a student that has been formed during this initial meeting in my office can be strengthened during conversations that have occurred in the few minutes before the start of class (i.e., how was it driving forklift this weekend?). This shows students I really did listen and do care about them and their success, which makes it more likely they will ask for help in and out of the classroom.

One of the most interesting parts of my conversations with students is the end. Since many students come to my office expecting the questions to be about physiology, they are a little confused when the conversation ends without discussing any physiology. Often, they ask if I can ask them the four questions for extra credit. I respond by telling them the “getting to know you” questions were the four questions. Students then realize my goal isn’t to determine their foundational knowledge. Instead, they recognize my goal is to get to know them and that they are important to me.

Perhaps the biggest benefit is this activity has allowed me to better understand students who are from underrepresented/underserved communities. Often these students are first generation, and/or do not have a support system in place. Many of these students feel like they are alone, and/or that attending school is ultimately pointless and might be expensive. While I can’t directly relate to their situations, I know I can support them. Conversations with these students have helped me understand their struggles, which demonstrates I believe in them, and makes it easier to come up with a collaborative blueprint for success.

Anecdotally, it appears that most students complete this exercise for the extra credit. However, I have received the following comments from students which suggest this meeting can have a very powerful effect.

- [Dr. Davis] was interested in his students and that he genuinely wanted everyone to be successful.
- I got to know Dr. Davis better and got more comfortable with being in his class.
- Dr. Davis felt more approachable.
- I became more comfortable, and it made me more likely to ask questions in the future.
- Honestly it made me more comfortable with [Dr. Davis].

Although the beginning of the semester, especially the fall semester, is extremely busy, I have found that investing this time at the beginning of the semester results in huge dividends throughout the semester, because it builds an individual relationship between me and each student, which increases the likelihood of success in the classroom.

Considerations

As described, this activity will not work for everyone. Instructors will likely have additional teaching, service, and/or research commitments, which might prevent them from setting aside large blocks of time to meet with students. One alternative would be to meet with students in small groups, instead of individually. While this might not be as powerful of an experience, it still provides the opportunity for students and the teacher to get to know one another.

Additionally, many classes are now offered in an online or hybrid format. It would be foolish to ask or require most students enrolled in these classes to come to campus and meet with the instructor. Many of these classes are composed of non-traditional students who might live in a different city, and/or have significant family and work responsibilities that limit their availability. However, there are alternatives that could be used. Instructors could ask students to meet with them via Zoom utilize a discussion board, and/or have a conversation via email. I believe there

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are two critical elements when setting up this activity. First, students need to see benefit in the activity. On its face, students will likely not see the benefit, which is why I offer a small amount of extra credit. Second, there needs to be a dialogue between instructor and student. It isn't enough for a student to answer these questions. Based on the answers the students provide, the instructor should be able to share something about themselves which will allow the students to relate to them.

Going forward, a study needs to be completed to quantify the benefits of this activity. This could be done via a short, anonymous survey that is given to all students regardless of whether they completed the activity. Data could be gathered to find out why students did or did not complete the activity, the grades of students who did or did not complete the activity, and what benefits came out of the activity (i.e., were they more less likely to attend office hours, ask questions in class). These findings would help determine how this activity could be modified to better accomplish its purpose.

About the Author

Jim Davis is an assistant professor in the Department of Anatomy, Cell Biology, and Physiology in the School of Medicine at Indiana University, Bloomington (IUSMB). Prior to joining the faculty at IUSMB in July 2022, Dr. Davis worked for 6 years as an assistant professor in the Department of Kinesiology, Recreation, and Sport at Indiana State University. During these seven years, Dr. Davis has primarily taught basic human physiology. His education research interests include exam retakes, use of a flipped classroom model in a large setting, and student engagement.

Literature Cited

- Cooper, K. M., Hendrix, T., Stephens, M. D., Cala, J. M., Mahrer, K., Krieg, A., et al. (2018). To be funny or not to be funny: Gender differences in student perceptions of instructor humor in college science courses. *PloS one*, 13(8), e0201258. <https://doi.org/10.1371/journal.pone.0201258>
- Hsu, J. L., & Goldsmith, G. R. (2021). Instructor strategies to alleviate stress and anxiety among college and university STEM students. *Cbe-Life Sciences Education*, 20(1), es1. <https://doi.org/ARTN es110.1187/cbe.20-08-0189>
- Miller, A. C., & Mills, B. (2019). 'If they don't care, I don't care': Millennial and generation Z students and the impact of faculty caring. *Journal of the Scholarship of Teaching and Learning*, 19(4), 78-89. <https://doi.org/10.14434/josotl.v19i4.24167>
- O'Shea, P. M. (2020). Flipped learning at the university level. *Flipped classrooms with diverse learners: International perspectives*, 171-181. <https://doi.org/10.1007/978-981-15-4171-1>
- Paciulli, L., Estrada, M., & Echols, H. (2022). Re-engage with your students by being more authentic and showing your humanity! <https://ofdblog.wordpress.ncsu.edu/2022/08/22/re-engage-with-your-students-by-being-more-authentic-and-showing-your-humanity/>



Lessons from the Pandemic: A Scoping Review on Online Student Assessment in Anatomy Education

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Abstract

The effectiveness of online anatomy teaching in acquiring knowledge and professionalism by medical and health sciences students has come under increased scrutiny by the educators' spotlight during the COVID-19 pandemic. Following the easing of COVID-19 restrictions, anatomy educators need to analyze their online experience to assure preparedness for similar situations or, more importantly, incorporate technical advances in their future curriculum designs to catch up with the rapidly evolving educational system. A fundamental component of this system that is a major determinant and driver of the learning process is assessment. Given the pre-pandemic debate about the effectiveness of assessment in the context of online anatomy courses, we ask the question: what are the different strategies of student assessment that were reported and/or evaluated in the literature regarding anatomy online teaching during the pandemic? The five-stage scoping review approach suggested by Arksey and O'Malley was implemented, and 41 titles were included out of 1755 searched titles. The review generated four themes: a) Assessment and examination standards in online anatomy courses, b) Student engagement and participation in formative assessment formats of online anatomy courses, c) Comparisons between in-person and online anatomy students' performance and d) Student and anatomy faculty perception about online anatomy assessment. There were many gaps in the reviewed reports that need attention in the future such as students' academic background needs, marks distribution, and the formative vs summative assessment contribution to the course outcome. Longitudinal studies to evaluate knowledge and professional attainment comparing online vs face-to-face approaches are lacking. Whenever online teaching of anatomy is considered, assessment strategies should be aligned to fit an online design, and both the faculty and the students need to be familiarized with the applied technologies. <https://doi.org/10.21692/haps.2023.012>

Key words: anatomy, COVID-19, assessment, performance, online education

Introduction

The introduction of online learning and assessment into undergraduate anatomy courses in medical and health sciences programs is not a new concept. It has been proposed and applied in different institutions worldwide before the COVID-19 pandemic (Attardi et al., 2018). The motivation behind applying online education in anatomy courses was to answer the increasing popularity and demand for distance learning and to keep up with advances in digital learning (Barbeau et al., 2013). Before the pandemic, several studies and reviews were published about the utilization of information technology resources in anatomy education in the form of online lectures and labs, anatomy software/applications or pre-recorded learning materials (Beale et al., 2014; Estai & Bunt, 2016; Johnson et al., 2013; Wilson et al., 2018). The outcomes of anatomy online learning were

as variable as the settings of these studies. Using online resources showed either better outcomes compared to conventional methods (Choi-Lundberg et al., 2016; Yammine & Violato, 2015) or non-superior outcomes combined with students' belief that online should not replace face-to-face anatomy course delivery (Attardi et al., 2016; Johnson et al., 2013; Langfield et al., 2018). Nonetheless, there was a common notion that, while integrating information technology resources into anatomy curricula is inevitable, several measures are needed to improve the online experience regarding students' engagement, access to the learning resources, and the assessment methodologies (Attardi et al., 2016; Chang Chan et al., 2019; Estai & Bunt, 2016).

Considering assessment as a major determinant and driver of

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the learning process (Ferris & O'Flynn, 2015) led to coining the concept of "assessment for learning" where both formative and summative assessment should serve the interest of the learning process (Walsh, 2015). Traditionally, the low-stakes formative assessment aims to monitor learning via mutual feedback between the student and the teacher while the high-stakes summative assessment helps to decide the competency of the student for an upgrade (Perera-Diltz & Moe, 2014; Walsh, 2015). Formative and summative assessments in modern medical education represent a continuous assessment process requiring active student engagement, motivation, and effective feedback (Castillo-Merino & Serradell-López, 2014; Perera-Diltz & Moe, 2014). Most of the studies that evaluated online anatomy education in the pre-pandemic era used online resources only for course delivery while the assessment component was done mostly in person, except for very few studies that reported conducting online summative assessments (Attardi et al., 2016; Johnson et al., 2013). Pre-pandemic reports showed that the utilization of online formative and summative assessments was still encountering many concerns about its credibility, effectiveness in engagement and communication, and suitability for anatomy and medical education (Attardi et al., 2016; Walsh, 2015; Yammine & Violato, 2015).

Unlike the voluntary application of online anatomy courses prior to the COVID-19 pandemic, the imposed restrictions to contain the spread of the virus starting spring of 2020 forced medical and health sciences schools to shift abruptly to an online course delivery format (Longhurst et al., 2020). Undoubtedly, advances in digital tools in teaching anatomy that were applied at some institutions before the pandemic have been very helpful in the transition from face-to-face to online anatomy course delivery, including virtual lectures, digital dissection, and online assessment (Harmon et al., 2021). However, the debate about the effectiveness of online anatomy education in supporting knowledge acquisition and professionalism by medical and health sciences students has strongly resurged under the educators' spotlight after the pandemic (Attardi et al., 2016; Jones, 2021; Walsh, 2015; Yammine & Violato 2015). This becomes particularly an issue when considering that anatomy teaching is a fundamental subject for health professionals.

Anatomy teaching was classically based on didactic lectures, real dissection, or interactive in-person demonstration classes coupled with different assessment methods of students' participation and knowledge gained through practical and theory examinations (Harrell et al., 2021). The application of the new online methods of assessment such as electronic voting applications, web-based annotated photographs, and interactive scenario-based online quizzes (Johnson et al., 2013), as well as virtual participation strategies, impose different challenges related to the familiarity of anatomy educators with these techniques and might prove to be time and cost-ineffective (Balta et al., 2021).

As we witness the gradual resolution and ease of COVID-19

restrictions, anatomy educators still need to study their experiences of online anatomy teaching and identify the benefits and the weaknesses they encountered during the pandemic. This is crucial to assure their preparedness for similar situations or, more importantly, to allow them to incorporate technical advances in their future anatomy curriculum designs to prepare technologically capable learners (Perera-Diltz & Moe, 2014). The one aspect of the pandemic experience we highlighted in this review is the anatomy online assessment experience during the pandemic. While a systematic review is meant to answer a well-defined question from relatively similar quality-assessed studies, a scoping review addresses a broader topic from different study designs that are not necessarily quality-assessed (Arksey & O'Malley, 2005). Given that the literature about anatomy online education during the pandemic included a wide variety of anatomy subjects, diverse teaching approaches, and different assessment methodologies, we found that a scoping review approach was suitable for the study purpose. Therefore, we aim in this scoping review to examine the extent of reporting students' assessment methodologies and the strategies used to evaluate knowledge and skills acquisition in the published anatomy education studies from the COVID-19 pandemic.

Methods

Review protocol

This scoping review followed the five-stage scoping review approach suggested by Arksey and O'Malley (2005) as explained below.

1. Identification of research questions
We tried to answer the following question in our scoping review: What are the different students' assessment strategies that were reported and/or evaluated in the literature regarding anatomy online teaching during the pandemic for the undergraduate medical and health sciences programs?
2. Identification of relevant studies
An electronic web search was done using: CINAHL, EMBASE, ERIC, PubMed, Scopus, and Web of Science databases. Articles published from April 2020 to December 2022 were included using the following keywords: (anatomy education) AND (COVID-19) AND (student assessment). The eligibility criteria included published original articles, commentaries/letter to editor or guidelines, and studies on online anatomy courses during the COVID-19 pandemic conducted for medical, dental, and health sciences undergraduate students since 2020. The studies should be published in English reporting students' assessment, or evaluation of anatomy exclusively. Postgraduate programs were excluded to avoid bias caused by previous knowledge of anatomy in undergraduate-level programs. Reviews on online

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anatomy education or assessment were excluded from the theme synthesis; however, some reviews were referenced to acknowledge similar work.

3. Selection of specific studies

Title search in the 6 databases performed by AM and MZ resulted in 1755 titles that met the reach of the keywords. After removing the duplicates, 1688 titles entered the abstract screening phase (GT and JB) to ensure fulfilling inclusion criteria and a further 1620 articles were eliminated. Next, a full-text screening was performed on 68 articles by three independent authors (AM, GT, and MZ) to decide the studies to be included in the review and to be eligible for data charting. An article was included if it was decided eligible by at least two authors. The review protocol was documented and is available upon request.

4. Data charting

This process was done while the three authors conducted the full-text screening (AM, GT and MZ). Data was extracted into a Google form that included author(s), year and month of publication, geographical location, type and design of the study, main outcomes/results, identification of main themes, and the most relevant findings/outcomes/recommendations pertinent to the subject of our scoping review. For variables with a controversy between authors, a discussion among the team was carried out to reach a consensus.

5. Collating, summarizing, and reporting

The extracted data from the web form were used to produce a descriptive analysis of the articles' characteristics, study types, and the geographical distribution of the reviewed articles. Then the themes that were identified by the three authors who performed the data charting were collated and compared. Based on similarities in these themes, four main themes were defined for the review, as described later.

Results

Literature search and article selection

The initial count of titles identified by the title search was 1755, out of which only 41 titles were included in the review after excluding 67 duplicates, 1620 titles through the abstract screening process and finally 25 titles after the full-text screening. The reasons for exclusion at the full-text screening were "The study was not specific about anatomy" (n = 2), "Nothing on assessment" (n = 10), "Not about undergraduate students" (n = 1), "Assessment mentioned in the keywords but not tested in the text" (n = 2), "Study conducted before COVID-19 pandemic/not online" (n = 5) or "Review article" (n = 5). Figure (1) illustrates the steps followed to conduct the review process.

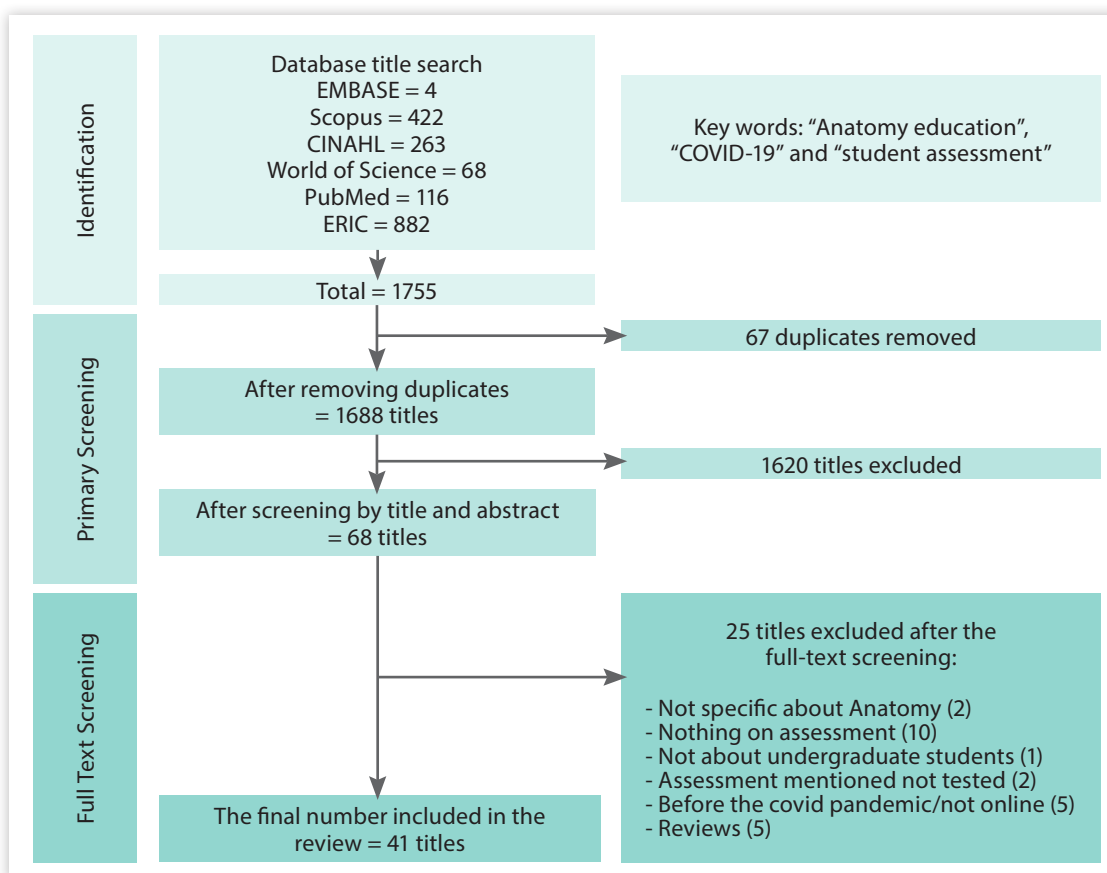


Figure 1. Schematic presentation of the review process using a PRISMA flow chart.

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The majority of the articles were original articles (n = 38, 92.7%) and the other two fell under “guidelines/practical tips” and “letters to editor/commentary/viewpoint”. Regarding the study design, cross-sectional/survey was the most common (n = 28, 68.3%) followed by cohort and case report studies (n = 6 and n = 3, 14.6% and 7.3%, respectively; Table 1). Geographically, about 20% of the studies were conducted in the United States (n = 8) followed by India (n = 6, 14.6%) and the United Kingdom (n = 5, 12.2%). China and the Kingdom of Saudi Arabia each contributed 3 articles (7.3%). Other countries contributed two or one as shown in Table 2.

Type of Study	n (%)
Original Article	38 (92.7%)
Guidelines/practical tips	2 (4.9%)
Letter to editor/commentary/viewpoint	1 (2.4%)
Study Design	n (%)
Cross-sectional/survey	28 (68.3%)
Cohort study	6 (14.6%)
Case report	3 (7.3%)
Not identified	4 (9.8%)

Table 1. Type and study design of the final titles included in the review.

United States of America	8 (19.5%)
India	6 (14.6%)
United Kingdom	5 (12.2%)
China	3 (7.3%)
Saudi Arabia	3 (7.3%)
Egypt	2 (4.9%)
Germany	2 (4.9%)
South Korea	2 (4.9%)
Turkey	2 (4.9%)
Australia	1 (2.4%)
Bahrain	1 (2.4%)
Italy	1 (2.4%)
Oman	1 (2.4%)
Pakistan	1 (2.4%)
South Africa	1 (2.4%)
Taiwan	1 (2.4%)
United Arab Emirates	1 (2.4%)

Table 2: Countries of origin of the included titles in descending order.

Main themes of the review

Screening of the articles identified a good number of articles ($n = 1688$) in the literature that addressed the topic of medical education during the COVID-19 pandemic. A good proportion of these publications focused on anatomy education and the related challenges encountered during the pandemic restriction and the sudden shift to online education. However, the number of articles that specifically dealt with the students' assessment of anatomy online education for undergraduate medical and allied health science was relatively limited. We found that these articles did not principally discuss online assessment only, but other aspects were also highlighted that we found relevant to include (students' engagement and participation as means of the continuous formative assessment process) as they are closely related to the assessment process (Conard & Openo, 2018, Rahim, 2020).

In an attempt to evaluate the effectiveness of online anatomy education, several educators compared the students' performance when taking in-person courses conducted before the pandemic or during the pandemic vs their performance in absolute online anatomy courses conducted during the pandemic. In addition, the majority of the selected studies collected feedback from the students and faculty about the process of assessment, which we strongly believe adds value to the evaluation of the assessment process as a true reflection by those who lived through the experience. Thus, the four themes that were produced were: a) Examination standards and summative assessment in online anatomy courses, b) Student engagement in the formative assessment of online anatomy courses, c) Comparisons between in-person and online anatomy students' performance, and, d) Student and anatomy faculty perception about online anatomy assessment. A summary of the included studies and their main findings pertinent to this scoping review can be found in Appendix 1.

Theme 1: Examination standards and summative assessment in online anatomy courses.

Online examination was not entirely a novel trend in anatomy courses. As reported by Yan et al. (2021), about 50% of anatomy educators used online assessment before the pandemic. The pandemic restrictions forced most anatomy departments worldwide to conduct online theory and practical examinations (Longhurst et al., 2020; Yan et al., 2021), except for some universities that either cancelled their summative examinations (Cheng et al., 2021; Harmon et al., 2021; Longhurst et al., 2020) or conducted on-campus exams following an online or blended anatomy course (Chang et al., 2022; Messerer et al., 2022; Yun et al., 2022).

Strength, weakness, opportunity, and threat (SWOT) analysis identified the online assessment of anatomy courses as one of the weaknesses of the pandemic teaching experience by 14% of institutions that adopted online anatomy teaching. This led 36% of the institutions to cancel the summative element of their exams while 21% changed to online assessment to maintain progression with the teaching format. Responding institutions justified their decisions by stating that teaching activities and assessment tasks could lose the necessary constructive alignments between expected competencies and assessment with the sudden switch to online evaluation (Longhurst et al., 2020). Furthermore, cheating was one of the main worries of online assessment (Pather et al., 2020). This concern led educators to employ invigilation via cameras or invigilation software or shuffling answers to minimize the chances of cheating (Mishall et al. 2022; Roy et al., 2020).

Nonetheless, the development of new online alternative assessment methodologies and formats was considered an opportunity for the anatomy online education experience (Longhurst et al., 2020) and was recommended by anatomy educators (Mishall et al., 2022). The reported format of online anatomy assessment was versatile reflecting the effectiveness of advanced technologies for developing new assessment tools. However, the summative assessment structure did not show a clear difference in their format between before and during the pandemic in anatomy departments at different locations (Harmon et al., 2021). Theory exams followed mainly the following formats: multiple-choice questions (MCQs), extending matching questions (EMQs), single-answer questions (SAQs), single-best-answer (SBAs), USML-type questions (testing knowledge, comprehension and application aspects corresponding to Bloom's levels 1, 2 and 3, respectively) and open-book exams (that should be testing critical thinking) (Cheng et al., 2021; Harmon et al., 2021; Harrell et al., 2021; Longhurst et al., 2020; Memon et al., 2021; Naidoo et al., 2021). Adding images-based MCQs to an online summative assessment format was an advantage as it helped to improve student performance and their comprehension of applied anatomy compared to text-only MCQs (Magi et al., 2022).

Interestingly, online course delivery and the conversion of different summative examination formats from paper to the computer did not cause a change in medical students' learning approach where the majority showed deep or strategic learning approaches compared to 15% showing surface or mixed approaches, a distribution comparable to pre-pandemic reports (Stone et al., 2022). Practical online examinations were video-based or image-based exams, in addition to viva voce (Ediger and Rockwell, 2020; Harrell et al., 2021). Rabbani et al. (2022) compared the discriminative

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index (DI) from three formats of summative exams used before and during the pandemic (MCQs, Essay and Viva Voce) and found that online viva voce examinations outperformed online MCQs and short essays. The authors linked that to the chance of cheating on online written exams while students experienced less stress and anxiety during online viva voce exams (Rabbani et al., 2022). To avoid possible inflation of online summative examination grades, pass/fail course evaluation was considered an alternative (Mishall et al., 2022). The comparison between online versus in-person anatomy courses regarding their effectiveness and users' perspectives are discussed in the following themes.

Theme 2: Students' engagement in the formative assessment of online anatomy courses.

Applying the formative assessment style in online education is recommended to improve student learning and engagement (Mishall et al., 2022). This was achieved by increasing the frequency of active learning practices whilst allotting special classes to discuss exam questions and provide feedback (Cheng et al., 2021; Ediger & Rockwell, 2020; Naidoo et al., 2021). However, a noticeable reduction in student engagement during online lectures and laboratory demonstrations was reported frequently (Ghosal et al., 2021; Singal et al., 2021) and was considered as a challenge by 36% of responses from different universities (Longhurst et al., 2020). Unluckily, only a few studies have directly evaluated or measured student engagement in anatomy online sessions (Cheng et al., 2021; Harrell et al., 2021; Naidoo et al., 2021).

Remarkably, anatomy educators took early steps to modify their course design and syllabi to optimize student engagement during online theory and practical classes. Adjusting the curricular design into a student-centric approach (where the student's interest is what drives the education) to fit online delivery through a versatile distant learning framework was implemented by Naidoo et al. (2021) by integrating the principles of the Analyse, Design, Develop, Implement, and Evaluate (ADDIE) instructional model. Furthermore, other anatomy educators described the integration of more active learning sessions into their courses such as flipped classrooms, problem-based learning (PBL), team-based learning (TBL), near-peer teaching, and small group discussion classes (Al-Neklawy & Ismail, 2022; Alsharif et al., 2020a; Cheng et al., 2021; Harrell et al., 2021; Stevenson et al., 2022). To ensure the maximum benefit of integrating active learning into the anatomy online courses, Ediger and Rockwell (2020) highlighted the importance of onboarding of students and staff to familiarize them with online course delivery and improve the student-faculty interaction during online classes. Another study emphasized the need to adjust the lecture material to give more time for student interaction and engagement (Cheng et al., 2021).

During online classes, course instructors utilized variable applied technologies to enhance active participation by students such as real-time interaction via written or voice chat, Zoom polls, embedding questions in PowerPoint presentations, 3-dimensional (3D) dissection videos, and collaborative annotation on anatomy diagrams (Alsharif et al., 2020; Chan et al., 2021; Cheng et al., 2021; Harrell et al., 2021; Yoo et al., 2021). Another innovative approach to boost student participation was to engage students in the preparation of the teaching material, instruction, and assessment in a neuroanatomy online course (Border et al., 2021). The authors stated that enriching formative assessment in online anatomy courses has improved the students' ability to integrate anatomy into clinical sciences and enhanced their performance (Border et al., 2021). Likewise, online near-peer teaching followed by online assessment was also reported in undergraduate courses, but no significant differences in test scores compared to the in-person course format were identified (Stevenson et al., 2022; Thom et al., 2021). Adding group assignments, report writing or short answer quizzes at the end of the unit to the online anatomy course was seen to increase students' interactions in a formative assessment context (Boulos, 2022; Zhang et al., 2022). Online formative assessments, as opposed to summative assessments, have motivated medical students by promoting the deep learning style (as they think critically and become intrinsically motivated to understand the meaning and monitor their learning) and allowing for more feedback and self-assessment (Stone et al., 2022).

Theme 3: Comparisons between in-person and online anatomy students' performance.

When compared to anatomy courses provided and evaluated in person before the pandemic, the switch to online delivery produced either improved scores (Boulos, 2022; Chang et al., 2022; Memon et al., 2021; Naidoo et al., 2021; Relucenti et al., 2022) or no significant difference (Bhat et al., 2022; Messerer et al., 2022; Stevenson et al., 2022; Thom et al., 2021; Yoo et al., 2021; Zhang et al., 2022). The increased capacity for self-learning, student relaxation in response to lower stress levels, and the availability of online study materials for students to use at their convenience were cited as factors contributing to better results in both theory and practical tests (Boulos, 2022; Yoo et al., 2021).

Other factors that were related to better online performance were the examination settings and the utilization of blended teaching (online and restricted in-person). Students performed better on image-based online MCQs than on text-based ones in terms of grades (Magi et al., 2022). Alblushi et al. (2022) reported that non-proctored online exams caused inflation of the students' scores while they observed no difference in

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scores or knowledge gain between online and in-person exams when the online exams were proctored virtually. The blended approach was found to be beneficial to summative exam performance and student confidence by Bhat et al. (2022) and Schulte et al. (2022) where an online theory course was followed by restricted in-person teaching or dissection demonstration. However, Yun et al (2022) reported that in-person theory exam scores following a blended anatomy course were inferior to previous years when the course teaching and assessment were conducted on-campus. Despite the preference for 3D applications by faculty and students, their usage did not significantly affect theory exam performance between 3D application users and non-users (Rosario, 2021).

If we consider the practical components of assessment in other studies, contradictory results can be seen. According to Potu et al. (2022), student scores on online MCQs significantly improved, while practical test results were comparable to pre-pandemic course scores. On the other hand, while no significant difference in theory scores was noticed, students performed better with video-based practical exams compared to their scores on in-person exams before the pandemic (Harrell et al., 2021; Yun et al., 2022). Other studies reported better lab performance for the in-person approach compared to the online image-based practical exams which could be due to technical limitations such as internet and image quality (Sadeesh et al., 2021; Stokes & Silverthorn, 2021).

In general, studies that provided a structured comparison between anatomy course scores before and during the pandemic are limited in the literature. Furthermore, careful interpretation of these results needs to be considered. Despite a higher pass rate in the online anatomy course observed by Fisher et al. (2022), the marks distribution did not show a significant difference between the two modes of course delivery indicating that the course proficiency was not improved with the online teaching or assessment.

Theme 4: Student and anatomy faculty perception of online anatomy assessment.

Most of the included studies had conducted surveys to obtain students and anatomy faculty feedback to evaluate different aspects of the online anatomy course delivery, assess their level of satisfaction, and provide suggestions for improvement (Mishall et al., 2022). In general, student feedback was positive regarding the application of online course delivery and assessment, and they generally believed that it helped overcome the pandemic situation (Ghosal et al., 2021; Naidoo et al., 2021; Stone et al., 2022). A blended online format (with limited in-person dissection) was preferred by medical students as the course materials were more accessible giving the students more freedom to plan their study time, and it increased their confidence

(Schulte et al., 2022; Yoo et al., 2021;). Similarly, online teaching was seen by 50% of the students as an effective tool in preparing them for the final exam and 62% of students found that assessment was linked to the online taught material (Asharif et al., 2022b). Others considered 3D applications and videos to remarkably facilitate the reading and the understanding of anatomy topics (Chan et al., 2021; Rosario et al., 2021).

However, other students preferred offline courses as they found online courses a poor learning experience and complained about the lack of proper references or reading materials (Ghosal et al., 2021). While prompt, comfortable, enjoyable, and effective communication through online tools such as chat, emails, and active sessions (such as TBL) was seen as an advantage for online courses (Al-Neklawy & Ismail, 2022; Cheng et al., 2021; Ghosal et al., 2021), the contrary was felt by other students who found it less interactive with peers and faculty, imparting a poor discussion atmosphere, especially when they compared it to the real cadaveric dissection classes and in-person practical sessions (Sadeesh et al., 2021; Singal et al., 2021; Thom et al., 2021). The latter deficiency of online practical teaching made 50% of students report encountering “little” to “a lot of problems” in their practical exams (Yan et al., 2022) and more than 50% of them voted against online practical examinations (Özen et al., 2022a).

Moreover, students preferred online theory exams as they were easier (Ghosal et al., 2021; Özen et al., 2022a), image-based vs text-based MCQs (Magi et al., 2022), video-based practical exams compared to image-based (Chan et al., 2021; Harrell et al., 2021) and online viva voce exams (Sadeesh et al., 2021). On the flip side, students were equally divided about the difficulty level of the online exams, and they also did not trust online evaluation and had a strong preference for cadaveric examinations over the 2D printed dissection images (Özen et al., 2022a; Sadeesh et al., 2021; Singal et al., 2021). Contradictory reviews by the students on the application of assignments as a formative assessment method in online anatomy courses were reported, where it was evaluated positively by Boulos (2022) and negatively by Zhang et al. (2022). Online near-peer teaching was not favoured by students, and they preferred it to be in-person (Stevenson et al., 2022).

Anatomy faculty showed variability in appraising online course delivery, yet they commonly believed that they have improved their technical knowledge and were introduced to interesting innovative methods of teaching and assessment, despite the variable familiarity with technology among anatomy educators (Dulohery et al., 2021; Memon et al., 2021). They reported, however, that online course delivery negatively affected student-faculty interaction and their ability to mentor students' progress, relationships that are crucial for developing

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students' professionalism and proper communication skills. Along with the previous point, technical difficulties and unexpected failures rendered online platforms a nonstable teaching environment for some (Roy et al., 2020; Yan et al., 2021) and they needed to improve their online assessment skills (Alsharif et al., 2022). In addition, preparing online teaching material increased their workload (Yan et al., 2021).

Even though they were simpler to administer, only 5% of the faculty thought that students could demonstrate their competency through online exams because they were unreliable (Roy et al., 2020). Anatomy educators were equally divided regarding the effectiveness of an online anatomy course (Cheng et al., 2021). Regarding their choice of conducting online assessments, 61% of anatomy faculty considered online practical exams as a poor option while 47% thought the same about theory online exams (Özen et al., 2022b). While it can be discerned that anatomy educators are cautious about online assessment in general, Mishall et al. (2022) recommended that evidence-based online assessment be incorporated in online anatomy courses so as to enrich the formative styles with instant feedback and to align the learning approaches with the online assessment methods.

Discussion

This review included 41 studies about student assessment in online anatomy courses during the COVID-19 pandemic published between April 2020 and December 2022, a good number that reflects the enthusiasm of anatomy educators for evaluating their experiences. The title search produced plenty of studies that evaluated students' performance in online medical courses, but the focus of this review was on anatomy education which resulted in the exclusion of several high-quality articles and significant reviews about this matter. Anatomy teaching is unique among basic medical sciences as it classically involves in-person teaching activities and real-time study of 3D structures during dissection labs and practical exams (Harrell et al., 2021). Nevertheless, anatomy education is inevitably subject to the incorporation of online teaching and assessment tools with technological advancement and the current trend of curricular development in higher education (Barbeau et al., 2013).

The COVID-19 pandemic was a great opportunity for anatomy educators to accelerate the integration of online pedagogy while benefiting from the strengths and overcoming the weaknesses encountered during the lockdown (Longhurst et al., 2020). Careful evaluation of the reported course designs and assessment tools would also ensure optimal learning experiences and readiness of anatomy educators for similar emergencies in the future. Anatomy educators responded promptly to the pandemic by publishing useful recommendations and guidelines for best practices for a smooth transition from in-person to online course

designs (Mishall et al., 2022; Rahim, 2020; Wadi et al., 2020). However, we need more reports that verify the outcomes of implementing these strategies in real life and validate their applicability and effectiveness through longitudinal and follow-up studies. Obviously, despite the presence of good-quality reports, the available literature currently is not enough to analyse the whole experience and decide whether these results were only pandemic-related or could lead to a persistent change in anatomy education (Harmon et al., 2021).

It is well recommended that online assessment follows evidence-based guidelines to answer the main purpose of the assessment which is indeed a driver for learning and a fundamental determinant of the quality of learning (Ferris and O'Flynn, 2015; Mishall et al., 2022). Briefly, these guidelines state that assessment should be planned only after evaluating the technical prerequisites for online implementation, ensuring alignment of assessment methods and learning outcomes, addressing students' diversity, balancing formative and summative assessments with suitable formats, stimulating learning and communicating clearly with the students, selecting suitable ambience for the exam, providing high-quality feedback, and validating the assessment methods (Mishall et al., 2022; Rahim, 2020).

We found in a few reports that examinations were taken from their written, cadaver-based format into online MCQ, 2D image format, keeping the most weight on summative assessments. Furthermore, analyses and comparisons of the online scores did not show stratification of students according to other demographics such as housing, socioeconomic status, or internet accessibility. Studies on online gross anatomy and histology courses prior to the COVID-19 pandemic showed that the prediction of anatomy scores was mainly affected by students' characteristics revealed by previous academic performance, not by the instructional method (Attardi et al., 2018; Barbeau et al., 2013). It is also believed that motivation, among other factors, is the main variable that significantly determines students' performance in e-learning (Castillo-Merino & Serradell-López, 2014). We believe that future reports about the assessment outcomes of anatomy online education should take these important points into consideration.

Moreover, it is indisputable that no one assessment method can fit all purposes and, different formats of assessment have pros and cons (Ferris & O'Flynn, 2015). In this review, different methods of assessment were adopted by anatomy educators with suitable utilization of features provided by the internet. However, we agree with many reports that more formative assessment can be implemented throughout online anatomy courses to ensure student learning and to allot more time for constructive feedback which is equally essential for both students and faculty (Alsharif et al., 2020). In accordance with Van Der Vleuten's formula of assessment utility (Van Der Vleuten, 1996), it is advisable that during a crisis, such as the COVID-19 pandemic, we focus more on the reliability,

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educational impact, and accessibility aspects of the selected assessment methods (Wadi et al., 2020).

Regardless of the finding that the methods used to ensure students' engagement were variable and prompt, students and educators still felt that these methods were not as effective as in-person settings (Ghosal et al., 2021; Roy et al., 2020). Student engagement in online anatomy courses was evaluated as a threat (Longhurst et al., 2020) and anatomy educators need to consider improvements to the curricular design to guarantee more student participation in the classes. Notably, more effective participation was achieved in anatomy online courses where student participation and active learning were principal components of the design such as PBL or TBL and when the course was designed to meet Analyse, Design, Develop, Implement, and Evaluate (ADDIE) instructional model, or to include assignments (Boulos, 2022; Cheng et al., 2021; Naidoo et al., 2021). Optimal utilization of technology such as 3D dissection videos improved student engagement as well (Chan et al., 2021). Studies that tried to correlate student participation in online classes during the pandemic with their academic performance are lacking.

As a crucial aspect of any assessment process, student and faculty feedback must be meticulously reviewed so we can incorporate online strength features in future anatomy courses regardless of crisis restrictions. Some of these useful features are 3D dissection videos, the availability of lecture recordings for future reference, the variability of communication tools, 3D anatomy applications, and the easier administration of online exams. On the other hand, there is a great scope for improvement given that online anatomy teaching and assessment was one of the opportunities to improve anatomy education (Longhurst et al., 2020). Among the aspects that anatomists need to consider is getting more familiar with new digital education tools to help engage and motivate learning, identifying students' needs and defining their technical shortages before implementing an online course (Mishal et al., 2022; Özen et al., 2022b). Online courses need to be equally accessible to all students, and anatomy educators should create a sound and encouraging atmosphere to communicate with students and listen to their academic and personal needs (Cheng et al., 2021).

Important educational aspects that were poorly reported in the reviewed reports

There were many important aspects that we found insufficient in the available literature about this topic. As mentioned earlier, considering student diversity and previous academic backgrounds need to be included in any analyses of assessment outcomes. Stratifying students according to their gender, socioeconomic status, or ethnicity was done infrequently. However, we can observe that preference for traditional teaching was reported in developing countries or when access to technology or the internet was not limited

in rural areas (Sadeesh et al., 2021). The breakdown and marks distribution were missing in many studies and the formative vs summative assessment contribution to the course outcome was hardly highlighted. More longitudinal studies to evaluate knowledge and professional attainment would be an interesting field of research to compare students exposed to offline and online anatomy courses. As several studies reported the technical difficulties encountered by students as well as faculty, anatomy faculty need also to ensure familiarizing students and colleagues about any change in learning and assessment methodology ahead of its implementation. The measures taken to fulfil this requirement need to be clearly reported and correlated with the outcome parameters.

Strengths and limitations

The review followed the five stages of a scoping review (Arksey & O'Malley, 2005) and the duration of review production started with the title search on October 27 2021 to December 2022 followed by the production of the review in two phases to include articles that were published later.

Certain limitations were encountered during this review. The keywords retrieved a huge number of articles but unfortunately, the final number to be used was relatively low ($n = 41$). We believe that some reports could have been missed due to differences in the keywords or publication languages. Even though anatomy can not be separated from other medical sciences and some reports included data on anatomy as a component of the curriculum, we abided with the inclusion criteria to include studies exclusively reporting anatomy courses for the undergraduate level and this resulted in excluding important reports.

Conclusion:

Anatomy education witnessed a great challenge during the COVID-19 pandemic to convert what was essentially in-person instruction to totally online course delivery. In spite of the different methods to enhance student engagement, students and faculty still felt that these measures were suboptimal. The assessment was equally affected by the sudden transition to an online format as the speed of transition was considered a potential weakness that may not have permitted careful selection of the assessment tools, a balance between summative and formative assessment, minimizing the chances for misconduct and cheating, and enriching the course design with tools of assessment. The inevitable utilization of the online approach in future anatomy undergraduate curricula should follow careful planning to ensure effective students' engagement and abide by the basic guidelines of the online assessment. The online experience that anatomists had during the pandemic opened the door wide for fundamental improvements in future modernized anatomy curricular designs.

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Literature Cited

- Al-Neklawy, A. F., & Ismail, A. S. A. (2022). Online anatomy team-based learning using blackboard collaborate platform during COVID-19 pandemic. *Clinical Anatomy*, 35(1), 87-93. <https://doi.org/10.1002/ca.23797>
- Albalushi, H., Al Mushaiqri, M., Sirasanagandla, S. R., & Das, S. (2022). Students' performance in face-to-face, online, and hybrid methods of teaching and assessment in anatomy. *International Journal of Environmental Research and Public Health*, 19(20), Article e13318. <https://doi.org/10.3390/ijerph192013318>
- Alsharif, M. H. K., Gasmalla, H. E. E., Elamin, A. Y., Almasaad, J. M., & Elhag, A.E. (2020). In light of COVID-19 crisis: Proposed guidelines for the "new norm" of anatomy teaching. *Medical Science* 24(105), 3281-90. <https://pesquisa.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/pt/covidwho-1022661>
- Alsharif, M.H.K., Gasmalla, H.E.E., Almasaad, J.M., Muhammad, J.S., Elamin, A.Y., Alamro, A. et al. (2022a). Online anatomy education in the COVID-19 pandemic: Challenges and suggested practices as per student and faculty experiences in the Saudi Arabia and United Arab Emirates. *Education in Medicine Journal*, 14(2), 61-77. <https://doi.org/10.21315/eimj2022.14.2.5>
- Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology*, 8(1), 19-32. <https://doi.org/10.1080/1364557032000119616>
- Attardi, S.M., Barbeau, M. L., & Rogers, K. A.. (2018). Improving online interactions: Lessons from an online anatomy course with a laboratory for undergraduate students. *Anatomical Sciences Education*, 11(6), 592-604. <https://doi.org/10.1002/ase.1776>
- Attardi, S. M., Choi, S., Barnett, J., & Rogers, K.A. (2016). Mixed methods student evaluation of an online systemic human anatomy course with laboratory. *Anatomical Sciences Education*, 9(3), 272-285. <https://doi.org/10.1002/ase.1584>
- Balta, J. Y., Supple, B., & O'Keeffe, G.W. (2021). The universal design for learning framework in anatomical sciences education. *Anatomical Sciences Education*, 14(1), 71-78. <https://doi.org/10.1002/ase.1992>
- Barbeau, M. L., Johnson, M., Gibson, C., & Rogers, K.A. (2013). The development and assessment of an online microscopic anatomy laboratory course. *Anatomical Sciences Education*, 6(4), 246-256. <https://doi.org/10.1002/ase.1347>
- Beale, E. G., Tarwater, P. M., & Lee, V.H. (2014). A retrospective look at replacing face-to-face embryology instruction with online lectures in a human anatomy course. *Anatomical Sciences Education*, 7(3), 234-241. <https://doi.org/10.1002/ase.1396>

continued on next page

- Bhat, G. M., Bhat, I. H., Shahdad, S., Rashid, S., Khan, M. A., & Patloo, A.A. (2022). Analysis of feasibility and acceptability of an e-learning module in anatomy. *Anatomical Sciences Education*, 15(2), 376-391. <https://doi.org/10.1002/ase.2096>
- Border, S., Woodward, C., Kurn, O., Birchall, C., Laurayne, H., Anbu, D. et al. (2021). Working in creative partnership with students to co-produce neuroanatomy e-learning resources in a new era of blended learning. *Anatomical Sciences Education*, 14(4), 417-425. <https://doi.org/10.1002/ase.2090>
- Boulos, A. N. (2022). Evaluation of the effectiveness of online education in anatomy for medical students during the COVID-19 pandemic. *Annals of Anatomy-Anatomischer Anzeiger*, 244, Article e151973. <https://doi.org/10.1016/j.aanat.2022.151973>
- Castillo-Merino, D., & Serradell-López, E. (2014). An analysis of the determinants of students' performance in e-learning. *Computers in Human Behavior*, 30, 476-484. <https://doi.org/10.1016/j.chb.2013.06.020>
- Chan, V., Larson, N. D., Moody, D. A., Moyer, D. G., & Shah, N. L. (2021). Impact of 360° vs 2D videos on engagement in anatomy education, *Cureus*, 13(4), Article e14260. <https://doi:10.7759/cureus.14260>
- Chang Chan, A. Y-C., Custers, E. J. F. M., van Leeuwen, M. S., Bleys, R. L. A. W., & ten Cate, O. (2019). Does an additional online anatomy course improve performance of medical students on gross anatomy examinations? *Medical Science Educator*, 29, 697-707. <https://doi.org/10.1007/s40670-019-00751-z>
- Chang, M-F., Liao, M-L., Lue, J-H., & Yeh, C-C. (2022). The impact of asynchronous online anatomy teaching and smaller learning groups in the anatomy laboratory on medical students' performance during the Covid-19 pandemic. *Anatomical Sciences Education*, 15(3), 476-492. <https://doi.org/10.1002/ase.2179>
- Cheng, X., Chan, L. K., Pan, S-Q., Cai, H., Li, Y-Q., & Yang, X. (2021). Gross anatomy education in China during the Covid-19 pandemic: A national survey, *Anatomical Sciences Education*, 14(1), 8-18. <https://doi.org/10.1002/ase.2036>
- Choi-Lundberg, D. L., Cuellar, W. A., & Williams, A-M. M. (2016). Online dissection audio-visual resources for human anatomy: Undergraduate medical students' usage and learning outcomes. *Anatomical Sciences Education*, 9(6), 545-554. <https://doi.org/10.1002/ase.1607>
- Conrad, D., & Openo, J. (2018). *Assessment strategies for online learning: Engagement and authenticity*. Athabasca University Press. <https://doi.org/10.15215/aupress/9781771992329.01>
- Dulohery, K., Scully, D., Longhurst, G. J., Stone, D. M., & Campbell, T. (2021). Emerging from emergency pandemic pedagogy: A survey of anatomical educators in the United Kingdom and Ireland, *Clinical Anatomy*, 34(6), 948-60. <https://doi.org/10.1002/ca.23758>
- Ediger, T. L., & Rockwell, K. A. (2020). Re-designing a 2-semester anatomy and physiology lab course for the online environment, *HAPS Educator*, 24(3), 75-82. <https://eric.ed.gov/?id=EJ1282950>
- Estai, M., & Bunt, S. (2016). Best teaching practices in anatomy education: A critical review. *Annals of Anatomy-Anatomischer Anzeiger*, 208, 151-157. <https://doi.org/10.1016/j.aanat.2016.02.010>
- Ferris, H., & O'Flynn, D. (2015). Assessment in medical education; What are we trying to achieve? *International Journal of Higher Education*, 4(2), 139-144. <https://doi.org/10.5430/ijhe.v4n2p139>
- Fisher, D., Solomons, D., & Makhathini, K.B. (2022). Face-to-face versus online-based lectures: A COVID-19 induced study on assessments. *Frontiers in Education*, 7, Article e1045311. <https://doi.org/10.3389/feduc.2022.1045311>
- Ghosal, T., Sadhu, A., Mukherjee, P., & Mukhopadhyay, P. (2021). Assessment of online learning procedure through the eyes of medical students in COVID-19 scenario. *Journal of Clinical and Diagnostic Research*, 15(5), AC01-AC05. <https://pesquisa.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/pt/covidwho-1227171>
- Harmon, D. J., Attardi, S. M., Barremkala, M., Bentley, D. C., Brown, K. M., Dennis, J. F. et al. (2021). An analysis of anatomy education before and during Covid-19: May–August 2020. *Anatomical Sciences Education*, 14(2), 132-147. <https://doi.org/10.1002/ase.2051>
- Harrell, K. M., McGinn, M. J., Edwards, C. D., Foster, K. W., & Meredith, M.A. (2021). Crashing from cadaver to computer: Covid-driven crisis-mode pedagogy spawns active online substitute for teaching gross anatomy. *Anatomical Sciences Education*, 14(5), 536-551. <https://doi.org/10.1002/ase.2121>
- Johnson, I. P., Palmer, E., Burton, J., & Brockhouse, M. (2013). Online learning resources in anatomy: What do students think? *Clinical Anatomy*, 26(5), 556-563. <https://doi.org/10.1002/ca.22219>
- Jones, D. G. (2021). Anatomy in a post-Covid-19 world: Tracing a new trajectory, *Anatomical Sciences Education*, 14(2), 148-153. <https://doi.org/10.1002/ase.2054>
- Langfield, T., Colthorpe, K., & Ainscough, L. (2018). Online instructional anatomy videos: Student usage, self-efficacy, and performance in upper limb regional anatomy assessment. *Anatomical Sciences Education*, 11(5), 461-470. <https://doi.org/10.1002/ase.1756>

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- Longhurst, G. J., Stone, D. M., Dulohery, K., Scully, D., Campbell, T., & Smith, C.F. (2020). Strength, weakness, opportunity, threat (SWOT) analysis of the adaptations to anatomical education in the United Kingdom and Republic of Ireland in response to the Covid-19 pandemic. *Anatomical Sciences Education*, 13(3), 301-311. <https://doi.org/10.1002/ase.1967>
- Magi, M., Jayagandhi, S., Kumar V, D., Rajprasath, R., Prasad G, B., & Devi, R. (2022). Analysing the effect of incorporating images while framing MCQs for online clinical anatomy assessment among first year medical students. *International Journal of Anatomy and Research*, 10(4), 8482-8488. <https://doi.org/10.16965/ijar.2022.225>
- Memon, I., Feroz, Z., Alkushi, A., Qamar, N., & Ismail, F. (2021). Switching from face-to-face to an online teaching strategy: How anatomy and physiology teaching transformed post-COVID-19 for a university preprofessional program. *Advances in Physiology Education*, 45(3), 481-485. <https://doi.org/10.1152/advan.00233.2020>
- Messerer, D. A. C., Behr, J. L., Kraft, S. F., Schön, M., Horneffer, A., Kühl, S.J. et al. (2022). The gross anatomy course: SARS-CoV-2 pandemic-related effects on students' learning, interest in peer-teaching, and students' perception of its importance. *Anatomical Sciences Education* 16(4), 629-643. <https://doi.org/10.1002/ase.2245>
- Mishall, P. L., Meguid, E. M. A., Khalil, M. K., & Lee, L. M. J. (2022). Transition to effective online anatomical sciences teaching and assessments in the pandemic era of COVID-19 should be evidence-based. *Medical Science Educator*, 32, 247-254. <https://doi.org/10.1007/s40670-021-01435-3>
- Naidoo, N., Azar, A. J., Khamis, A. H., Gholami, M., Lindsbro, M., Alsheikh-Ali, A., & Banerjee, Y. (2021). Design, implementation, and evaluation of a distance learning framework to adapt to the changing landscape of anatomy instruction in medical education during COVID-19 pandemic: A proof-of-concept study. *Frontiers in Public Health*, 9. <https://doi.org/10.3389/fpubh.2021.726814>
- Özen, K. E., Erdoğan, K., & Malas, M. A. (2022a). Assessment of the opinions and experiences of anatomy educators regarding the distance anatomy education in medical facilities under the effect of COVID-19 in Turkey. *Surgical and Radiologic Anatomy*, 44(5), 791-802. <https://doi.org/10.1007/s00276-022-02934-7>
- Özen, K. E., Erdoğan, K., & Malas, M. A. (2022b). Evaluation of views and perceptions of the medical faculty students about distance anatomy education during the COVID-19 pandemic. *Surgical and Radiologic Anatomy*, 44(1), 61-71. <https://doi.org/10.1007/s00276-021-02867-7>
- Pather, N., Blyth, P., Chapman, J. A., Dayal, M. R., Flack, N. A. M. S., Fogg, Q. A. et al. (2020). Forced disruption of anatomy education in Australia and New Zealand: An acute response to the Covid-19 pandemic. *Anatomical Sciences Education*, 13(3), 284-300. <https://doi.org/10.1002/ase.1968>
- Perera-Diltz, D. M., & Moe, J. L. (2014). Formative and summative assessment in online education. *Journal of Research in Innovative Teaching*, 7(1), 130-142. https://digitalcommons.odu.edu/chs_pubs/37
- Potu, B. K., Atwa, H., Nasr El-Din, W. A., Othman, M. A., Sarwani, N. A., Fatima A. et al. (2022). Learning anatomy before and during COVID-19 pandemic: Students' perceptions and exam performance. *Morphologie*, 106(354), 188-194. <https://doi.org/10.1016/j.morpho.2021.07.003>
- Rabbani, M. A., Syed, H. B. S., & Ikram, F. (2022). Comparison of assessment tools in online and on-campus undergraduate medical examinations amidst COVID-19 pandemic. *Journal of the College of Physicians and Surgeons Pakistan*, 32(03), 359-363. <https://doi.org/10.29271/jcpsp.2022.03.359>
- Rahim, A. F. A. (2020). Guidelines for online assessment in emergency remote teaching during the COVID-19 pandemic. *Education in Medicine Journal*, 12(2), 59-68. <https://doi.org/10.21315/eimj2020.12.2.6>
- Relucanti, M., Alby, F., Heyn, R., Marino, F., Fatigante, M., Miglietta, S. et al. (2021). Face-to-face vs distance learning in human anatomy education: a longitudinal study of students' perspective and learning outcomes during COVID-19 pandemic. *Italian Journal of Anatomy and Embryology*, 125(1), 37-54. <https://doi.org/10.36253/ijae-12800>
- Rosario, M. G. (2021). Gross anatomy during COVID-19: The effectiveness of utilizing a 3-D anatomy application among occupational therapy students in a pandemic-induced online course. *Journal of Learning and Teaching in Digital Age*, 6(2), 90-96. <https://dergipark.org.tr/en/pub/joltida>
- Roy, H., Ray, K., & Bhakata, A. 2020. Faculties perception on anatomy teaching and assessment in lockdown and post-lockdown new normal phase. *Journal of Clinical & Diagnostic Research*, 14(11), 5-9. <https://search.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/en/covidwho-958447>
- Sadeesh, T., Prabavathy, G., & Ganapathy, A. (2021). Evaluation of undergraduate medical students' preference to human anatomy practical assessment methodology: a comparison between online and traditional methods. *Surgical and Radiologic Anatomy*, 43, 531-535. <https://doi.org/10.1007/s00276-020-02637-x>

- Schulte, H., Schmiedl, A., Mühlfeld, C., & Knudsen, L. (2022). Teaching gross anatomy during the Covid-19 pandemic: Effects on medical students' gain of knowledge, confidence levels and pandemic-related concerns. *Annals of Anatomy-Anatomischer Anzeiger*, 244, Article e151986. <https://doi.org/10.1016/j.aanat.2022.151986>
- Singal, A., Bansal, A., Chaudhary, P., Singh, H., & Patra, A. (2021). Anatomy education of medical and dental students during COVID-19 pandemic: A reality check. *Surgical and Radiologic Anatomy*, 43, 515-521. <https://doi.org/10.1007/s00276-020-02615-3>
- Stevenson, S. E., Anbu, D., Wijeyendram, P., Laurayne, H., & Border, S. (2022). Can synchronous online near-peer teaching offer the same benefits as the face-to-face version when used in clinical neuroanatomy education? In O. Varsou, P.M. Rea, M. Welsh (Eds.), *Biomedical visualisation: Advances in experimental medicine and biology*, vol. 1397, Springer International Publishing. https://doi.org/10.1007/978-3-031-17135-2_9
- Stokes, J. A., & Silverthorn, D. U. (2021). Updating anatomy and physiology lab delivery: Shifting from a paper-based to an online lab instruction platform, just in time for a global pandemic. *Advances in Physiology Education*, 45(2), 290-98. <https://doi.org/10.1152/advan.00190.2020>
- Stone, D., Longhurst, G. J., Dulohery, K., Campbell, T., Richards, A., O'Brien, D. et al. (2022). A multicentre analysis of approaches to learning and student experiences of learning anatomy online. *Medical Science Educator*, 32(5), 1117-1130. <https://doi.org/10.1007/s40670-022-01633-7>
- Thom, M. L., Kimble, B. A., Qua, K., & Wish-Baratz, S. (2021). Is remote near-peer anatomy teaching an effective teaching strategy? Lessons learned from the transition to online learning during the Covid-19 pandemic. *Anatomical Sciences Education*, 14(5), 552-561. <https://doi.org/10.1002/ase.2122>
- Van Der Vleuten, C. P. M. (1996). The assessment of professional competence: Developments, research and practical implications. *Advances in Health Sciences Education*, 1, 41-67. <https://doi.org/10.1007/BF00596229>
- Wadi, M., Abdalla, M. E., Khalafalla, H., & Taha, M. H. 2020. The assessment clock: A model to prioritize the principles of the utility of assessment formula in emergency situations, such as the COVID-19 pandemic [version 1]. *MedEdPublish*, 9. <https://doi.org/10.15694/mep.2020.000086.1>
- Walsh, K. (2015). Point of view: Online assessment in medical education – current trends and future directions. *Malawi Medical Journal*, 27(2), 71-72. <https://doi.org/10.4314/mmj.v27i2.8>
- Wilson, A. B., Miller, C. H., Klein, B. A., Taylor, M. A., Goodwin, M., Boyle, E. K. et al. (2018). A meta-analysis of anatomy laboratory pedagogies. *Clinical Anatomy*, 31(1), 122-133. <https://doi.org/10.1002/ca.22934>
- Yamine, K., & Violato, C. (2015). A meta-analysis of the educational effectiveness of three-dimensional visualization technologies in teaching anatomy. *Anatomical Sciences Education*, 8(6), 525-538. <https://doi.org/10.1002/ase.1510>
- Yan, Y., Cheng, X., Zhou, C., Yang, X., & Li, Y-Q. (2021). The perceptions of anatomy teachers for different majors during the COVID-19 pandemic: a national Chinese survey. *Medical Education Online*, 26(1), Article e1897267. <https://doi.org/10.1080/10872981.2021.1897267>
- Yoo, H., Kim, D., and Lee, Y-M. (2021). Adaptations in anatomy education during COVID-19. *Journal of Korean Medical Science*, 36(1), Article e13. <https://doi.org/10.3346/jkms.2021.36.e13>
- Yun, Y. H., Jo, D. Y., Jeon, S. K., Kwon, H. Y., Jeon, Y.M, Shin, D. H., & Choi, H. J. (2022). The impact of the modified schedules of anatomy education on students' performance and satisfaction: Responding to COVID-19 pandemic in South Korea. *PLoS ONE*, 17(4), Article e0266426. <https://doi.org/10.1371/journal.pone.0266426>
- Zhang, J-F., Zilundu, P. L. M., Fu, R., Zheng, X-F., Zhou, L-H., & Guo, G-Q. (2022). Medical students' perceptions and performance in an online regional anatomy course during the Covid-19 pandemic. *Anatomical Sciences Education*, 15(5), 928-942. <https://doi.org/10.1002/ase.2208>

Appendix 1: Summary of the Included Studies in the Scoping Review

No.	Author Reference	Country and Continent	Study Design	Main Findings	Theme
1	Al-Neklawi and Ismail 2022	Egypt, Africa	Cross-sectional/ Survey	TBL was applied for learning and formative assessment during the online teaching of Anatomy using BlackBoard which provides evidence of successful e-learning as a challenging interactive learning strategy	2 & 4
2	Albalushi, Halima, 2022	Oman, Asia	Experimental/ Trial	Students scored higher when the online exam was non proctored so "insufficient planning compromised the assessment through score inflation and reduced variation". The proctored online assessment of theoretical and practical anatomical knowledge was found to be as good as traditional face-to-face assessment in terms of average scores and variation among scores	3
3	Alsharif, Mohammed, et al. 2020, a	Saudi Arabia, Asia	NA	Recommendations for more of formative assessment and open-book examination as an alternative during online anatomy teaching	2
4	Alsharif, Mohammed, 2022, b	Saudi Arabia, Asia	Cross-sectional/ Survey	Faculty suggested improved assessment system for the online anatomy teaching. Students feedback about assessment: only 50% of students felt that online teaching prepared them for the final exam, 62% felt that the assessment was linked to the material covered during the online teaching. Several challenges facing assessment were outlined: cheating, time, internet connectivity, faculty and staff readiness for online assessment) with suggestion to overcome (aligning with outcomes, formative assessment, eliminate cheating, training ..etc.).	4
5	Bhat, Ghulam Mohammad, 2022	India, Asia	Cohort study	Blended approach resulted in better scores (summative assessment) than traditional or online courses in the knowledge gain (no comment on the type or the assessment approach). Students' feedback did not include direct evaluation of the assessment process.	3
6	Border, Woodward et al. 2021	United Kingdom, Europe	Case report	Formative assessment is superior in online courses to enhance the integration of anatomy in the clinical sciences. Involving students in course delivery will enhance their performance and they will consider assessment/exams as a part of the learning process rather than an end to the course	2
7	Boulos, Atef, 2022	Egypt, Africa	Cross-sectional/ Survey	Adding assignments as a formative assessment approach to increase students' interaction Online performance was better than on-campus exams, due to relaxation and lower stress levels imparted by exam hall and cadavers. Students gave positive feedback about assignments as a mode of assessment in online course, but they miss the on-campus activities.	2, 3 & 4

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8	Chan, Larson et al. 2021	United States of America, North America	Cohort Study	Utilization of animation and 3D instrument to illustrate anatomy lab can improve student engagement, however, the impact on achieving the learning outcomes was not evaluated.	2 & 4
9	Chang, Ming-Fong, 2022	Taiwan, Asia	Cross-sectional/ Survey	Assessment methods were not changed after the pandemic, done in-person. Better scores in general for the online delivery. Practical (midterm) was better with the F2F delivery but the final practical exam after online course delivery was better. Theory scores can predict practical scores (strongly correlated).	1 & 3
10	Cheng, Chan et al. 2020	China, Asia	Cross-sectional/ Survey	The new online assessments' formats included online tests, recording the attendance for online sessions, subjective assessments by teachers, and peer assessment of homework Online assessment was continued in 49.4% of the 77 medical schools. Another 26 (33.8%) schools initiated online assessment during the pandemic.	1, 2 & 4
11	Dulohery, Scully et al. 2021	United Kingdom, Europe	Cross-sectional/ Survey	52.6% of academics preferred traditional methods of assessment to online. Remote online assessment was difficult to protect against collusion but provided time saving opportunities for academics. Academics reported improving their technology skills.	4
12	Edinger and Rockwell 2020	United States of America, North America	Case report	Anatomy and physiology lab assessments were changed so that more frequent quizzes and activities need to be completed by the students. Onboarding students for online learning and assessment is crucial.	1 & 2
13	Fisher, David, 2022	South Africa, Africa	Experimental/ Trial	The pass rates were high for online vs F2F (Anatomy & Physiology) exam but the distribution of marks was not different, so both are identical with regards to course proficiency (no superiority for online home-based exams). No rationale for thinking that the home-based online mode of assessment is equivalent to or better than the orthodox modes of assessment.	3
14	Ghosal, Sadhu et al. 2021	India, Asia	Cross-sectional/ Survey	Students were equally divided about the difficulty level of online assessment. Although students feel that online exams were easier to score and more comfortable, they still prefer the traditional ways.	2 & 4
15	Harmon, Attardi et al. 2020	United States of America, North America	Cross-sectional/ Survey	Computer-based assessment increased during the pandemic and cadaveric use for practical assessment was replaced by images. Despite the utilization of different online and computer-based assessment, the assessment structure was not different. Effectiveness of the assessment methods was not reported.	1

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16	Harrel, McGinn et al. 2021	United States of America, North America	Cohort Study	<p>Online exam scores were improved vs previous in person dissection based.</p> <p>Online formative assessment was applied utilizing online features of Zoom.</p> <p>Summative assessment was conducted at the end to test theory knowledge at three levels of Bloom's.</p> <p>Practical exams included video clips that resulted in better performance and students' satisfaction.</p>	All
17	Longhurst, Stone et al. 2020	United Kingdom, Europe	Cross-sectional/Survey	<p>Development of alternative assessment was considered as an opportunity.</p> <p>36% of universities identified reductions in student engagement, 21% teacher-student relationship, and 14% assessments as challenges.</p> <p>Assessment of online anatomy course was considered as a weakness of this approach by 14% or a threat by 36%</p> <p>The study highlighted the assessment methods modifications and showed that assessment and student engagement can be considered as challenges or even threats to the success of the online approach.</p>	1 & 2
18	Magi, M., et al. 2022	India, Asia	Experimental/Trial	<p>Image-based MCQs were used in the summative online exam and showed better students' performance.</p> <p>The students reported preference for image-based MCQs in online exams as they were interesting, improved their reasoning and lateral thinking abilities with better appreciation of applied anatomy aspects.</p>	1, 3 & 4
19	Memon, Feroz et al. 2021	Saudi Arabia, Asia	Case report	<p>Assessments were open-book exams, and the exam scores were significantly higher compared to pre-covid scores for the same course</p> <p>Students feedback showed their preference to closed-book exam considering academic dishonesty as the main drawback.</p> <p>If open-book exam format needs to be considered for an online course, the questions need to be more of critical thinking which necessitate familiarizing students on this type of questions and training faculty to formulate such kind of exams to avoid inflation in the scores.</p>	1, 3 & 4
20	Messerer, David, et al. 2022	Germany, Europe	Cross-sectional/Survey	<p>Students' scores were comparable before and during the covid.</p> <p>No change in the assessment methods was done and exams were done in-person, despite delivering the course online.</p>	1 & 3

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21	Mishall, Priti, et al. 2022	The United States of America, North America	NA	<p>Recommendations towards an evidence-based online assessment strategies:</p> <p>Part of examinations (keep both theory and practical)</p> <p>Utilize formative and summative.</p> <p>Use test administration software wisely, proctoring strategies to avoid inflation of marks: pass/fail vs grades</p> <p>Aligning learning outcomes and objectives with digital learning</p> <p>Spell out competencies (in case of online learning and lack of in-person interaction) and specify the methods to ensure their acquisition</p> <p>More frequent formative assessment with instant feedback</p> <p>Understand the needs of the learners by frequent feedbacks and surveys</p>	1, 2 & 4
22	Naidoo, Azar et al. 2021	United Arab Emirates, Asia	Cross-sectional/Survey	<p>The process of designing a student centric and versatile DL-framework integrating precepts of Analyse, Design, Develop, Implement, and Evaluate (ADDIE) instructional model was described.</p> <p>Both the perception and the knowledge gain were assessed systematically to evaluate the newly designed course.</p> <p>Systematic approach to assess the students' perception and knowledge acquisition of a distant learning course delivery.</p>	All
23	Özen, Kemal Emre, 2022(a)	Türkiye, Asia/Europe	Cross-sectional/Survey	The students were more positive about theory exams being conducted online but they were more than 50% were against conducting online practical exams.	4
24	Özen, Kemal Emre, 2022(b)	Türkiye, Asia/Europe	Cross-sectional/Survey	<p>61% of faculty believe online practical assessment was a poor choice, while 47% believe theory online assessment was the wrong choice.</p> <p>Fewer than 20% of the faculty felt that the online evaluation was a weakness in the online anatomy teaching environment.</p>	4
25	Pather, Blyth et al. 2020	Australia, Oceania	NA	<p>Assessment is a critical aspect, yet not clearly defined by the anatomy educators.</p> <p>Collusion/cheating is a concern when online exam/assessment is planned</p> <p>More interpretation and analysis rather than recall questions need to be used</p>	1
26	Potu, B., 2021	Bahrain, Asia	Cross-sectional/Survey	<p>Students' performance in the online theory (MCQ) is better than F2F while it not the same for the OSPE.</p> <p>The authors did not do a comparison between similar courses (which made interpreting these results difficult!).</p>	3

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27	Rabbani, Muhammad Ali, 2021	Pakistan, Asia	Cross-sectional/ Survey	<p>Comparison of the discriminative index (DI) of the summative anatomy exams given online and in person (MCQs, essays, and viva voce)</p> <p>In contrast to on-campus exams, viva voce had the highest DI when compared to MCA and essay questions.</p> <p>According to the authors, this is because online viva voce is less stressful, whereas online MCA and essay exams have a higher potential for malpractice.</p>	1
28	Relucenti, Michela, et al. 2021	Italy, Europe	Cross-sectional/ Survey	<p>Online performance (course and assessment) was better than in-person.</p> <p>The authors find online superior (and not just alternative) to in-person anatomy course, so that the two approaches should be considered modes with different characteristics that offer different educational benefits.</p>	3
29	Rosario 2021	United States of America, North America	Cross-sectional/ Survey	<p>No significant differences in exam performance between 3D application users and non-users.</p> <p>However, the students' perception about the app was very positive and they preferred the usage of the app over the textbook or models.</p>	3 & 4
30	Roy, Ray et al. 2020	India, Asia	Cross-sectional/ Survey	<p>Online MCQs with shuffled answers was the preferred assessment modality for the theory exam, while OSPE with CCTV camera to conduct practical exams</p>	1 & 4
31	Sadeesh, Prabavathy et al. 2021	India, Asia	Cross-sectional/ Survey	<p>Students preferred the traditional anatomy practical examination over the online format.</p> <p>Verbal communication (viva voce) was preferred to be online (online interviewing might be less stressful, while for the written parts or the 2D images, they referred the traditional.</p> <p>Online images to replace dissected specimens are not preferred by the students</p> <p>Should online anatomy exams be inevitable, high-quality images/2D images need to be selected to avoid students' confusion."</p>	3 & 4
32	Schulte, Henri, et al. 2022	Germany, Europe	Cohort Study	<p>Despite having the course online, students who attended a dissection course after the theory part were able to score better (a trend) in image and text-based questions with higher confidence.</p> <p>Online courses followed by dissection can improve students' confidence level.</p>	3 & 4

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33	Singal, Bansal et al. 2021	India, Asia	Cross-sectional/ Survey	This cohort of students showed preference to in-person anatomy learning, and about 50% did not trust online assessment methods. The authors briefly highlighted online assessment methods.	2 & 4
34	Stevenson, Samuel Eugene, et al. 2022	The United Kingdom, Europe	Cohort study	Near-peer teaching compared to F2F teaching (online teaching and exam). Knowledge gain was significant in both approaches but no difference between the two approaches. Students did not prefer online NPT	2, 3 & 4
35	Stokes and Silverthorn 2021	United States of America, North America	Cross-sectional/ Survey	Students performed better on the laboratory assessments that were completed in person with their laboratory groups or that were in a familiar format (virtual microscopy) than they did on the virtual laboratory.	3
36	Stone, Danya. et al 2022	The United Kingdom, Europe	Cross-sectional/ Survey	The online anatomy teaching and the online summative assessment did not cause a change in the learning approach (deep, strategic or surface). Formative assessment encourages deep learning, motivates students and allows self-assessment The students described online resources as effective but clear guidance is needed to optimize the benefit.	1, 2 & 4
37	Thom, Kimble et al. 2021	United States of America, North America	Cohort Study	Though the scores of the online course were statistically less than the in-person courses, careful analysis of the effect size indicates no significant impact of the online delivery on the students' scores nor their score quartile distribution. Students' satisfaction, however, showed lower levels with the online course delivery.	2, 3 & 4
38	Yan, Cheng et al. 2021	China, Asia	Cross-sectional/ Survey	Anatomy teachers reported 50% usage of online assessment before and after covid pandemic, while 1/3 of them reported implementing online examination only after covid	1 & 4
39	Yoo, Kim et al. 2021	South Korea, Asia	Cross-sectional/ Survey	While the course was delivered virtually, the exams were not online (blended). Exam item analysis shows similarity in the scores between 2019 and 2020. Supportive evidence was provided that blended learning approach promoted individual tailored of self-directed learning, with more self-study time and possibility of repeated access to lecture recordings.	2, 3 & 4

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40	Yun, Young Hyun, 2022	South Korea, Asia	Cross-sectional/ Survey	<p>The course integrated online theory with restricted dissection. Exams were conducted in-person but with restrictions of social distancing (not online) and it followed the same format of pre-covid era.</p> <p>IN GENERAL, performance was less with the online teaching, some modules there was no difference. Using virtual anatomy applications significantly improved practical exam scores.</p> <p>Around 50% students expressed little to a lot of problems in practical exams due to partial cadaver dissection.</p>	1, 3 & 4
41	Zhang, Ji-Feng, 2022	China, Asia	Cross-sectional/ Survey	<p>Both formative (at the end of the unit as short answer quizzes) and summative (at the end of the course) assessment were delivered online.</p> <p>Final exam scores were similar to previous years.</p> <p>Assignments and report writing were not taken positively by the students.</p> <p>No significant difference was observed between the scores of online vs F2Fcourse delivery.</p> <p>Devised self-assessment methods to monitor anatomy learning need to be implemented.</p>	All



An Alternative Grading Approach in Undergraduate Anatomy & Physiology Courses

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Abstract

Ungrading or alternative grading strategies are gaining more attention, but instructors of STEM content courses often struggle to implement such a strategy. Various types of barriers may exist that prevent implementation of this innovative approach. This paper follows my Human Anatomy and Physiology Society (HAPS) workshop (Johnson, 2022) and describes the process of implementing this alternative grading scheme in an anatomy & physiology course, benefits that were realized by both students and instructor, and ongoing challenges to implementing the grading scheme in different contexts.

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Key words: alternative grading, undergraduate, anatomy physiology

Background

The term “ungrading” has exploded into educational discussions since the publication of Susan Blum’s book by the same name (2020). Blum cites a variety of terms used by instructors and educational practitioners – ungrading, degrading, going gradeless – but notes the following “most of the authors of this book act on the conviction that our principal task is educating all students, not ranking them” (Blum, 2020). Since then, book reviews, conference presentations, blogs, social media posts, and more have discussed and investigated this pedagogical practice. For examples, see Howitz et al. (2020), Jarvis (2020), Stenson (2022), and von Renesse and Wegner (2022).

In her review of Blum’s book, Moya (2021, p.2) stated the following: “Ungrading is not intended as a finish line or as a recipe to be replicated. It represents a bottom-up transformation that must be acted upon, monitored, and analyzed to benefit students’ learning. However, questions remain for those who teach pre-requisite courses for graduate and professional schools about whether this idea can be adapted to our classrooms. In this paper, I describe how I have applied the principles of ungrading in my anatomy & physiology courses in the hope of providing ideas and a framework for others to adapt to their own context.

Definition of Ungrading/ Alternative Grading

To begin the discussion, it is important to have a similar starting point. So, what is “ungrading?” In a talk I gave at the 2022 Human Anatomy and Physiology Society (HAPS)

Annual Conference (Johnson, 2022), I didn’t provide a single definition of the term “ungrading.” I still think this is appropriate, because most practitioners have their own definitions of the term and practice. For the purposes of this paper, I define “ungrading” in a similar manner to Elena Bray Speth (Speth, 2022) as “practices that decenter grades and points to center learning and growth”. Students still receive a grade in my course, but the daily practices focus on continual learning of course material through an ongoing process of feedback, improvement, and assessment.

Recent blog posts, conversations and publications have expanded the terms associated with “ungrading.” David Clark and Robert Talbot (2023) provided excellent information about their experience with these practices in their undergraduate mathematics courses. They proposed the term “alternative grading” to capture the wide range of different implementation strategies that would fall under the definition provided by Speth. For the remainder of this paper, I will describe my approach as “alternative grading”.

Problems with Traditional Grading Systems

Traditional grading systems usually assign a course grade based on a student’s performance on various types of assignments. Some have argued that this system may not provide a true measure of a student’s proficiency with course learning objectives. Carberry and colleagues (2016, p. 2) describe the shortcoming in this way: “Such an approach inherently fails to meet the conditions of sound assessment of student learning because the resulting final

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course grades only display how well students performed at completing separate assignments rather than how well they learned specific course objectives.”

Various sources have documented the unhealthy relationship that students often have with their grades. The practice of assigning a grade to an assignment has previously been shown to decrease students’ intrinsic motivation (Blum, 2020). Student motivation has been strongly linked to student success. This may take the form of extrinsic or intrinsic motivation. Extrinsic motivators are anything external, and grades or other academic achievements fall into this category. Intrinsic motivation is internal and present when an individual finds an activity interesting or satisfying. Various studies have sought to identify ways to increase intrinsic motivation and how pedagogical practices may impact such motivation in a student (Barak et al., 2016; Grunert & Bodner, 2011; McMorran & Ragupathi, 2020; Simon et al., 2015). In one specific example, Butler and Nisan (1986) found that intrinsic motivation was undermined in students when their submitted work was marked with only a grade.

Schinske and Tanner (2014) have provided an excellent resource on grading in a life science course. In addition to the impact of grades on student motivation, they examined various claims about the purpose and impact of grading. Citing several research studies on the topic, they concluded that providing a grade on assignments does not provide feedback that allows students to understand and improve their deficiencies. They also provided evidence that grades do not provide reliable information about student learning, summarizing with this quote: “Grades often fail to provide reliable information about student learning. Grades awarded can be inconsistent both for a single instructor and among different instructors for reasons that have little to do with a students’ content knowledge or learning advances. Even multiple-choice exams, which can be graded with great consistency, have the potential to provide misleading information on student knowledge” (Schinske & Tanner, 2014, p. 163).

Benefits of Alternative Grading

Instructors who have adopted alternative grading practices may cite many reasons for their choice. I adopted this grading approach based on my concern about decreasing intrinsic motivation and a strong desire to help students identify and address their own weaknesses and deficiencies with the material.

Building off the literature related to grading, Talbert (2022b) provided a helpful graphic to describe alternative grading strategies (Figure 1). Each pillar represents a principle toward encouraging and supporting student learning. The idea of “clearly defined standards” works to address the concerns raised by Schinske and Tanner (2014) regarding the ability to provide reliable information about student learning. These standards are provided by the instructor to students and provide the basis of all marked assignments.

In my case, I have adopted a subset of the Human Anatomy and Physiology Society (HAPS) learning goals and anatomy and physiology (A&P) learning outcomes (Human Anatomy and Physiology Society, 2020). The pillars of “helpful feedback” and “marks indicate progress” address the concerns identified in the work of Butler and Nisan (1986) by providing feedback that assists students in addressing their deficiencies while also encouraging them to continue in their study and practice to progress toward mastery or proficiency. Finally, the pillar of “re-attempts without penalty” is a practical step toward maintaining student motivation and implementation of instructor feedback.

As an example of how these pillars work to encourage student learning, mastery, and proficiency consider this example. In a traditionally graded course, a student makes a low grade on an exam about the skeletal system. They have no incentive to learn that material following the exam and may have a lower course grade based on this performance. When they move to the muscular system, they are focused solely on the new system and structures, missing an opportunity to integrate their knowledge of both systems. However, in an alternatively graded course, a student learning muscles, origins, and insertions has an additional context and opportunity to learn the bones and their markings. This student could reattempt the original assessment, demonstrate their newly acquired knowledge, and finish the course with a high grade. This structure also encourages students to remain motivated in the course. McMorran and Ragupathi (2020, p. 3) shared a similar sentiment in their paper describing alternative grading, “When we succeed, we do not need a grade, since the skills and knowledge are sufficient reward. When we do not succeed, a failing grade does not add to our stress. In fact, the lack of repercussions means we are likely to try again. Advocates of gradeless learning suggest that eliminating grades would lead to such positive outcomes for students, improving both their learning and their well-being.”

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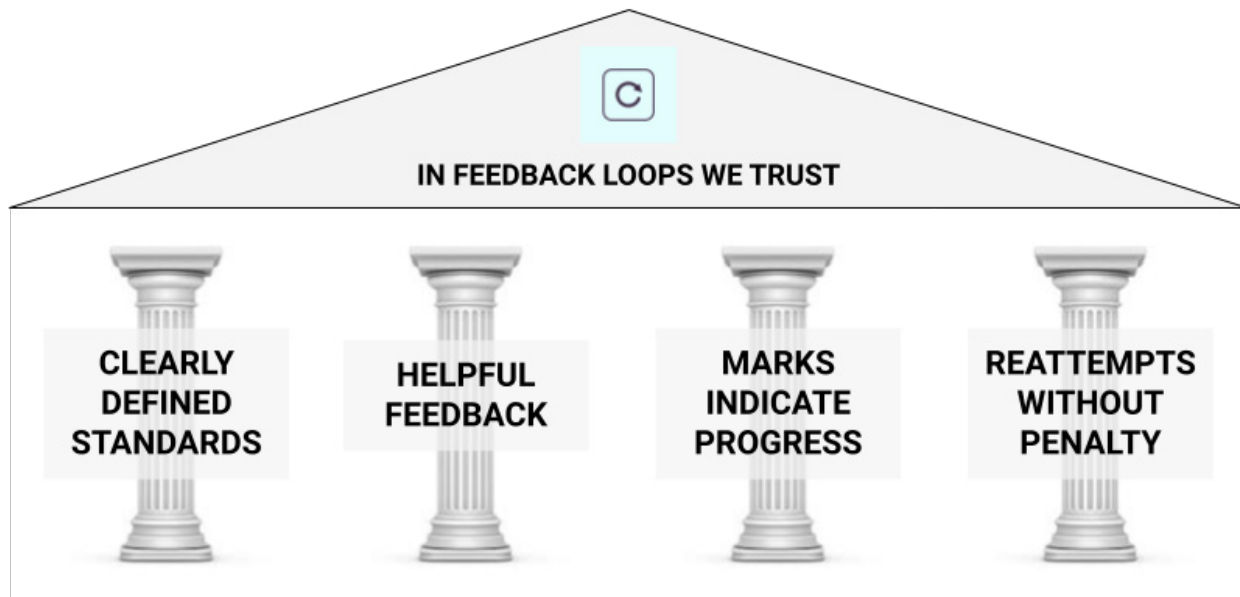


Figure 1. The four pillars of alternative grading (Talbert 2022b). Creative Commons Attribution-ShareALike 4.0 International License.

Alternative Grading in Undergraduate Anatomy & Physiology Courses

An Example of Alternative Grading in an Anatomy & Physiology Course

I teach a two-semester sequence of A&P courses (1 and 2). A&P 1 covers body organization, tissues, and the integumentary, skeletal, muscular, and nervous systems while A&P 2 covers the endocrine, cardiovascular, respiratory, lymphatic, digestive, urinary, and reproductive systems. Each course is worth four credits with three contact hours of weekly lecture time and one three-hour laboratory period. I am assisted during lab time by an undergraduate lab assistant who is responsible for locating and setting up appropriate materials for weekly laboratory activities and cleaning and reorganizing items after the session. We offer one section of each course per semester (A&P 1 is offered in the fall semester, A&P 2 is offered in the spring semester) and the class sizes have ranged from 20 to 48 students.

My courses were created using a backward-design approach (Carberry et al., 2016). Although not unique to alternative grading, backward design is essential for creating a cohesive set of objectives, assignments, and policies. If you have never used a backward-design approach, I recommend this blog post by Talbert (Talbert 2022a) as a starting point. Within this post, he provides a thorough list of questions to consider. When I was revising my anatomy & physiology course to use an alternative grading scheme, I found the following questions very helpful:

- What is the course about?
- What level of creative control do you have?
- Why does the course exist?

I spent time answering these questions before moving into the details of how my course would run and found this activity to be very helpful in making sure the practical decisions of how to run the course remained consistent with my overall course goals.

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Objectives

I have modeled my overall course-level objectives following the recommendations of the HAPS Learning Goals (Human Anatomy and Physiology Society, 2020). Both A&P 1 and A&P 2 have identical overall course-level learning objectives.

1. Identify anatomical structures and describe the complex interrelationships between structure and function.
2. Explain how body systems work together to maintain homeostasis by applying the core concepts.
3. Apply knowledge of anatomy & physiology to real-world situations.
4. Propose evidence-based hypotheses to explain physiological responses or the functions of anatomical structures.

Course objective 1 is assessed through annotated reading assignments, identification exams, and multiple-choice exams. To provide more guidance and structure for the students, I have paired these objectives with module-level learning objectives for each body system. I created this list from the HAPS learning objectives and refined it based on my selected textbook and course calendar.

Assignments

In keeping with the alternative assessment pillar of “re-attempts without penalty”, all assignments receive a mark of “complete” or “incomplete/ revision needed”. Most assignments may be submitted again if a “revision needed” mark is assigned. Course assignments range from multiple-choice exams generated from the textbook author’s test bank to essays discussing current events articles or scientific literature. Each assignment is specifically linked to a particular course learning objective, as described in Table 1.

Course Learning Objective (LO)	Anatomy & Physiology I	Anatomy & Physiology II
LO1: Identify anatomical structures and describe the complex interrelationships between structure and function	<ul style="list-style-type: none"> • 5 Multiple choice exams with questions related to the interrelationships between structure/function and module learning outcomes. • 5 Identification exams/lab practicals 	<ul style="list-style-type: none"> • 4 Multiple choice exams with questions related to the interrelationships between structure/function and module learning outcomes. • 4 Identification exams/lab practicals
LO2: Explain how body systems work together to maintain homeostasis by applying the core concepts	<ul style="list-style-type: none"> • Concept maps to diagram how homeostasis is maintained in the body. (3 maps submitted) 	<ul style="list-style-type: none"> • Concept maps to diagram how homeostasis is maintained in the body. (3 maps submitted)
LO3: Apply knowledge of anatomy & physiology to real-world situations.	<ul style="list-style-type: none"> • 1 A&P in the News essay 	<ul style="list-style-type: none"> • 1 A&P in the News essay
LO4: Propose evidence-based hypotheses to explain physiological responses or the functions of anatomical structures.	<ul style="list-style-type: none"> • 1 Mini literature review on a topic related to student-selected body system 	<ul style="list-style-type: none"> • 1 Team research project and final research report

Table 1. Alignment of course assignments with course learning objectives.

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Exams are marked “complete” if students answer 85% of the questions correctly. For the other assignments, I provide a rubric with the required specifications to earn a “complete”. All assignments listed on Table 1 may be marked “revision needed”. In these cases, the student is provided with feedback on what needs to be addressed or improved so that the assignment can be revised appropriately. For exams, student can sign up for a time to review their exams. During these times, I provide the exam document and the student’s graded scantron form. There is desk space outside my office where students are allowed to take notes and review their answers. I do not allow the students to take photos of the exam, but they are permitted to write or type information from the exam for their purposes.

Feedback on non-exam assignments is provided in the form of narrative feedback using either annotations/ comments on the document or a text comment in Canvas’s SpeedGrader. As one of the four pillars of alternative assessment, providing feedback is essential for supporting student progress in class. Percell (2017, p. 1) noted: “Providing feedback to students is a critically important step in the learning process, and yet in many classrooms feedback only occurs at the end of assignments, almost serving as a postmortem in justifying a student’s final grade”. In their case description of feedback in an alternatively graded high school setting, they described that “feedback needs to be process-oriented, personal, and is best presented in an informal, but genuine fashion” and “feedback is commentary designed to assist students as they advance from one competency to the next” (Percell, 2017, p. 2).

In the past, I have seen discussions on social media among faculty members who lament the lack of student attention to feedback on assignments. However, it is important to note that this arose in the context of a traditionally graded course. Given the option for resubmission that is possible in my courses, students pay much more attention to the feedback I provide and seek to implement it in future submissions, as evidenced by both student ability to successfully complete the assignment on their second submission and questions they ask me during formal and informal meetings.

In addition to assignments described in Table 1, there are assignments that expose students to the course material and those that require them to reflect on the course and their learning. Students are expected to read assigned textbook chapters before class discussion in our lecture time. I use Perusall (www.perusall.com) for this purpose (Gray, 2021). Perusall is a cloud-based reading tool that allows students to annotate documents, ask questions, and make connections on what they are reading and learning. This tool and the associated assignments are integrated in my course learning management system (Canvas). I have used the platform-recommended grading settings with the threshold of 67% set for the assignment to receive

a “complete” grade. The Perusall platform provides the instructor with the option to release the grade prior to the due date. This allows students to track their progress toward “complete”. However, if a student does not earn the grade of “complete” prior to the due date, they must use a course token (“extra credit”) to extend their due date.

Students also complete reflection essays which are submitted at the beginning, middle, and end of the course. Each of these essays asks the students to reflect on the grade they wish to earn and describe their plan for completing that work. The submissions move from planning the grade they wish to earn to reflecting on how their plan has worked and any changes they need to make to continue their path or correct due to unforeseen issues. A specific prompt is provided for each reflection with details of the information requirements. Students can resubmit this essay without penalty if a mark of “revision needed” is earned. When this mark is provided, I include narrative feedback using either annotations/ comments on the document or a text comment in the Canvas tool, SpeedGrader.

Students are provided with a link to my electronic calendar to make a 30-minute meeting appointment at midterm and during the final weeks of the course. At the midterm feedback meeting, I discuss the information present in the student’s achievement essay and ask about their progress toward that goal. I also ask what questions they have about course content or the grading system that they have. Most students want more information about calculating their grade or need clarification about revisions or exam retakes. Occasionally they wish to discuss the feedback they have received on an assignment and desire more information about how to revise that assignment to earn “complete” credit. Even though I spend time during our class meetings about these topics, some students only seem comfortable asking these questions in a one-on-one setting. The final reflection meeting follows a similar format. However, most questions center around specific details of what work remains for them to earn the grade they desire. In order to receive the mark of “complete” for feedback meetings, students only need to attend and participate in the meeting. I have never needed to count this assignment as “needs revision”.

Number of Submissions

While learning is the most important component of my class, due dates and other guidelines are put in place for the good of the student and the instructor. There is no set limit on the number of attempts a student may take on an exam. However, I do limit students to two exam reattempts in a single week. For example, during the first week of November, a student can sign up to reattempt Exam 1 and ID Exam 1 only. Any additional exam retakes in a single week require a “token” which is described in the next section. On occasion, I have used other means of assessing knowledge after a student has attempted any one exam

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three times. For example, one student hadn't completed the skeletal system ID Exam. When they signed up to review the material with me, I asked for the names of a number of bones that were included in one of the exam versions. In this case, the student identified without notes all but one of the bones or bone parts correctly. Since they demonstrated mastery of the material, I counted that exam as "complete".

To request an exam retake, students must first review their most recent attempt on that exam. After this review, they are required to complete an online form that asks them to summarize the material they struggled with on the exam, describe the content they need to review or learn more thoroughly, and outline their study plan to succeed on the reattempt. Once that is completed, they may schedule a reattempt on our class exam calendar. I use SignUpGenius (www.signupgenius.com) for this purpose.

Due Dates

My syllabus includes a "Late Work and Flexibility Policy" that outlines a Token System to provide a balance of structure and flexibility. Each student begins the semester with 5 tokens. Each of the following may be "purchased" with one token:

- A one-week extension to the due date (as published in Canvas) for any assessment or reading assignment.
- One additional re-test opportunity in a week.

Final Course Grade

The grade a student earns is related to how many of the learning objectives and modules are completed at the conclusion of the semester. To earn a specific grade, students must complete all requirements listed in the row for that grade. Only "complete" assignments or exams are counted toward these totals. Assignments that have been attempted but have received the mark of "incomplete" or "revision needed" are not counted in these totals.

The syllabus describes that the course grade will be based on the lowest number of "complete" assignments for a category (Table 2). For example, if a student completes 9 exams, successfully shows mastery of 2 additional learning objectives, completes 13 reading assignments, completes 3 reflection essays, attends 2 feedback meetings, they will earn a B for the course.

	A	A-	B+	B	B-	C+	C	C-	D+	D	F
LO1: Exams Complete (Score ≥85%)	9	8	7	6	6	5	4	4	3	3	<3
LO2, LO3, LO4: Additional Learning Objectives Complete	3	3	2	2	2	1	1	1	0	0	0
Perusall Reading Assignments	15	15	14	13	12	11	10	9	<9	<9	<9
Reflection Essays	3	3	3	3	3	3	3	3	<3	<3	<3
Feedback Meetings	2	1	2	1	0	2	1	0	2	1	0

Table 2. Grade table that describes how students in my class earn specific grades.

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Helpful Tools that Make it Work

It is important to realize that this grading approach may be novel for students. This lack of familiarity is another hurdle in navigating your class. It has been consistently noted that student buy-in is important for success (Howitz et al., 2020). In my experience, it is very important to review how assignment of grades in an alternatively graded course works throughout the semester. The novelty of the system can cause increased stress for students, even when they are performing very well in the class. Howitz and colleagues (2020, p.18) noted a similar concept, stating: "To prevent student misconceptions about their course grade standing, which can result in an overwhelming number of complaints in a larger course, it will be essential to establish buy-in and consistently provide reminders about the big picture of the grading system". During my A&P 2 course feedback meetings, students noted that they felt less stress and much more comfortable than they had felt in A&P 1. This has been consistent across all student performance and achievement levels. Therefore, having in-class and one-on-one conversations about how grading works in the class and using additional tools to provide easily accessible information to students is extremely important.

The traditional gradebooks in most learning management systems are not helpful to students in an alternatively graded course, since they likely show an incorrect 'grade' to the students. My institution uses Canvas, which introduced a Learning Mastery Gradebook feature. Getting this set up at the front end of your course is somewhat time consuming. In addition to adding your learning outcomes to the Canvas course, rubrics must be created and aligned to the appropriate mastery areas. When complete, students can more clearly see their progress toward mastery in any of the course learning outcomes. My students have indicated that this is very helpful as they track progress in a course.

Another helpful tool has been creating a simple way for students to sign up for exam reviews and reassessments. For this purpose, SignUpGenius (www.signupgenius.com) has been used. I can add new times that I am available for reassessment/review, along with the relevant number of seats. The website also collects contact information and sends reminders to students of their appointments.

Along with choosing an appointment time, I created a form that requires students to reflect on their exam performance and indicate what practices were used to learn the material prior to reassessment. My own experience has shown that some students retain a mindset of cramming by reviewing and retaking an exam on the same day, sometimes in the same session.

Observed Benefits of Alternative Grading in Anatomy & Physiology Courses

Some literature exists that describes various alternative grading strategies and their impacts on students. In one example, Carberry and colleagues (2016) reported on the experience of ten instructors at multiple institutions who implemented an alternative grading strategy (standards-based grading) within engineering courses. The participating instructors described additional benefits provided to students in the alternative grading structure. "1. Provides clear and direct feedback toward expectations that allows students to gauge their strengths and weaknesses toward relevant skills. 2. Provides a mechanism for students to effectively self-assess their learning. 3. Allows a student to fail early and learn from their mistakes by rewarding improvement. 4. Better connects to real world assessment and skill building. 5. Encourages students to focus on learning rather than what needs to be done to earn a grade." (Carberry et al., 2016, p. 4) In the four semesters I have adopted this approach, I have observed each of these ideas in action.

Students are engaged with my feedback and that leads to additional conversations, both through email and in person. This happens with each assignment type required in the course. When students review their exams, I see them engaged with the course material. They frequently use the course textbook to look up relevant information. When they struggle to understand the question or answer, they initiate a conversation with me to get targeted explanations to help with any misconceptions.

My reflection assignments and reassessment questionnaire require students to self-assess their own learning and progress. In both cases, students are required to describe what information has been most difficult for them and what misconceptions they have identified. This practice brings them face to face with areas that require additional study. They may also need to discuss additional options for studying and learning the material. I enjoy these conversations because I learn more about each student and how they approach the course. I strive to work with the student to outline a reasonable plan that the student is excited to try. As the semester continues, they need less guidance from me and complete these tasks effectively with the help of classmates or with no assistance at all. The opportunity for reassessment helps students to focus on their learning and allows them to fail early and learn more from their mistakes.

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A System that Encourages Continued Effort and Improvement

Many instructors have recognized how alternative grading systems cultivate students' growth mindsets (Percell, 2017). Other adopters of alternative grading noticed certain changes in the types of conversations they had with students. Howitz and colleagues (2020) noted this type of improvement when adopting an alternative grading scheme in an organic chemistry course. They noted, "the TAs also reported spending more time discussing student understanding of course material, over email and in person, than discussing complaints over assignment grading" (Howitz et al., 2020, p. 15). In a more personal example, a participant in Percell's study (2017, p. 3) noted, "Some of these kids may not get it right at the beginning of the semester, but as long as they get it by the end, we're good. I mean, that's the goal: that *by the time they leave the class, they've learned what they're supposed to have learned.*" One of my students provided this quote about her experience in A&P 1: "I am grateful for the teachings this class has given me academically, but as well personally, such as time management, as I just realized I was not as good as I thought. I am also grateful for the study groups that turned into friendships, and you, Dr. Johnson, that although I wasn't a first or second pass exam student, that I never felt belittled nor treated differently due to my grades and I believe that it is one of the most important factors a teacher can have in order to have an impact on a student's learning and life."

Challenges of Implementing Alternative Grading in A&P Courses

Making a change of this magnitude in any course will result in some challenges. The instructors in Carberry et al. (2016, p. 4) noted the following obstacles that may be encountered when implementing an alternative grading strategy. "1. Faculty and student pushback to change based on lack of familiarity with the grading scale. 2. Student confusion and frustration in understanding their current grade/standing in the course. 3. Difficulty integrating the grading system within currently available course management systems. 4. Increased initial faculty workload. 5. Consistency in scores across instructors, teaching assistants, graders, and programs. 6. Fit within the variety of courses taught within an engineering program." I have experienced some of these obstacles in my own courses. However, it is important to realize that addressing these challenges is not additional work but a different type of work.

I would consider the student's comfort level to be one of the most significant issues. Most students do better in my second-semester course because now they are now used to the grading system and know what to expect. Students in anatomy and physiology courses have a strong outcome orientation that is centered on grades and course

assessments (Johnson & Gallagher 2021). This leads to various forms of negative affect when they are not sure of their performance in the class. This is the main topic of conversation in Meeting 1. Most students need time and multiple explanations and reassurances about the course processes and guidance about how to calculate their grade.

Most learning management systems are not designed for alternative grading. Our campus uses Canvas and I've discovered two possible workarounds to make grade calculation more straightforward for my students. Most recently, I have used the Learning Mastery Gradebook in Canvas. This requires additional set up that is beyond the scope of this paper. I am considering using a simpler approach in the coming semester as outlined on the Grading for Growth blog (Noyce & Largent, 2023).

In my own context, I complete all marking of assignments, so the concerns about consistency in grading across instructors is not relevant, but that is not true for all.

Implementation of an alternative grading system will differ based on class size. One of the four pillars of alternative assessment (Figure 1) is "re-attempts without penalty". However, this does not require *unlimited* attempts. Some instructors of larger classes have addressed concerns about the possible number of submissions by using a token system that provides the option for resubmission. This approach is one I have adopted. This limits the number of resubmissions, while also providing increased ownership and agency for students (Howitz et al., 2020). They may also allow students to earn a small number of additional tokens by completing reflections or other course tasks (Howitz et al., 2020). Howitz and colleagues (2020) describe their system, which is nearly identical to my own practice, of using a placeholder assignment in Canvas paired with a Google form for token use.

The example course discussed in this paper was a small course with a maximum enrollment of 48 students. Similar grading systems have been implemented successfully in larger courses. Howitz and colleagues (2020) tested a similar alternative grading system with specifications grading in an upper level organic chemistry course with the intent to scale up in courses with over 1000 students across 60 sections in a semester. Their suggestions for managing various workload issues would be a helpful resource for faculty members with larger classes.

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Future Directions

The movement of alternative grading holds promise for addressing some of the pressing concerns in higher education. In addition to providing examples of implementation in various contexts, discipline-based education research should assess the impact of such a system on student learning and pedagogical practice. The following are some possible research questions to consider in this area of inquiry:

What are the benefits and challenges of implementing alternative grading in undergraduate A&P courses?

How do alternative assessments compare in terms of improving student learning outcomes and reducing anxiety related to grading?

Continued implementation of alternative grading structures can provide additional evidence and information about its benefits to students. However, based on our current understanding of how learning works, there is ample support for practitioners to adopt these changes in their courses and expect positive results.

About the Author

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Literature Cited

- Barak, M., Watted, A., & Haick, H. (2016). Motivation to learn in massive open online courses: Examining aspects of language and social engagement. *Computers & Education, 94*, 49–60. <https://doi.org/10.1016/j.compedu.2015.11.010>
- Blum, S. D. (2020). *Ungrading: Why Rating Students Undermines Learning (and What to Do Instead)*. West Virginia University Press.
- Butler, R., & Nisan, M. (1986). Effects of no feedback, task-related comments, and grades on intrinsic motivation and performance. *Journal of Educational Psychology, 78*(3), 210–216. <https://doi.org/10.1037/0022-0663.78.3.210>
- Carberry, A. R., Siniawski, M., Atwood, S. A., & Diefes-Dux, H. A. (2016). *Best practices for using standards-based grading in engineering courses*. [Conference presentation abstract and paper]. 2016 ASEE Annual Conference & Exposition, New Orleans, LA, United States. <https://doi.org/10.18260/p.26379>
- Clark, D., & Talbert, R. (2023). *Grading for growth: A guide to alternative grading practices that promote authentic learning and student engagement in higher education*. Routledge.
- Gray, L. (2021). How Can We Get Students to Do the Reading? Perusal May Help. *Journal of Innovation, Teaching & Digital Learning Excellence, 1*, 23–27.
- Grunert, M. L., & Bodner, G. M. (2011). Finding fulfillment: Women's self-efficacy beliefs and career choices in chemistry. *Chemistry Education Research and Practice, 12*(4), 420–426. <https://doi.org/10.1039/c1rp90050a>
- Human Anatomy and Physiology Society. (2020). *HAPS learning goals*. https://www.hapsweb.org/page/learning_goals
- Howitz, W. J., McKnelly, K. J., & Link, R. D. (2020). Developing and implementing a specifications grading system in an organic chemistry laboratory course. *Journal of Chemical Education, 98*(2), 385–394. <https://doi.org/10.1021/acs.jchemed.0c00450>
- Jarvis, C. L. (2020). Testing an 'ungrading' approach. *Chemical & Engineering Global Enterprise, 98*(16), 20–23. <https://doi.org/10.1021/cen-09816-feature1>
- Johnson, S. N. (2022, May 28). *An ungrading approach to A&P courses*. [Conference workshop abstract]. Thirty-sixth Annual Conference of the Human Anatomy and Physiology Society, Fort Lauderdale, FL, United States.
- Johnson, S. N., & Gallagher, E. D. (2021). Learning processes in anatomy & physiology: A qualitative description of how undergraduate students link actions and outcomes in a two-semester course sequence. *Advances in Physiology Education, 45*(3), 486–500. <https://doi.org/10.1152/advan.00135.2020>
- McMorran, C., & Ragupathi, K. (2020). The promise and pitfalls of gradeless learning: Responses to an alternative approach to grading. *Journal of Further and Higher Education, 44*(7), 925–938. <https://doi.org/10.1080/0309877x.2019.1619073>
- Moya, B. (2021). Ungrading: Why rating students undermines learning (and what to do instead). *The International Journal for Educational Integrity, 17*, Article e11. <https://doi.org/10.1007/s40979-021-00077-7>
- Noyce, A., & Largent, D. (2023, March 6). *Grading for Growth: Using the Canvas gradebook with specifications grading*. <https://gradingforgrowth.com/p/using-the-canvas-gradebook-with-specifications>
- Percell, J. C. (2017). Lessons from alternative grading: Essential qualities of teacher feedback. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 90*(4), 111–115. <https://doi.org/10.1080/00098655.2017.1304067>

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Schinske, J., & Tanner, K. (2014). Teaching more by grading less (or differently). *CBE—Life Sciences Education*, 13(2), 159–166. <https://doi.org/10.1187/cbe.cbe-14-03-0054>

Simon, R. A., Aulls, M. W., Dedic, H., Hubbard, K., & Hall, N. C. (2015). Exploring student persistence in STEM programs: A motivational model. *Canadian Journal of Education*, 38(1), 1-27. <https://journals.sfu.ca/cje/index.php/cje-rce/article/view/1729>

Speth, E.B. [@ebspeth1]. (2022, May 13). *I also feel that #ungrading is decentering grades and points to center learning and growth (even when we can't/don't completely.* [Tweet]. Twitter. <https://twitter.com/ebspeth1/status/1525150621829054465>

Stenson, M. (2022). Implementing ungrading in undergraduate exercise physiology. *The FASEB Journal*, 36(S1). <https://doi.org/10.1096/fasebj.2022.36.s1.r6135>

Talbert, R. (2022a, June 13). *Grading for growth: What to do before you do alternative grading.* <https://gradingforgrowth.com/p/what-to-do-before-you-do-alternative>

Talbert, R. (2022b, June 27). *Grading for growth: Planning for grading for growth: Building the structure.* <https://gradingforgrowth.com/p/planning-for-grading-for-growth-building>

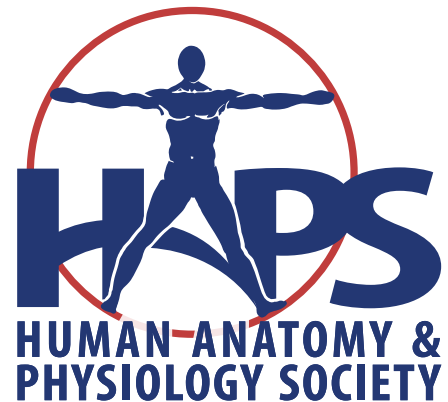
von Renesse, C., & Wegner, S. A. (2022). Two examples of ungrading in higher education from the United States and from Germany. arXiv: 2209.14240v1 [Math.HO]. <https://doi.org/10.48550/arXiv.2209.14240>



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2024 ANNUAL HOST COMMITTEE

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This committee is in charge of coordinating the 2024 Annual Conference to take place in Pittsburgh, Pennsylvania

ANATOMICAL DONOR STEWARDSHIP COMMITTEE

[Kelsey Stevens](#)

This committee is charged with developing, reviewing, and recommending policies and position statements on the use of cadavers for human anatomy and physiology education in colleges, universities and related institutions.

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COMMUNICATION

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This committee is tasked with helping HAPS establish its voice in a technological landscape shaped by social media. Committee members work closely with the Marketing Committee to facilitate connections within HAPS as well as recruiting potential members via social media.

CONFERENCE

[Edgar Meyer](#)

This committee actively encourages HAPS members to consider hosting an Annual Conference. We provide advice and assistance to members who are considering hosting an annual conference.

CURRICULUM & INSTRUCTION

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This committee develops and catalogs resources that aid in anatomy and physiology course development and instruction.

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This committee consists of all committee chairs. It coordinates activities among committees and represents the collective committee activity to the HAPS BOD.

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Special Committees and Programs:

HAPS EDUCATOR

[Jackie Carnegie, Editor-in-Chief](#)
[Brenda del Moral, Managing Editor](#)

This committee is responsible for publishing a quarterly edition of the HAPS Educator, the journal of the Human Anatomy and Physiology Society. The committee works closely with the Steering Committee and the President of HAPS.

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[Janet Casagrand](#)

This committee has completed, tested and approved the HAPS Comprehensive Exam for Human A&P and is developing an on-line version of the exam.

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Composed of the HAPS President, President-Elect, Past President, Treasurer and Secretary

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[Kyla Ross](#)

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