

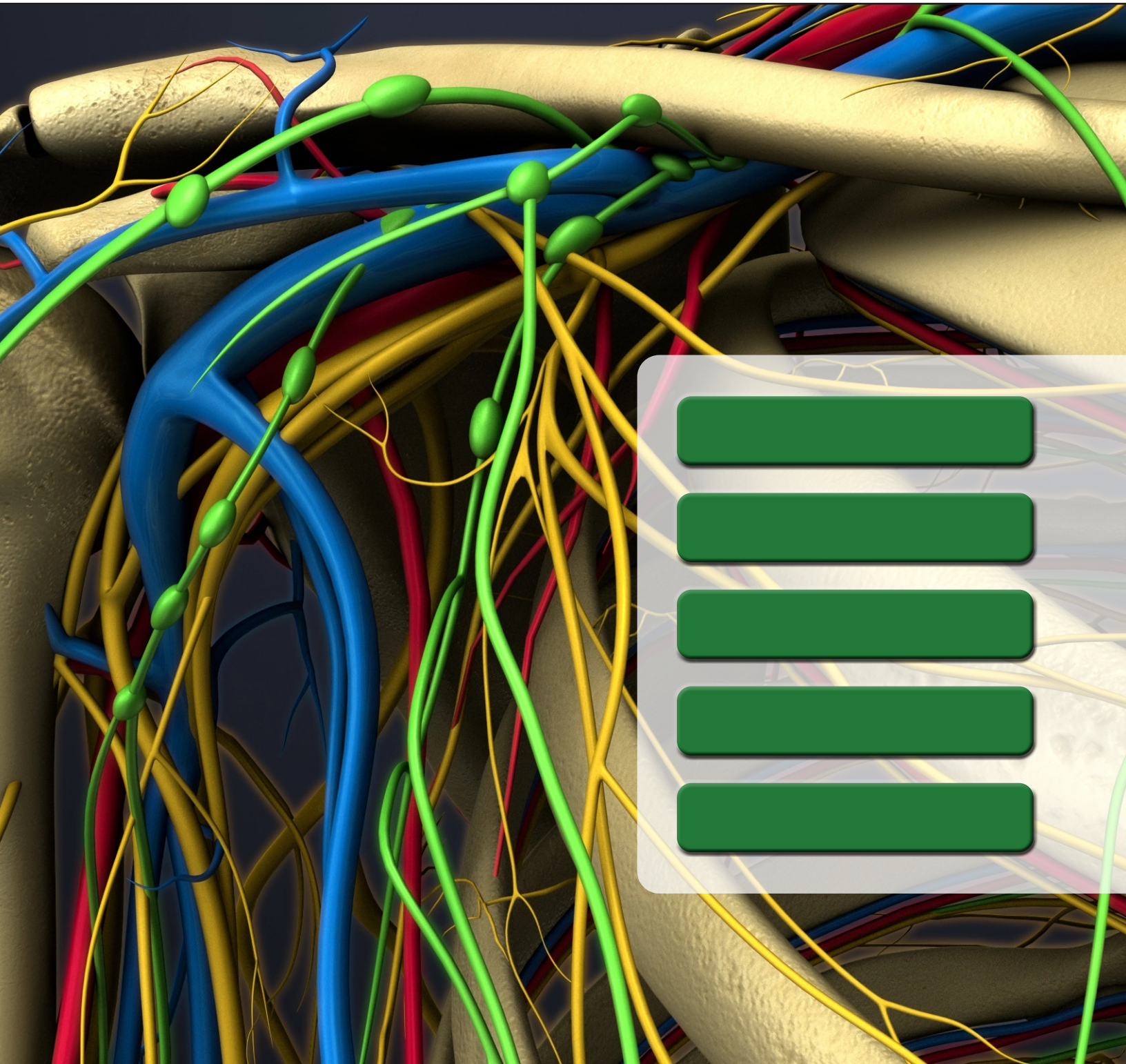


Volume 28, Issue 3 | December, 2024

# The EDUCATOR

*Journal of the Human Anatomy and Physiology Society*

Established in 1989 by Human Anatomy & Physiology Teachers



A white rectangular box containing five horizontal green bars, likely serving as a placeholder for a table of contents or a list of articles.



# HAPS EDUCATOR JOURNAL

## HAPS BOARD OF DIRECTORS

### PRESIDENT

Melissa Quinn

[mquinn@hapsconnect.org](mailto:mquinn@hapsconnect.org)

### PAST-PRESIDENT

Kerry Hull

[khull@hapsconnect.org](mailto:khull@hapsconnect.org)

### PRESIDENT-ELECT

Rachel Hopp

[rhopp@hapsconnect.org](mailto:rhopp@hapsconnect.org)

### SECRETARY

Carol Britson

[cbritson@hapsconnect.org](mailto:cbritson@hapsconnect.org)

### TREASURER

Tracy Ediger

[tediger@hapsconnect.org](mailto:tediger@hapsconnect.org)

### REGIONAL DIRECTORS

**Central:** Hisham Elbatarny

[helbatarny@hapsconnect.org](mailto:helbatarny@hapsconnect.org)

US: IA, IL, IN, MI, MN, OH, WI, MO

International: MB, ON, all other

non-Canadian members

**Eastern:** Anya Goldina

[agoldina@hapsconnect.org](mailto:agoldina@hapsconnect.org)

US: CT, DC, DE, MA, MD, NH, NJ, NY, PA,

RI, VA, VT, WV

International: NB, NF, NS, PE, QC

**Southern:** Cindy Wingert

[cwingert@hapsconnect.org](mailto:cwingert@hapsconnect.org)

US: AL, AR, FL, GA, KY, LA, MS, NC, OK,

SC, TN, TX; Territory: PR

**Western:**

Juanita Jellyman

[jjellyman@hapsconnect.org](mailto:jjellyman@hapsconnect.org)

US: AK, AZ, CA, CO, HI, ID, IS, MY, NE,

ND, NM, NV, OR, SD, UT, WA, WY

International: AB, BC, NU, NT, SK, YT

WINTER 2024

## TABLE OF CONTENTS

### EDUCATIONAL RESEARCH

#### *Eliciting Academic Help-Seeking in a Hybrid Human Anatomy & Physiology Course Using Muddiest Point Assignments*

<https://doi.org/10.21692/haps.2024.013>

Hilary Engbretson, PhD, Suzanne Hood, PhD ..... 4

#### *Pre-Clerkship Medical Students' Perceptions of Learning Objectives: Definitions, Uses, and Communication*

<https://doi.org/10.21692/haps.2024.014>

Kayla Pavlick, PhD, Casey Boothe, PhD, Andrew Notebaert, PhD ..... 13

#### *A Survey of Exam Methods in College A&P Courses*

<https://doi.org/10.21692/haps.2024.016>

Benjamin L. Wiggins, PhD, Gregory J. Crowther, PhD ..... 24

### PERSPECTIVES ON TEACHING

#### *An Unconventional Cadaveric Prosection for Neuroanatomy Education: Extraction of the Central and Peripheral Nervous Systems with Anatomical Landmarks*

<https://doi.org/10.21692/haps.2024.015>

Madeline M. Damjanovic, MSc, Isabella G. Damjanovic, MSc, Christine A. Majors, MS, DC, Logan S. W. Bale, MSc .... 45

#### *Interlacing and Unweaving the Brachial Plexus: A Visual Demonstration Highlighting Form and Function*

<https://doi.org/10.21692/haps.2024.017>

Lindsay Renee Dresang, PhD ..... 53

**HAPS Educator Crossword 3: The Skeleton**..... 64

**Answers for Crossword 3: The Skeleton** ..... 65

**HAPS Committees and Boards**..... 66

# HAPS Educator Journal of the Human Anatomy and Physiology Society

**Editor-in-Chief** – Jackie Carnegie

**Managing Editor** – Brenda del Moral

## Editorial Board

Carol Britson  
Jackie Carnegie

Greg Crowther  
Brenda del Moral

Tracy Ediger  
Hisham Elbatarny

Elizabeth Granier  
Kimberly Jeckel

Zoë Soon  
Joanne Savory

## Reviewer Panel

Jessica Adams  
Teresa Alvarez  
Heather Anderson  
Amy Bauguess  
Imaan Benmerzouga  
John Bradley Barger  
Emily Bradshaw  
Carol Britson  
Kirsten Brown  
Kathy Burseson  
Patrice Capers  
Jackie Carnegie  
Janet Casagrand  
Deborah Christensen  
James Clark  
Greg Crowther

James Davis  
Leslie Day  
Brenda del Moral  
Jennifer Dennis  
James Doyle  
Stacey Dunham  
Jayme Dyer  
Tracy Ediger  
Anthony Edwards  
Hisham Elbatarny  
Jennifer Elinich  
Hilary Engebretson  
Juno Farnsworth  
Stephanie Fretham  
Burhan Gharaibeh  
Any Goldina

Craig Goodmurphy  
Jeremy Grachan  
Elizabeth Granier  
Amanda Haage  
Katey Hughes  
Polly Husmann  
Michael Ibiwoye  
Jon Jackson  
Jenna Nicole Jarvis  
Kimberly Jeckel  
Will Jonen  
Inez Jones  
Sean Kardar  
Catherine Kirn-Safran  
Barbie Klein  
Tres Kutcher

Alice Lawrence  
Hollie Leavitt  
Sara Lombardi  
Kanchana Mendes  
Amber Miller  
S. Richelle Monaghan  
Tracy Mowery  
Soma Mukhopadhyay  
Zachary Murphy  
Chasity O'Malley  
Raj Narnaware  
John Neisser  
Ogochukwu Onyiri  
Nicole Palenske  
Kayla Pavlick  
Andrew Petto

Matthew Picha  
Gilbert Pitts  
Kristen Platt  
Katrina Porter  
Disa Pryor  
Melissa Quinn  
Peter Reuter  
Wendy Riggs  
Krista Rompolski  
Usha Sankar  
Joanne Savory  
Josh Schmerge  
Melanie Schroer  
Casey Self  
Lola Smith  
Zoe Soon

Maria Squire  
Janet Steele  
Leslie Stone-Roy  
Parker Stuart  
Mark Tran  
Cinnamon VanPutte  
Sheela Vemu  
Matthew Vilburn  
Michael Waterson  
Erica Wehrwein  
Adrienne Williams  
Peggie Williamson  
Jonathan Wisco  
Larry Young  
Melissa Zolnierz

## Digital Media UX – L. Katie Roberts

The *HAPS-Educator*, *The Journal of the Human Anatomy and Physiology Society*, aims to foster teaching excellence and pedagogical research in anatomy and physiology education. The journal publishes articles under three categories. Educational Research articles discuss pedagogical research projects supported by robust data. Perspectives on Teaching articles discuss a teaching philosophy or modality but do not require supporting data. Current Topics articles provide a state-of-the-art summary of a trending topic area relevant to anatomy and physiology educators. All submitted articles undergo peer-review. Educational Research articles will additionally be reviewed for the quality of the supporting data. All issues of the *HAPS Educator* are freely available, and individual articles are uploaded to the Life Science Teaching Resource Community (and link to <https://www.lifescitrc.org/>) and available in the Education Resources Information Center (ERIC).

The *HAPS Educator* is published in April, August and December. The deadlines for submission are March 1, July 1 and November 1.

### Submission Guidelines for Authors

Information for authors on the terms of submission, the submission procedure, formatting the manuscript, formatting the references, the submission of illustrations, and the peer review process, is available [HERE](#).

### Submission Link

When ready, please follow this [link](#) to submit your manuscript to the *HAPS Educator*.

You do not need to be a member of the Human Anatomy and Physiology Society (HAPS) to publish in the *HAPS Educator*. For more information see the complete submission guidelines using the link above.

### Human and animal research subjects

Research that includes dissection and manipulation of animal tissues and organs must adhere to the Human Anatomy and Physiology Society (HAPS) [Position Statement on Animal Use](#), which states that the use of biological specimens must be in strict compliance with federal legislation and the guidelines of the National Institutes of Health and the United States Department of Agriculture. The use of humans or animals in research must fulfill clearly defined educational objectives.

Experimental animals must be handled in accordance with the author's institutional guidelines and informed consent must be obtained for studies on humans. It is the responsibility of the author(s) to secure IRB approval for research on humans.

### Plagiarism

Authors must obtain permission to reproduce any copyright material and the source of this material must be acknowledged in their manuscript.

### Disclaimer

Responsibility for (1) the accuracy of facts, (2) the expression of opinion and (3) the authenticity of any supporting material presented by the author rests solely with the author. The *HAPS-Educator*, its publishers, editors, reviewers and staff, take no responsibility for these things.

[CONTACT THE HAPS-Educator Editor](#) if you have additional questions or concerns.

*The HAPS Educator is published electronically by The Human Anatomy and Physiology Society (HAPS). The written and visual contents of this magazine are protected by copyright. Temporary permission is granted for members of the Human Anatomy and Physiology Society to read it on-line, to print out single copies of it, and to use it unchanged for any non-commercial research and educational purpose, including making copies for classroom use provided the materials are not modified and appropriate acknowledgment is made of the source. All other uses of this material are conditional and require the consent of the editor - and when applicable, the other copyright owners. Requests for permission should be directed to the editor via the contact information stated above.*

© December, 2024 All rights reserved.

# Eliciting Academic Help-Seeking in a Hybrid Human Anatomy & Physiology Course Using Muddiest Point Assignments

Hilary Engebretson, PhD<sup>1</sup>, Suzanne Hood, PhD<sup>2</sup>

<sup>1</sup>Whatcom Community College, Bellingham, WA, USA

<sup>2</sup>Bishop's University, Sherbrooke, QC, Canada

Corresponding author: [hengebre@whatcom.edu](mailto:hengebre@whatcom.edu)

## Abstract

Academic help-seeking can allow students to moderate their anxiety in difficult academic contexts, but students often shy away from asking for needed assistance. Muddiest point assignments in a hybrid human anatomy and physiology (A&P) course can address student struggles with academic help-seeking by making it an activity in which all students are expected to participate. The purpose of this pilot study was to investigate the use of a muddiest point reflection as a regular, mandatory component of a hybrid A&P course to determine if it could increase students' academic self-efficacy and reduce their anxiety around asking for assistance. Data was collected through pre-and post-course surveys to compare students' self-assessed self-efficacy and anxiety scores before and after using muddiest point reflections over the whole term. There was no significant difference between student self-efficacy or anxiety between the start and end of term. This pilot study suggests that further investigations into which factors influence and are influenced by academic help-seeking will clarify the development of effective help-seeking interventions. This study was supported as part of the Community College Anatomy and Physiology Education Research (CAPER) project (2111119). <https://doi.org/10.21692/haps.2024.013>

**Key words:** help-seeking, muddiest point, anxiety, evidence-based instructional practice

## Introduction

Human anatomy and physiology (A&P) courses are extremely challenging and are often considered gatekeeper courses to healthcare and allied health disciplines such as nursing and physical therapy due to the high failure and attrition rates (Lunsford & Diviney, 2020; Vitali et al., 2020). Therefore, A&P courses represent a critical area for the study of evidence-based instructional practices (EBIPs) that have a record of classroom effectiveness (Entezari & Javdan, 2016; Hood et al., 2021). Moreover, investigations into mechanisms to support students' self-regulated learning (SRL), which can be described as students' self-directed, proactive learning approaches (Dunn-Lewis et al., 2016; Eleazer & Scopa Kelso, 2018; Farr et al., 2020), are important for determining how to best support the success of A&P students in these important courses. As pressure to increase the health care workforce grows, so will the need for A&P courses to improve student success rates (Forgey et al., 2020; Hull et al., 2016; Slominski et al., 2019; Sturges & Maurer, 2013; Sturges et al., 2016).

One promising avenue toward supporting students' self-efficacy and their success in the higher education classroom is the SRL strategy of help-seeking. According to Chu and colleagues (2018), asking for academic help is the result of a student's metacognition: the student asks for help following self-reflection of their thinking, learning, and performance. Richards (2020) suggested that supporting students' development of help-seeking behaviors can be a method for developing their ability to mitigate anxiety in difficult educational contexts such as the ones found in A&P classrooms. Some research has also suggested correlations between effective help-seeking and strong academic self-efficacy, which is defined as a student's belief that they can achieve the academic task at hand (Ding & Er, 2018).

While there is little research on help-seeking as an SRL approach in the higher education A&P classroom, one recent study has shown that SRL study approaches, in general,

*continued on next page*



support student learning in A&P courses (Eleazer & Scopa Kelso, 2018). In this study, more successful A&P students reported using social components of SRL, including asking questions of the instructor and quizzing their peers, at a significantly greater rate than less successful A&P students. In the specific area of the SRL behaviors of help-seeking and peer learning, research by Hebert and Guenther (2020) found that A&P students were not likely to take advantage of optional study sessions with their peers without the incentive of extra credit. Moreover, the students in that study reported that, even though they felt the peer study sessions helped them prepare for exams, they did not find that the help from their peers translated into improved course grades. In another recent study using think-pair-share activities in an A&P class, researchers found that students reported they would be more likely to collaborate with their fellow students after the intervention. This suggests that repeated practice in both engaging with fellow students and seeking help from one's peers are effective methods for supporting further engagement with the SRL behavior of help-seeking specifically in an A&P course (Farr et al., 2020).

Help-seeking in the context of education can be separated into two general forms: executive help-seeking and instrumental help-seeking (Nelson-LeGall, 1985). Executive help-seeking is defined as actions in which a student seeks an answer to reduce their own effort or time on the learning task. This form of help-seeking is also sometimes called maladaptive, dependent, expedient, or inappropriate help-seeking (Chowdhury & Halder, 2019). In contrast, instrumental help-seeking behaviors include asking for direction, clarification, or hints that help improve the student's own work and that do not directly request an answer or solution to the given academic task (Karabenick, 2003). Instrumental help-seeking is adaptive and supports increasing autonomy on the part of the student as it aids the student in deeper levels of understanding of the content (Finney et al., 2018). As such, instrumental help-seeking is the type of help-seeking identified as a critical sub-strategy of SRL (Karabenick, 2003).

Several studies have demonstrated that students choose to employ maladaptive help-seeking behaviors such as help-avoidance or executive help-seeking in some educational contexts. For example, a recent study found negative correlations between a lack of prior knowledge, high cognitive load, and decreased engagement in instrumental help-seeking behaviors (Dong et al., 2020), suggesting that students who are struggling to learn new content back away from asking for assistance. In addition, students who are less familiar with the material being addressed in a course may be overconfident in their abilities and less likely to ask for help when they need it, as demonstrated by first-year pharmacy students when presented with questions about

novel content (Chu et al., 2018). Other research has shown that when students focused on their performance, especially as compared to their peers, they were less likely to seek help (Karabenick, 2003, 2004).

This performative focus, at the expense of instrumental help-seeking, can also be inadvertently prompted by the instructor in a course. Ryan and Shim (2012) found that instructional contexts in which the instructor emphasized performative goals and public comparisons between students' success prompted maladaptive executive help-seeking in those students. Finally, there may be a disconnect between students' feelings about which kinds of help-seeking pose the most threat and their intentions to use various modes of help-seeking. Students in a study by Reeves and Sperling (2015) reported greater anxiety about using face-to-face modes of asking for assistance, such as after class and through office hours, but expressed greater intention to use these modalities over digital help-seeking avenues such as discussion boards or online office hours.

Just as context may inhibit students from help-seeking, some sub-groups of learners experience anxiety that inhibits asking for help. In a study by Gonida et al. (2019), high-achieving students who focused on others' perceptions of them as having already mastered the material were less likely to perceive the benefits of help-seeking and were less likely to seek help when needed. Inhibition of help-seeking due to concern over others' social perceptions is not unique to high performing students. First-generation college students are also affected by concern about others' judgments of their academic abilities and may reduce help-seeking behaviors as a result (Chang et al., 2020). Similarly, anxiety about an ability to effectively communicate with others, either due to language barriers or other issues with speaking or writing, can hinder a student's academic help-seeking actions (Sobotka & Raman, 2020). Furthermore, research has shown that students of color who experience identity threat may also avoid seeking help as they struggle with anxiety about how they will be perceived by others if they ask for assistance (Qayyum, 2018; Thompson et al., 2019).

A simple approach to encouraging students to engage more readily in academic help-seeking may be by reducing students' anxiety about asking for help and increasing their self-efficacy in the course. This may be achievable through the regular use of a muddiest point reflection. This EBIP asks students to consider what component of their recent learning is confusing (a.k.a. "muddy") (Carberry et al., 2013; Waters et al., 2016). According to Carberry and colleagues (2013), this practice is effective because it gives students time to actively and intentionally reflect on what they have recently been learning as they ask for help. In addition, this approach directly prompts student metacognition as they consider where they may be struggling with their thinking

*continued on next page*

and learning. These reflections provide insight for instructors, too, as they see what material is most difficult for the class. Various approaches to solicitation of the muddiest point reflection include requesting written feedback during class time (Carberry et al., 2013; Mansson, 2013; Waters et al., 2016), using clickers or other digital survey tools where students could select their muddiest point from offered choices (Keeler & Koretsky, 2016; Onodipe & Ayadi, 2020; Perez et al., 2020; Srivastava et al., 2018), and asking students to share their muddiest point in a discussion forum in the course learning management system (LMS) (Hudson, 2014).

Results of research examining the muddiest point reflection practice have been promising. Akhtar and Saeed (2020) determined that students who engaged in muddiest point reflections achieved significantly higher scores than their peers who did not. In other research, students found muddiest point reflections to be motivating and valuable to their learning (Carberry et al., 2013; Hood et al., 2021). Research with computer science students who used a digital tool for reporting their muddiest points demonstrated a significant positive correlation between the number of times they engaged with the tool and their self-efficacy (Menekse et al., 2018). When students were asked to rate student-centered teaching practices for the level of anxiety they felt, muddiest point reflections were rated as some of the least anxiety-inducing of the EBIPs and that their anxiety regarding using muddiest point reflections decreased significantly with their use during a term (Hood et al., 2021). Interestingly, while many instructors have reported using the muddiest point reflection as a component of a flipped classroom or an active learning classroom (Entezari & Javdan, 2016; Srivastava et al., 2018), few have investigated the effectiveness of this intervention on its own. Therefore, it is difficult to tease out student gains, whether in course success, self-efficacy, or other areas, that can be directly attributed to the inclusion of this particular EBIP within a course.

Instructor perspectives regarding muddiest point reflections have been examined more thoroughly and instructors generally find them to be a positive addition to their teaching repertoire. Faculty reported that the muddiest point practice was easy to implement with just a small amount of careful attention to the details of the practice, as it does not need to take up much class time (Carberry et al., 2013; Waters et al., 2016). Instructors have also reported that a key benefit to the use of the muddiest point intervention was that it immediately illuminated where students were struggling so that difficult material could be re-addressed in the next class time (He, 2019; Keeler & Koretsky, 2016; Srivastava et al., 2018; Waters et al., 2016). Student misconceptions, which can be difficult to catch, are also revealed by the use of this

EBIP (Waters et al., 2016). Carberry et al. (2013) reported that qualitative data from instructors demonstrated that muddiest point reflections were a “catalyst for change in pedagogical practice” by opening new opportunities for trust and communication between students and instructor.

In some hybrid A&P classrooms, the lecture content is addressed through the online LMS, while the laboratory component is delivered face-to-face. It is possible that the use of a muddiest point EBIP in this format is even more valuable than in a face-to-face format, as students have fewer opportunities to see their fellow students asking for help or to engage with their peers and instructor to work through difficult points with the content of the course. Using the muddiest point reflection as a regular, mandatory component of a hybrid A&P course could be an effective help-seeking intervention by normalizing it as an activity in which all students are expected to engage. By normalizing help-seeking, students may increase their academic self-efficacy and reduce their anxiety around asking for assistance.

This pilot study addressed the following research questions:

1. To what extent does the use of a recurring muddiest point assignment in an A&P classroom affect academic self-efficacy?
2. To what extent does the use of a recurring muddiest point assignment in an A&P classroom affect anxiety about engaging in this EBIP?

## Methods

### *Participants*

The study population was comprised of college students in the first of two terms of hybrid A&P courses offered at a mid-sized community college in Washington State that offers face-to-face and hybrid A&P courses. The first term of these paired A&P courses, Human Anatomy and Physiology I (HAP I), addresses the structure and function of cells, bones, muscles, and the nervous system. Approximately 200 students enroll in HAP I each year at this institution. The students enrolled in A&P courses at this college are predominantly white (70%), and female (73%). Most students enrolled in HAP I are taking it as a prerequisite for application to a nursing program. This population was an appropriate choice for this study because a significant number of A&P students in the United States complete their A&P courses at a community college (McFarland & Pape-Lindstrom, 2016).

*continued on next page*



The study sample consisted of students enrolled in two sections of a hybrid HAP I course taught by one of the authors during the fall 2022 term. The course consists of both the lecture and lab components; the lecture component was delivered online asynchronously while the lab component was delivered through two 2-hour, face-to-face sessions per week. The project was approved by the Institutional Review Board of Whatcom Community College and informed consent was obtained from all participants. A total of 39 students began the study with 21 students completing all aspects of the study. The decrease in students included 15 students who dropped out of the course by the end of the term and 4 students who completed the initial survey but chose to not complete the final survey.

#### Procedure

The muddiest point reflection was used similarly to its use in flipped classroom approaches reported in previous publications (Keeler & Koretsky, 2016; Onodipe & Ayadi, 2020; Perez et al., 2020; Srivastava et al., 2018). Twice a week, after students had engaged with their online lecture content, they were required to complete an online quiz called a Muddiest Point Report. The first question stated, "The thing(s) I need the most help on right now is/are:" and students were able to choose one or more common difficulties with the associated content. Students were also provided an "other" option to choose. The common difficulties for each quiz were determined by the instructor based on often-asked questions and commonly missed areas on exams during previous terms. The second open-ended quiz question stated: "Explain, specifically, what you need help on: Are you having trouble understanding a process, when or why something would happen, what something looks like, etc? If you need help with a particular study guide prompt, address what part of the prompt is giving your trouble and why. If you answered "other", clearly describe what concept is giving you trouble.". Students were required to complete 18 muddiest point quizzes over the span of the 12-week term. These quizzes were valued at 3 points per quiz, matching the total point value of low stakes in-class assignments usually given in face-to-face sections of the same course.

A critical component of the muddiest point reflection was explicit instructor review of muddiest points at the start of each two-hour face-to-face lab session, which typically occurred twice a week unless a lab test was being given. In the face-to-face lab session that followed each online lecture assignment and muddiest point quiz, the instructor shared muddiest points reported by students in an anonymous manner by summarizing what students had written in the muddiest point quiz. The class then engaged in an

approximately 30-minute discussion to help clarify these areas of content. The instructor consistently framed the purpose of these reviews as covering where students had asked for help.

Because this course was in a hybrid format, students did not experience traditional lecture sessions. Nor were students exposed to other common instructional approaches such as clicker questions, being asked to volunteer answers to questions, or being cold called to answer questions in a classroom. Therefore, these other instructional strategies (lecture, clickers, clickers with a partner, volunteer, and cold calling) can be considered as other possible approaches to gaining content help in the course that were not available to students during this hybrid format course.

#### Measures

Students completed an initial survey during the first week of the course and the same survey during the last week of the course. This survey included questions evaluating how much anxiety students experienced in using common instructional practices including lecture, clicker questions, volunteering to answer a question, cold-calling by the instructor, and muddiest point assignments. These instructional practices were chosen to represent the types of classroom activities that students might engage in during the span of an A&P course to gain help with course content; only muddiest point assignments were used within the context of the course in this study. Students rated their anxiety on a Likert-type scale from 1 (no anxiety) to 5 (extreme anxiety). This questionnaire also measured students' self-reported academic self-efficacy using ten Likert scale questions developed by McIlroy and colleagues (2000). Students also completed questions regarding their gender, ethnicity/race, and first-generation as a college student status. Table 1 shows the survey questions and the scales used.

One of the two authors of this pilot study was the instructor for the course and did not see the anonymized questionnaire responses or any other data until after the end of the term. Therefore, as the pre- and post-surveys were linked for each student using a personal identifier, the second author (not the course instructor) independently performed the data analyses. Statistical analyses were carried out using SPSS statistical software (Version 28; IBM Corp., 2021), and an alpha value of 0.05 was established *a priori* for analyses.

*continued on next page*

**Part 1: Six questions using a 5-point Likert-style scale of no anxiety (1) to extreme anxiety (5)**

Evaluate the following classroom activities based on how much anxiety they cause you to feel.

1. Listening/watching the instructor deliver a PowerPoint lecture
2. Working alone to answer a question using an anonymous student response system (e.g., clicker) or an app (e.g., Top Hat, Socrative)
3. Working with another student to answer a question using an anonymous student response system (e.g., clicker) or an app (e.g., Top Hat, Socrative)
4. Volunteering to answer a question posed by the instructor
5. Being asked a question by the instructor without volunteering (cold calling)
6. Completing a muddiest point assignment

**Part 2: Ten questions using a 7-point Likert-style scale of strongly disagree (1) to strongly agree (5)**

Please indicate how strongly you agree with each of the following statements. Note that the statement 'give a good account of myself' here means 'to perform well.'

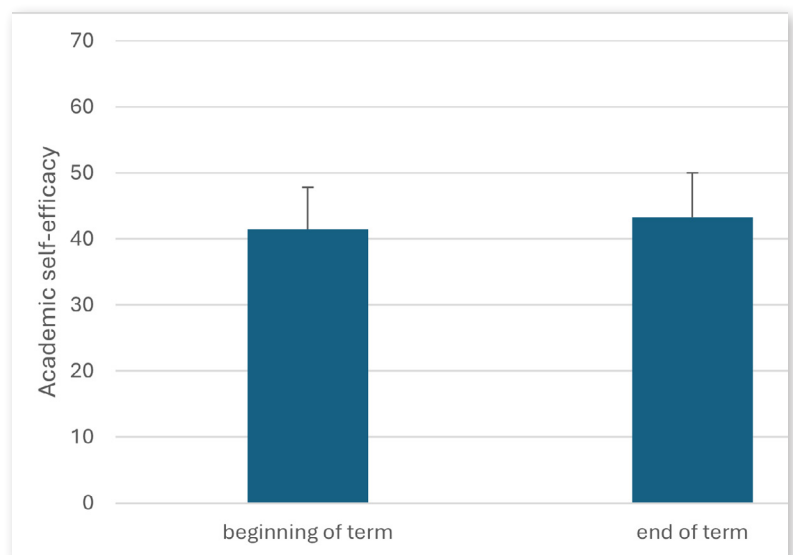
1. I am confident that I can achieve good exam results if I really put my mind to it
2. If I don't understand an academic problem, I persevere until I do
3. When I hear of others who have failed their exams, this makes me all the more determined to succeed
4. I am confident that I will be adequately prepared for the exams by the time they come around
5. I tend to put off trying to master difficult academic problems whenever they arise
6. No matter how hard I try, I can't seem to come to terms with many of the issues in my academic curriculum
7. I am convinced that I will eventually master those items in my academic course which I do not currently understand
8. I expect to give a good account of myself in my end-of-semester exams
9. I fear that I may do poorly in my end-of-semester exams
10. I have no serious doubts about my own ability to perform successfully on my exams

**Table 1.** Survey questions administered at the start and end of the course term and their scales.

## Results

Figure 1 shows that the use of a recurring muddiest point assignment in the A&P classroom did not significantly affect students' academic self-efficacy over the term. The distributions of academic self-efficacy scores were found to be normal (Shapiro-Wilk test,  $W = 0.976$ ,  $p = 0.863$ ) and so a paired samples t-test was used to compare these scores from the start and end of the term. This test indicated that there was no statistically significant difference between students' self-efficacy score from the start of the term ( $M=41.48$ ,  $SD=6.385$ ) to the end of the term ( $M=43.24$ ,  $SD=6.804$ ,  $t(20) = -1.247$ ,  $p = 0.227$ ).

**Figure 1.** Student self-assigned academic self-efficacy score at the beginning and end of term ( $n=21$ ). Scores can range from a minimum of 0 to a maximum of 70.

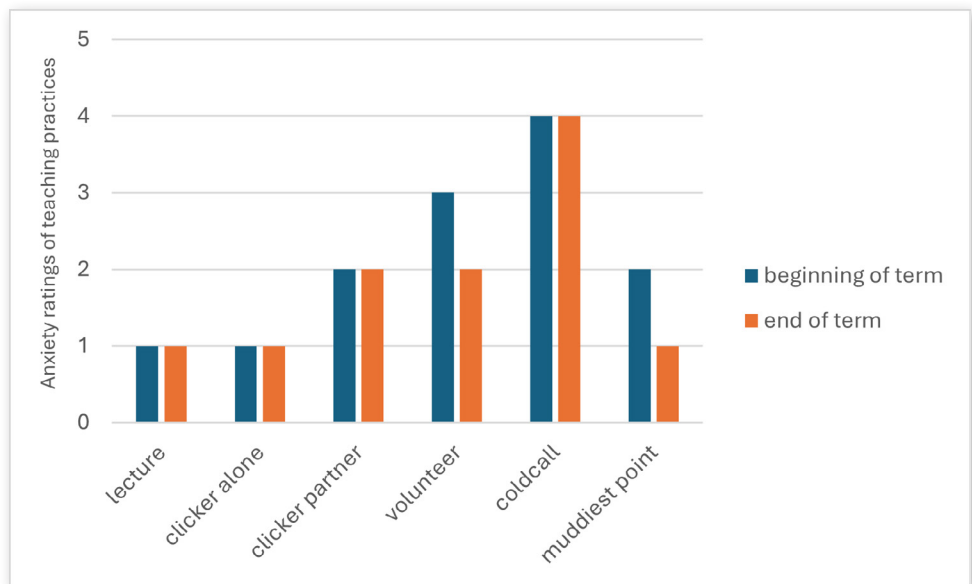


continued on next page



Furthermore, the use of a recurring muddiest point assignment in the A&P classroom did not significantly affect students' anxiety about engaging in this active-learning approach (Figure 2). A Wilcoxon signed-ranks test indicated that there was no statistically significant difference between students' rating of anxiety about muddiest point reflections from the start of the term (median rating = 2) to the end of the term (median rating = 1) ( $p = 0.869$ ).

**Figure 2.** Comparison of teaching-practice-related student ratings for anxiety (0-5) between the beginning and end of term ( $n=21$ ).



## Discussion

The lack of a significant difference in students' self-efficacy scores suggests that weekly use of the muddiest point reflection in this pilot study had no appreciable effect on students' confidence or perceived capabilities in this A&P course. These results contrast with the results of Menekse and colleagues (2018) who found that computer science students who regularly reflected on difficult course content through digital muddiest point assignments experienced an increase in their self-efficacy over the term. It is possible that student approaches in computer science differ significantly from those in A&P courses such that muddiest point assignments were not as effective in this pilot study. It is also possible that the small sample size of the current study reduced the ability for the researcher to measure changes to students' self-efficacy during the course.

Similarly, there was no significant difference in students' rating of their anxiety in using muddiest point assignments between the start and end of the term. As can be seen in Figure 2, it should be noted that students generally did not find the muddiest point assignments anxiety-inducing at either the start or end of the term. As such, their anxiety might have been at a low enough level at the start of term that further reductions in anxiety would not have been driven by an intervention. Again, the small sample size decreased the statistical power of the study, which made it difficult to determine whether student anxiety around muddiest points was significantly affected at the end of the term. As there was a slight drop in their perceived anxiety over the term, it is possible that some students experienced a shift in their anxiety about the muddiest point assignments as they repeatedly engaged in them over that time period.

Students also reported that muddiest point assignments generated less anxiety than engaging in either volunteering or being cold called to speak during class, while clicker questions generated similar anxiety levels. This may be due to the more anonymous nature of muddiest point assignments and clicker questions as compared to engaging in question-and-answer activities during class. The supposition that students' anxiety was less due to anonymity aligns with previous research by Reeves and Sperling (2015) and Li et al. (2023). As such, while the muddiest point assignments in this course were mandatory, help-seeking supports that allow students to anonymously explore where they need help might lead to greater engagement due to this reduced anxiety.

This pilot study appears to suggest that even a regular, required muddiest point assignment throughout a term may not be an effective intervention to change students' self-efficacy or anxiety about this teaching approach. However, these are only two factors that can be measured in relation to students' academic approaches in an A&P classroom. Moreover, because the assignment generated little anxiety, it suggests that assignments such as these are not great contributors to the academic stress that students are prone to encounter in an A&P classroom (Lunsford & Diviney, 2020; Vitali et al., 2020). Therefore, it is worth further investigation to determine if such low-anxiety approaches to improve student help-seeking have other unmeasured effects that were not explored in this study. As such, this pilot study opens the door for possible avenues for future research into how help-seeking prompts like muddiest point assignments can be used as interventions to effectively support student success in the A&P classroom.

*continued on next page*

The authors suggest that further research more directly investigate community college students' perceptions about their academic help-seeking. Specifically, the authors propose that measuring factors other than self-efficacy and anxiety can shed light on critical factors that influence community college student help-seeking. These other factors may include community college students' perceptions about their own resilience, their methods for help-seeking, perceived barriers to help-seeking, the perceived effect of help-seeking on their grades, and their thoughts about their relationships with their fellow students and instructor. In addition, a direct comparison between which factors influence help-seeking in hybrid classrooms versus face-to-face classrooms might clarify whether student perspectives differ between these two common delivery methods for community college A&P courses. Thus, student perspectives regarding their own help-seeking can elucidate whether the use of regular muddiest point assignments is a strong pedagogical choice for supporting the development of help-seeking skills in community college students. Furthermore, students' views about help-seeking can support the development of more effective help-seeking interventions in hybrid and face-to-face community college A&P classrooms.

## About the Authors

Hilary Engebretson, Ph.D., is an associate professor of biology in the Science and Engineering Department at Whatcom Community College in Bellingham, Washington. Hilary was the instructor for the A&P courses in this pilot study. Suzanne Hood, Ph.D. serves as an associate professor of Psychology at Bishop's University. Suzanne performed all statistical analyses for this study.

## Literature Cited

- Akhtar, M., & Saeed, M. (2020). Effect of Frayer model, choral response and muddiest point on students' academic achievement. *Journal of Educational Sciences & Research*, 7(2), 71-86.
- Carberry, A., Krause, S., Ankeny, C., & Waters, C. (2013, October 23-26). "Unmuddying" course content using muddiest point reflections. Proceedings 43<sup>rd</sup> IEEE Frontiers in Education Conference (FIE), Oklahoma City, OK, USA, pp. 937-942. <https://doi.org/10.1109/FIE.2013.6684966>
- Chang, J., Wang, S-W., Mancini, C., McGrath-Mahrer, B., & Orama de Jesus, S. (2020). The complexity of cultural mismatch in higher education: Norms affecting first-generation college students' coping and help-seeking behaviors. *Cultural Diversity and Ethnic Minority Psychology*, 26(3), 280-294. <https://doi.org/10.1037/cdp0000311>
- Chowdhury, S., & Halder, S. (2019). Motivational facilitators and barriers of adaptive academic help-seeking: A systematic review. *Indian Journal of Health and Well-Being*, 10(10-12), 324-333.
- Chu, Y., Palmer, S., & Persky, A. M. (2018). Assessing metacognition in the classroom: Student help-seeking behavior. *Currents in Pharmacy Teaching and Learning*, 10(11), 1478-1487. <https://doi.org/10.1016/j.cptl.2018.08.011>
- Ding, L., & Er, E. (2018). Determinants of college students' use of online collaborative help-seeking tools. *Journal of Computer Assisted Learning*, 34(2), 129-139. <https://doi.org/10.1111/jcal.12221>
- Dong, A., Jong, M. S.-Y., & King, R. B. (2020). How does prior knowledge influence learning engagement? The mediating roles of cognitive load and help-seeking. *Frontiers in Psychology*, 11, Article e591203. <https://doi.org/10.3389/fpsyg.2020.591203>
- Dunn-Lewis, C., Finn, K., & FitzPatrick, K. (2016). Student expected achievement in anatomy and physiology associated with use and reported helpfulness of learning and studying strategies. *HAPS Educator*, 20(4), 27-37. <https://doi.org/10.21692/haps.2016.029>
- Eleazer, C. D., & Scopa Kelso, R. (2018). Influence of study approaches and course design on academic success in the undergraduate anatomy laboratory. *Anatomical Sciences Education*, 11(5), 496-509. <https://doi.org/10.1002/ase.1766>
- Entezari, M., & Javdan, M. (2016). Active learning and flipped classroom, hand in hand approach to improve students learning in human anatomy and physiology. *International Journal of Higher Education*, 5(4), 222-231. <https://doi.org/10.5430/ijhe.v5n4p222>
- Farr, M. B., Lawford, H., Hull, K., Stowe, S., Jensen, M., & Ross, K. (2020). The impact of a bookend think-pair-share intervention on anxiety and student collaboration in a community college human physiology course. *HAPS Educator*, 24(1), 33-42. <https://doi.org/10.21692/haps.2019.030>
- Finney, S. J., Barry, C. L., Horst, S. J., & Johnston, M. M. (2018). Exploring profiles of academic help seeking: A mixture modeling approach. *Learning and Individual Differences*, 61, 158-171. <https://doi.org/10.1016/j.lindif.2017.11.011>
- Forgey, S. B., Williams, M. R., & Pribesh, S. (2020). Pathways to success in anatomy and physiology at the community college: The role of prerequisite courses. *The Community College Enterprise*, 26(1), 9-26.



- Gonida, E. N., Karabenick, S. A., Stamovlasis, D., Metallidou, P., & the CTY Greece. (2019). Help seeking as a self-regulated learning strategy and achievement goals: The case of academically talented adolescents. *High Ability Studies*, 30(1-2), 147-166. <https://doi.org/10.1080/13598139.2018.1535244>
- He, Y. (2019). Traffic light cards: A cross and modification between the minute paper and muddiest point. *College Teaching*, 67(1), 70-72. <https://doi.org/10.1080/87567555.2018.1522612>
- Hebert, A. K., & Guenther, M. F. (2020). Incentivizing students to encourage consistent study group attendance is associated with improved course performance. *HAPS Educator*, 24(1), 66-69. <https://doi.org/10.21692/haps.2020.008>
- Hood, S., Barrickman, N., Djerdjian, N., Farr, M., Magner, S., Roychowdhury, H., et al. (2021). "I like and prefer to work alone": Social anxiety, academic self-efficacy, and students' perceptions of active learning. *CBE-Life Sciences Education*, 20(1), 1-15. <https://doi.org/10.1187/cbe.19-12-0271>
- Hudson, K. A. (2014). Teaching nursing concepts through an online discussion board. *Journal of Nursing Education*, 53(9), 531-536. <https://doi.org/10.3928/01484834-20140820-01>
- Hull, K. L., Wilson, S., Hopp, R., Schaefer, A., & Jackson, J. (2016). Determinants of student success in anatomy and physiology: Do prerequisite courses matter? *HAPS Educator*, 20(2), 38-45. <https://doi.org/10.21692/haps.2016.005>
- IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY: IBM Corp. <https://www.ibm.com/support/pages/downloading-ibm-spss-statistics-28>
- Karabenick, S. A. (2003). Seeking help in large college classes: A person-centered approach. *Contemporary Educational Psychology*, 28(1), 37-58. [https://doi.org/10.1016/S0361-476X\(02\)00012-7](https://doi.org/10.1016/S0361-476X(02)00012-7)
- Karabenick, S. A. (2004). Perceived achievement goal structure and college student help seeking. *Journal of Educational Psychology*, 96(3), 569-581. <https://doi.org/10.1037/0022-0663.96.3.569>
- Keeler, J. M., & Koretsky, M. D. (2016). Surprises in the muddy waters of high-enrollment courses. *Journal of Chemical Education*, 93(11), 1830-1838. <http://dx.doi.org/10.1021/acs.jchemed.6b00372>
- Li, R., Che Hassan, N., & Saharuddin, N. (2023) College student's academic help-seeking behavior: A systematic literature review. *Behavioral Sciences*. 13(8), 637. <https://doi.org/10.3390/bs13080637>
- Lunsford, E., & Diviney, M. (2020). Changing perspectives on anatomy & physiology: From killer class to gateway course. *Bioscene: The Journal of College Biology Teaching*, 46(1), 3-9.
- Mansson, D. H. (2013). Assessing student learning in intercultural communication: Implementation of three classroom assessment techniques. *College Student Journal*, 47(2), 343-351.
- McFarland, J., & Pape-Lindstrom, P. (2016). The pipeline of physiology courses in community colleges: To university, medical school, and beyond. *Advances in Physiology Education*, 40(4), 473-476. <https://doi.org/10.1152/advan.00141.2016>
- McIlroy, D., Bunting, B., & Adamson, G. (2000). An evaluation of the factor structure and predictive utility of a test anxiety scale with reference to students' past performance and personality indices. *British Journal of Educational Psychology*, 70(1), 17-32. <https://psycnet.apa.org/doi/10.1348/000709900157949>
- Menekse, M., Anwar, S., & Purzer, S. (2018). Self-efficacy and mobile learning technologies: A case study of CourseMIRROR. In: C. Hodges (Ed) Self-efficacy in instructional technology contexts. Springer. [https://doi.org/10.1007/978-3-319-99858-9\\_4](https://doi.org/10.1007/978-3-319-99858-9_4)
- Nelson-LeGall, S. (1985). Help-seeking behavior in learning. *Review of Research in Education*, 12(1), 55-90. <https://doi.org/10.3102/0091732X012001055>
- Onodipe, G., & Ayadi, M. F. (2020). Using smartphones for formative assessment in the flipped classroom. *Journal of Instructional Pedagogies*, 23, 1-20.
- Perez, D., Zahedi, L., Ross, M., Zhu, J., Vinci-Cannava, T., Kramer, L., & Charters, M. (2020, October 21-24). WIP: An exploration into the muddiest points and self-efficacy of students in introductory computer science courses. *2020 IEEE Frontiers in Education Conference (FIE)*, Uppsala, Sweden, pp.1-5. <https://doi.org/10.1109/FIE44824.2020.9273932>
- Qayyum, A. (2018). Student help-seeking attitudes and behaviors in a digital era. *International Journal of Educational Technology in Higher Education*, 15, Article e17. <https://doi.org/10.1186/s41239-018-0100-7>
- Reeves, P. M., & Sperling, R. A. (2015). A comparison of technologically mediated and face-to-face help-seeking sources. *British Journal of Educational Psychology*, 85(4), 570-584. <https://doi.org/10.1111/bjep.12088>
- Richards, B. N. (2020). Help-seeking behaviors as cultural capital: Cultural guides and the transition from high school to college among low-income first generation students. *Social Problems*, 69(1), 241-260. <https://doi.org/10.1093/socpro/spaa023>

Ryan, A. M., & Shim, S. S. (2012). Changes in help seeking from peers during early adolescence: Associations with changes in achievement and perceptions of teachers. *Journal of Educational Psychology*, 104(4), 1122–1134. <https://doi.org/10.1037/a0027696>

Slominski, T., Grindberg, S., & Momsen, J. (2019). Physiology is hard: A replication study of students' perceived learning difficulties. *Advances in Physiology Education*, 43(2), 121–127. <https://doi.org/10.1152/advan.00040.2018>

Sobotka, M., & Raman, I. (2020). The role of communication apprehension and self-stigma of academic help-seeking in native and non-native English speakers: Evidence from UK university students. *International Journal of Education*, 12(3), 30–48. <http://dx.doi.org/10.5296/ije.v12i3.17355>

Srivastava, T., Mishra, V., & Waghmare, L. S. (2018). Formative assessment classroom techniques (FACTs) for better learning in pre-clinical medical education: A controlled trial. *Journal of Clinical and Diagnostic Research*, 12(9), 1–8. <https://doi.org/10.7860/JCDR/2018/35622.11969>

Sturges, D., & Maurer, T. (2013). Allied health students' perceptions of class difficulty: The case of undergraduate human anatomy and physiology classes. *The Internet Journal of Allied Health Sciences and Practice*, 11(4), Article e9. <https://doi.org/10.46743/1540-580X/2013.1460>

Sturges, D., Maurer, T. W., Allen, D., Gatch, D. B., & Shankar, P. (2016). Academic performance in human anatomy and physiology classes: A 2-yr study of academic motivation and grade expectation. *Advances in Physiology Education*, 40(1), 26–31. <https://doi.org/10.1152/advan.00091.2015>

Thompson, G., Ponterotto, J., & Dyar, C. (2019). Social identity pathways to college choice and attitudes toward help-seeking among Black students at a minority serving institution. *College Student Journal*, 53(1), 113–129.

Vitali, J., Blackmore, C., Mortazavi, S., & Anderton, R. (2020). Tertiary anatomy and physiology, a barrier for student success. *International Journal of Higher Education*, 9(2), 289–296. <https://doi.org/10.5430/ijhe.v9n2p289>

Waters, C., Krause, S. J., Callahan, J., Dupen, B., Vollaro, M. B., & Weeks, P. (2016, June). *Revealing student misconceptions and instructor blind spots with muddiest point formative feedback*. 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana. <https://doi.org/10.18260/p.26104>



## Become a Member of HAPS Today!

The Human Anatomy & Physiology Society (HAPS) is dedicated to promoting excellence in the teaching of Anatomy and Physiology at colleges, universities and related institutions.

- Connect with colleagues also pursuing success in teaching A&P
- Discounted rates for annual and regional conferences
- Access Teaching Tips for tough topics
- HAPS Institute short-courses for ongoing professional development
- Open access to our peer-reviewed journal, *The HAPS Educator*
- Grants and scholarships for research and travel
- Additional member resources listed [here](#).



For more information, contact HAPS at [info@hapsconnect.org](mailto:info@hapsconnect.org) or at 1-800-448-4277.

Follow [this link](#) to join and start benefiting from membership today!

# Pre-Clerkship Medical Students' Perceptions of Learning Objectives: Definitions, Uses, and Communication

Kayla Pavlick, PhD<sup>1</sup>, Casey Boothe, PhD<sup>2</sup>, Andrew Notebaert, PhD<sup>3</sup>

<sup>1</sup>Whiddon College of Medicine, University of South Alabama, Mobile, AL, USA

<sup>2</sup>Department of Advanced Biomedical Education, University of Mississippi Medical Center, Jackson, MS, USA

<sup>3</sup>School of Interdisciplinary Health Professions, Northern Illinois University, DeKalb, IL, USA

Corresponding author: [kvpavlick@southalabama.edu](mailto:kvpavlick@southalabama.edu)

## Abstract

Learning objectives are intended to be used as tools for both instructors and students. Student use of learning objectives is related to developing metacognitive skills and self-regulation of learning. Many medical institutions provide learning objectives to their pre-clerkship students, but it is unknown if or how the students use them. A questionnaire was designed to investigate current pre-clerkship medical students' perceptions of learning objectives to include definitions, degree and methods of use, and communication from instructors regarding learning objectives. Free-response data from complete and partial records (n = 279) underwent inductive thematic analysis. Quantitative data showed 98.5% of students are aware of learning objectives for their basic science courses but 59% of students do not use them. One hundred and thirty-six students indicated a perception that their instructors do not communicate about learning objectives (n = 273). Qualitative data was organized into three themes to further describe 1) the perception of communication regarding learning objectives from their instructors, 2) how these students define learning objectives, and 3) how these students use learning objectives. Interestingly, this study revealed that perceptions of learning objectives varied greatly among students within the same cohort despite the fact the conditions of their learning environments were consistent. Further research into why perceptions differ among students of the same cohort is merited. <https://doi.org/10.21692/haps.2024.014>

**Key words:** learning objectives, medical education, pre-clerkship education, thematic analysis

## Introduction

A learning objective refers to a measurable goal or standard of performance to be achieved by a student upon completion of a lesson or activity (Webb et al., 2013). Learning objectives are a useful tool for instructors and are often a crucial component of curricular design. Proper implementation of learning objectives can aid instructors in practicing backwards curriculum design, maintaining curricular alignment, and staying within the scope of knowledge appropriate for students (Biggs & Tang, 2007; Lachlan-Hache et al., 2012; McMahon & Thakore, 2006; Wang et al., 2013). Improper use of learning objectives can lead to detrimental results such as decreased instructor and student satisfaction, performance, and confidence, and increased frequency of miscommunication and feelings of frustration

(Alsheikh, 2014; Floyd et al., 2009; Leone et al., 2019; Orr et al., 2022).

Learning objectives are also intended as tools for students, but little literature exists to describe student use of learning objectives, especially within the pre-clerkship medical student population. The use of learning objectives in medical education is designed to aid students by helping them form expectations regarding specific aspects of the curriculum (Chatterjee & Corral, 2017). These include content topics, depth of understanding, and methods by and conditions under which the student will be assessed (Chatterjee & Corral, 2017; Orr et al., 2022). Benefits for students using learning objectives may include development of metacognitive habits such as self-assessing and monitoring

*continued on next page*



progress, even accurately predicting their own performance (Kuhn & Rundle-Thiele, 2009; Maher, 2005). Students may adopt deep learning approaches to enhance conceptual understanding, which are associated with higher levels of academic performance and long-term retention, rather than relying on surface learning and rote memorization. (Biggs & Tang, 2007; Boud, 1995; Floyd et al., 2009; Paliokas, 2009). Additional studies have shown that student use of learning objectives can also increase students' intrinsic motivation and performance (Campbell & Campbell, 1988; Stipek, 1996). While these studies identified some benefits to students using learning objectives, they did not account for other positive effects that may have resulted from having better curricular alignment or instructors using more active learning strategies. Acknowledging this fact, it becomes difficult to understand why the Liaison Committee on Medical Education (LCME) requires program-level learning objectives be made available to medical students as part of their accreditation standards (AAMC, 2024; Kassebaum, 1992).

Requiring learning objectives to be made available to pre-clerkship medical students is based on two assumptions, neither of which has been confirmed in the literature. The first assumption is that medical students will use learning objectives if they are made available. One study found over one-fourth of undergraduate college students do not use learning objectives with the most common reason being they found other resources to be more helpful for their learning (Osueke et al., 2018). It is not unreasonable to speculate that similar trends exist in pre-clerkship medical students, considering that many are transitioning from the undergraduate college population.

The second assumption is that medical students know how to use learning objectives prior to entering medical school. Research has shown many undergraduate college students never receive explicit instruction on how to use learning objectives; therefore it is reasonable to postulate that pre-clerkship medical students also do not possess this skill (Osueke et al., 2018). Additional research has shown that not only do students generally welcome this specific instruction, but that there are positive effects to providing it, such as the development of metacognitive habits (Bjork & Bjork, 2011; Osueke et al., 2018). This suggests the importance of communication regarding how to use learning objectives from instructor to student in the pre-clerkship years of medical education. Previous work suggests this communication may not consistently occur and that perceptions regarding this communication and the actual use of learning objectives differ between medical educators and pre-clerkship medical students (Pavlick et al., 2024).

This study was designed to explore if and how pre-clerkship medical students use learning objectives and their perception of how their basic science instructors communicate about learning objectives.

## Materials and Methods

### *Study Design*

This study utilized a mixed-methods phenomenological approach to explore existing pre-clerkship medical student perceptions and experiences with using learning objectives. The study adopted a constructivist framework while developing the free-response portion of the questionnaire to allow respondents the opportunity to express their unique experiences without bias from provided answer choices. This study was approved by the University of Mississippi Medical Center Institutional Review Board (#UMMC-IRB-2022-187).

### *Setting and Participants*

All first- and second-year medical students enrolled in an allopathic medical institution in the southeastern United States were invited to participate in this study.

### *Questionnaire Design*

The researchers created a questionnaire to explore several aspects of learning objectives as perceived by current pre-clerkship medical students. This included inquiry on experiences, degree and method of use, and perception of communication from pre-clerkship basic science medical educators regarding learning objectives. The questionnaire was constructed by the lead author (KP) and included nine categorical questions and six free response questions. The questionnaire was reviewed with the co-authors (AN and CB) on several occasions before a final version was created. Progression through the questionnaire was dependent on branching logic from several questions. For example, if a student responded "No" or "Not Sure" to Question 6 ("Do you know if there are learning objectives available for your basic science courses?") then they were instructed to omit Question 7 ("Do you use the learning objectives in your basic science courses?") and proceed directly to Question 8 ("Prior to entering medical school, were learning objectives available for your typical courses?"). Please refer to Appendix 1 for the full version of the questionnaire.

### *Data Collection*

The questionnaire was distributed in person and on paper during the fall semester of 2022. Distribution occurred in the last ten minutes of a mandatory didactic lecture in a medical histology and cell biology course for first-year students and a medical microbiology and immunology course for second-year students. Both course directors provided written permission for data collection and their choice of which session for researchers to collect data. An informed consent statement was read to students prior to the questionnaire distribution which described the study's purpose and nature. Students were informed that neither course director would have access to any collected data to mitigate potential student concerns and encourage participation. All attending students were provided with a blank questionnaire and ten

*continued on next page*

minutes to complete it if they chose. All students were asked to turn in their questionnaire to a collection box regardless of completion and/or participation to maximize anonymity.

All researchers had served in a teaching role in previous courses for both cohorts and were aware of potential biases this might cause. The lead and one additional researcher (KP and CB, respectively) served as graduate teaching assistants while the other additional researcher (AN) served as a course director and instructor. This was considered and addressed by waiting until their teaching roles ended and students were enrolled in different courses with which none of the researchers were involved before collecting data.

#### Data Management

All questionnaire data was transcribed into a Microsoft Excel file and original questionnaires were stored in three-ring binders within a locked filing cabinet. Only the lead researcher (KP) had direct access to the digital file through an institution affiliated password protected account. Additional researchers (AN and CB) were provided access to the deidentified digital data through shared permissions

from the lead researcher. Each record was given a cohort identification (M1 or M2) and Record ID number which indicated the order of sequence the lead researcher transcribed the data.

#### Data Analysis

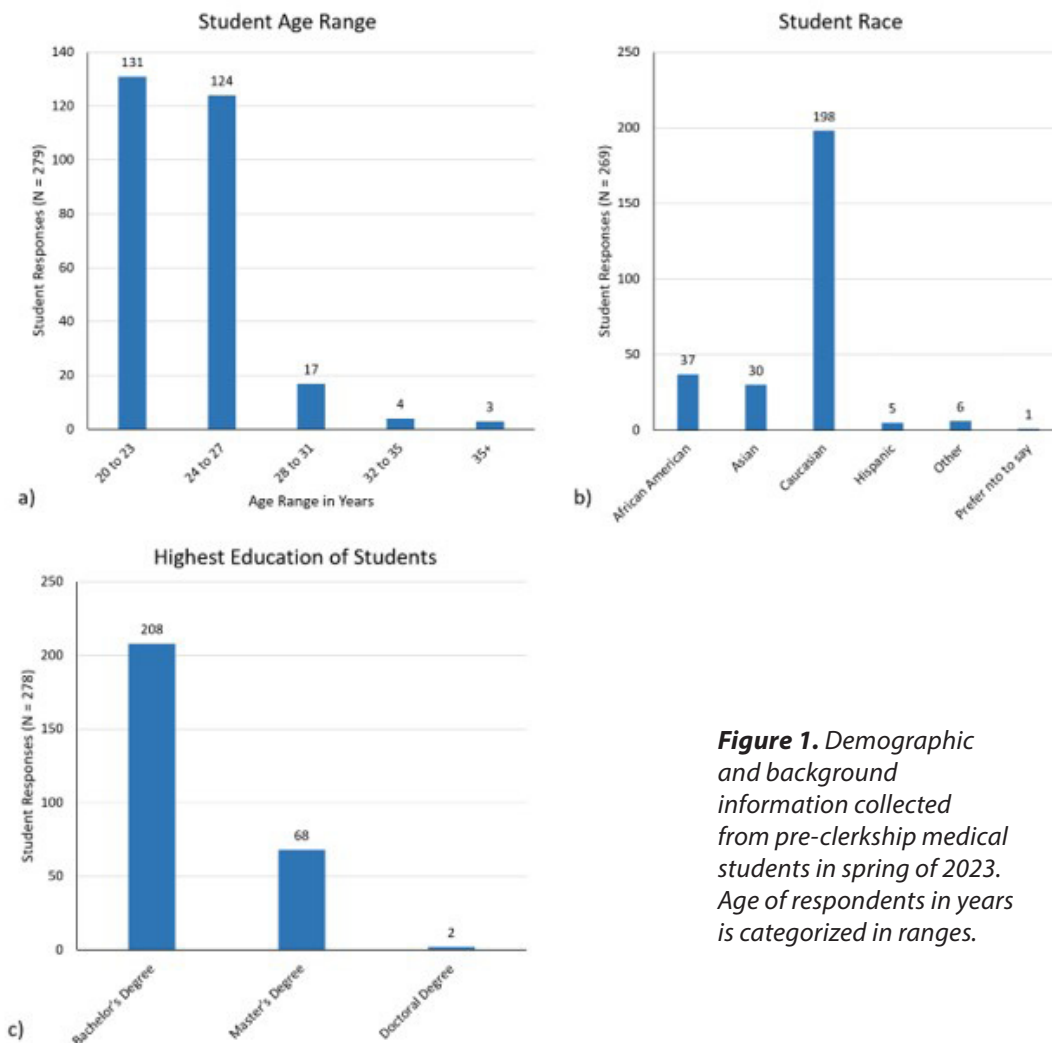
All questionnaire data was retained for analysis except when the respondent selected more than one response to a single selection question (e.g., selecting "Yes" and "No"). Quantitative data was analyzed using SPSS, Version 28.0. Chi-square tests were used to determine significant difference in cohort response rates to categorical questions with a  $p$ -value set at 0.05.

Free response questions underwent inductive thematic analysis as described by Kiger and Varpio (2020). All researchers reviewed the data before independently assigning initial codes. Initial codes were then compared among all researchers to discuss differences and modifications. The reiterative nature of thematic analysis necessitated all researchers to meet and discuss codes multiple times until consensus was reached among final codes. Themes and sub-themes were generated

independently by each researcher based on the final codes. All researchers then compared themes and sub-themes to discuss differences and generate final themes and sub-themes upon which all agreed.

## Results

Complete and partial questionnaires were retained for analysis ( $n = 279$ ), resulting in an 84% response rate. The first three questionnaire items asked participants' age range, race, and highest level of education (Figure 1). The most frequently reported age range, race, and highest degree earned were 20 to 30 years old ( $n = 131$ ), Caucasian ( $n = 198$ ), and bachelor's degree ( $n = 208$ ), respectively.



**Figure 1.** Demographic and background information collected from pre-clerkship medical students in spring of 2023. Age of respondents in years is categorized in ranges.

continued on next page

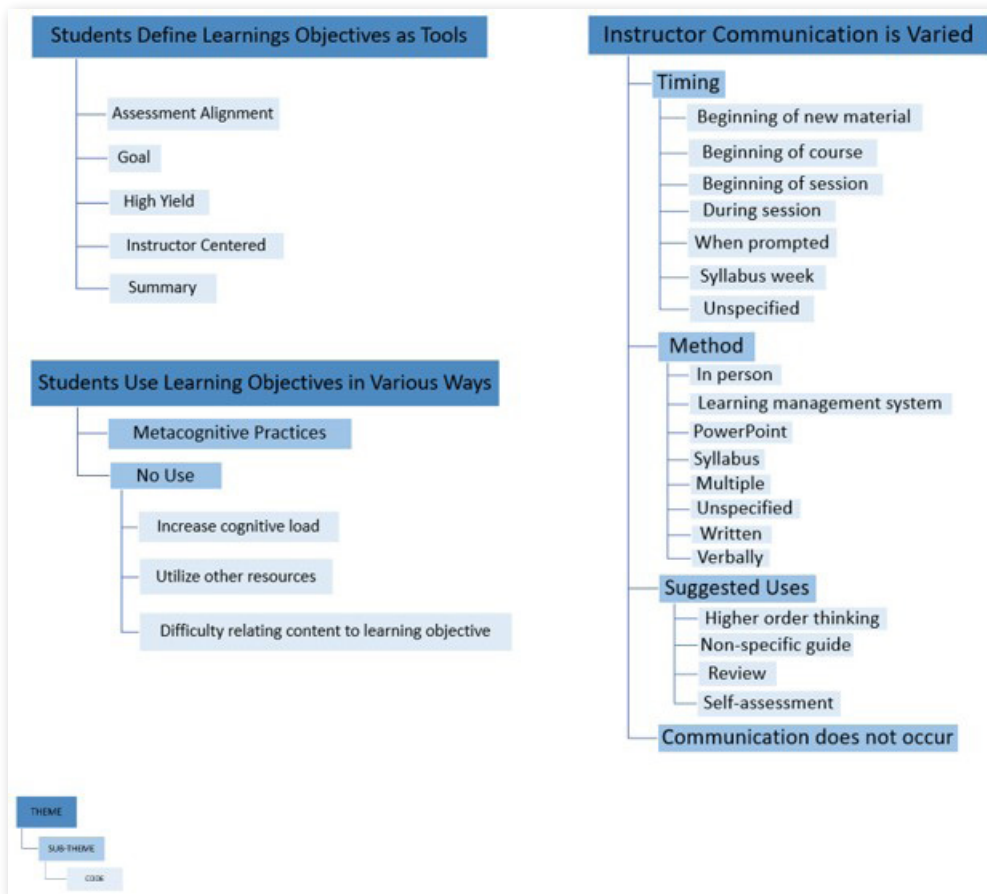
Five items on the questionnaire collected categorical data (Table 1). Combined cohort response rates were analyzed using Chi-square tests for independence with a  $p$ -value set at 0.05. The majority (68.7%,  $p < 0.001$ ) of students indicated they were aware of available learning objectives for previous undergraduate courses, with less than half (45.2%,  $p < 0.001$ ) indicating they knew how to use them prior to entering medical school. Nearly all students (98.5%) indicated they were aware of available learning objectives for their current basic science courses but the majority (59.7%,  $p = 0.0116$ ) indicated they do not use them. There was virtually no difference in responses regarding perceived communication from their instructors regarding learning objectives ( $p = 0.9517$ ).

Question	Responses	M1	M2	Total	
Do you know if there are learning objectives available for your basic science courses?	Yes	137	130	267	$<0.0001^*$ $\chi^2 (2, N = 271) = 518.288, p < 0.0001$
	Not Sure	3	0	3	
	No	1	0	1	
Do you use the learning objectives in your basic science courses?	Yes	56	49	105	$0.0116^*$ $\chi^2 (1, N = 261) = 9.965, p < 0.0016$
	No	80	76	156	
Prior to entering medical school, were learning objectives available for your typical courses?	Yes	101	90	191	$<0.0001^*$ $\chi^2 (2, N = 278) = 166.496, p < 0.0001$
	Not Sure	26	39	65	
	No	14	8	22	
Prior to entering medical school, did you know how to use learning objectives?	Yes	69	59	128	$<0.0001^*$ $\chi^2 (2, N = 283) = 19.216, p < 0.0001$
	Somewhat	27	48	85	
	No	44	26	70	
Have your basic science instructors communicated how to use their learning objectives?	Yes	80	57	137	0.9517 $\chi^2 (1, N = 273) = 0.004, p = 0.9517$
	No	59	77	136	

**Table 1.** Categorical questions and corresponding statistical measures from the pre-clerkship medical student data.

*Qualitative Data*

From the 279 records that were retained, 1,199 free responses underwent inductive thematic analysis which led to the researchers creating three independent themes: 1) Students define learning objectives as tools, 2) Students use learning objectives in various ways, and 3) Instructor communication about learning objectives is varied (Figure 2).



**Figure 2.** Thematic analysis of pre-clerkship medical student data visually represented in hierarchical format with themes located at the top of each tree. Sub-themes and their corresponding codes are located below each theme.

continued on next page



### Theme 1: Students define learning objectives as tools

The first theme was generated based on responses which described how the sampled students perceived learning objectives as a tool to be used during their pre-clerkship studies. This included perceptions of learning objectives as a communication tool to convey pre-determined goals, expectations for learning, or content to be included in the learning session. The following quotes represent these ideas:

"[A learning objective] is a pre-established goal given to students before studies begin. It is generally an important topic or concept for a course." (Record ID M1-21)

"A summary of expected learning before a given lecture and a check for making sure nothing is missed." (Record ID M2-13)

"What material will be covered within a lecture." (Record ID M2-28)

Also, students defined learning objectives as a preparation tool to aid in studying and preparing for assessments because they expected alignment between learning objective and assessment. That is, the learning objective describes what content the student should master to succeed on the assessment and evaluates understanding of the material described in the learning objectives.

"Topic list for exams – essentially mainly what we should know" (Record ID M1-102)

"Topics that will be tested on." (Record ID M2-24)

"A clear statement of expectation from professors as to what students are to gain from a particular topic, and what will be tested." (Record ID M1-39)

Similarly, learning objectives were defined as a guiding tool which helped students organize and prioritize high-yield information as described by Record ID M2-102 who stated learning objectives were a "summation of topics to be covered by a course/lecture. The most necessary information to learn." (Record ID M2-102).

### Theme 2: Student's use of learning objectives

The second theme was generated to describe if respondents utilized learning objectives. This theme was further organized into two sub-themes to distinguish between responses indicating use versus those who indicated they did not use learning objectives.

Sub-theme 2A: Metacognitive practices. Responses indicating active use of learning objectives followed questionnaire branching logic which asked in what ways they used learning objectives. Reported uses largely described practicing elements of metacognition. One practice included students using learning objectives to prepare for a learning session by priming themselves with the material.

"Generally, I look at them to get a good idea of what is going to be covered in the material." (Record ID M2-99)

"Sometimes, I will skim the [learning objective] at the beginning of each [PowerPoint] to get a brief idea of what to expect while I read." (Record ID M2-117)

"I read them to get an idea of important upcoming concepts before learning them, and later use them for quick review." (Record ID M1-21)

Another metacognitive practice for which the students indicated that they used learning objectives was to self-assess their understanding of the content by engaging in active recall to identify any gaps in knowledge. Based on this behavior, the students could then adjust their framework for studying to focus on high-yield material (i.e., material they anticipated would be assessed) or create their own additional study tools.

"Write practice questions; use for active recall." (Record ID M1-74)

"I made a bulleted list with the learning objectives and added info below to 'answer' the objective." (Record ID M2-04)

"I use them to alter how I will study." (Record ID M2-128)

Sub-theme 2B: Students do not use learning objectives for a variety of reasons. Responses indicating neglecting to use learning objectives followed questionnaire branching logic which asked for reasons for not using learning objectives. Responses described learning objectives as not being helpful for reasons such as being too broad, vague, or numerous as illustrated by the following quotes:

"They're too broad to study. They usually include every detail in the slides. We're tested on small details so they don't work. They're basically an outline of their lecture." (Record ID M1-55)

"I guess I should but they always seem so hard to grasp or too vague to be useful like 'students will know how to do a respiratory exam' which to me is like saying 'know everything'." (Record ID M2-47)

"Often times the objectives are redundant with the most blatantly presented material or there are too many so you have to learn it all anyway." (Record ID M1-70)

Additionally, there were students who indicated they did not find learning objectives helpful because they found learning objectives to be detrimental to their success. These included descriptions of an increased cognitive load (e.g., amount of information) and feelings of being overwhelmed, stressed, or anxious. Record ID M1-13 said they did not use learning objectives "because [learning objectives are] to [sic] spread out and stressful" while Record ID M2-58 echoed this with stating how learning objectives are "overwhelming to consider since I have no prior knowledge of the content."

*continued on next page*

Record ID M1-89 even stated learning objectives “don’t always clearly define what we need to know, so can hurt more than they help”.

Another reason students indicated they did not use learning objectives was because they found other resources to be more helpful. These resources were described as internal or external to the course but were largely used to assess the student’s understanding of material as described below:

“Practice exams gauge my comprehension much better than simply answering a learning objective.” (Record ID M1-06)

“So far, high yield outside resources have guided me to high yield class topics.” (Record ID M2-125)

Students also indicated that they did not use learning objectives due to a perceived curricular misalignment. Some responses described failure to meet an expectation for the learning objective to be all-inclusive regarding assessable content, such as the statements below:

“I typically don’t take time to read the learning objectives because I assume I am responsible for everything presented in class and sometimes information not presented. Although we have objectives, I often feel I must learn information outside of the objectives.” (Record ID M2-20)

“They do not help as professors test many things outside of learning objectives.” (Record ID M1-132)

Additional responses described students acknowledging they could not identify how the presented content related to a learning objective.

“Unsure of their relevance.” (Record ID M2-21)

“Sometimes I don’t know how strongly the assessments are geared toward the objective.” (Record ID M1-63)

Other responses described a similar frustration but reported explicit misalignment between learning objective and assessment.

“I don’t think exams are built around the learning objectives usually.” (Record ID M1-139)

“Generally, they do not show a parallel between their learning objectives and the content.” (Record ID M1-80)

Theme 3: Instructor communication about learning objectives is varied

This final theme was generated based on responses which described the variation of perceived communication from instructors regarding learning objectives. This theme was further organized into four sub-themes to describe different elements of communication.

Sub-theme 3A: Timing of communication. The first sub-theme captured responses to inquiry about when instructors communicated about learning objectives to these students.

Branching logic dictated response to this question only if the respondent indicated communication about learning objectives did occur. Responses were diverse but included introductory timepoints for the respective course or learning session as indicated by the following:

“On the first day of class” (Record ID M1-97)

“Right before lecture begins, they typically go over them briefly.” (Record ID M2-27)

Conversely, some respondents indicated this communication only occurred when the instructor was prompted as described by Record ID M1-26 stating, “Typically not until someone asks if they are followed”.

Sub-theme 3B: Method of communication. Students also indicated the method of communication regarding learning objectives was varied, but broadly fell into categories of verbal, written, or a combination thereof. This variation was described between courses and instructors.

“They tell us ‘Here’s the objectives’ or some will read them.” (Record ID M2-18)

“Put [learning objectives] in canvas [sic] or at the front of a PowerPoint...” (Record ID M1-61)

Sub-theme 3C: Suggested Uses. The questionnaire also asked students if there were specific things communicated about learning objectives regarding instruction on how to use them as a student. These suggested uses encouraged development of metacognitive habits and promoted higher order thinking such as application or synthesis of information.

“Instructors just tell us to be able to apply the knowledge gained from objectives.” (Record ID M1-32)

“Read them to make sure you have mastered them. Use them as a checklist.” (Record ID M2-20)

Sub-theme 3D: Instructors do not communicate about learning objectives. The last sub-theme was created to encompass responses indicative of a perception from respondents that their instructors did not communicate about learning objectives to the students. This included brief responses such as Record ID M1-93 stating, “they usually don’t”. This sub-theme also included responses which described how the instructor may acknowledge the existence or appearance of learning objectives but does not discuss anything further. The quotes below illustrate this occurrence:

“They don’t, they just say ‘these are the learning objectives’” (Record ID M2-50)

“[Instructors say] ‘here are the objectives; I won’t read them to you, but you can on your own time.’” (Record ID M2-106)

## Discussion

This study provides insight into how pre-clerkship medical students perceive learning objectives, including thoughts on their value and how they are used. Data revealed that the majority of students (59.7%) did not use learning objectives for their basic science courses even though nearly all students (98.5%) indicated they were aware that learning objectives were available. Notably, the sampled students shared several constant variables including instructors, courses, and learning environments respective to each cohort, but *p*-values suggest there may be additional unidentified factors driving these students' choice to not use learning objectives. Similarly, the qualitative data revealed stark contrasts in developed perceptions regarding learning objectives which may lead to identifying the driving factor(s), but further research is necessary.

Students who indicated that they use learning objectives largely described using them as tools to aid in guiding their studies in several ways. First, students indicated learning objectives provide guidance as to what content or concepts should take priority, often described as "high yield". Additional uses described metacognitive habits such as using the learning objectives to self-assess their understanding of the knowledge and identify gaps which may exist (Tanner, 2012). This allowed the student to reiteratively restructure their study approaches to best address these gaps in knowledge to ensure ample preparation for the future assessment. These students may have utilized learning objectives prior to entering medical school, and potentially were already practicing metacognitive strategies for their learning, although this was not confirmed with the current study.

Students who indicated they did not use learning objectives provided several reasons for not using them. One deterring factor expressed was encountering a perceived curricular misalignment. This was frequently described as the student feeling as though the presented learning objective was not tested during the subsequent assessment. This led to feelings of frustration and mistrust, as expressed in the data and the literature (Leone et al., 2019). Curricular misalignment can also lead to feelings of an academic version of learned helplessness in which the student feels as though their study efforts do not matter and will not make a difference toward their inevitable poor performance on the assessment (Filippello et al., 2019; Fincham et al., 1989). Development of these negative feelings toward learning may also harm the development of a growth mindset and skills related to life-long learning, such as self-directing and self-regulating (Husmann et al., 2018).

Further investigation is necessary to determine whether curricular misalignment truly exists or if other factors may contribute to the students developing this perception. One possibility could be the lack of formal pedagogical training

of medical educators (AAMC, 2022). If the educators do not know how to use learning objectives to achieve curricular alignment, there is a possibility for them to present content outside of the students' scope or create invalid assessment items (Alsheikh, 2014; Ferguson, 1998). Additionally, the educators may not consider how students might use learning objectives and neglect to incorporate them into the teaching and learning activities. Lastly, a possible contributing factor may be what is known as the "curse of knowledge" (Wiemann, 2007). This phenomenon occurs when the educator possesses an unconscious understanding of foundational knowledge and may not recall what it was like when they did not. This can result in the omission of information which is foundational and necessary for students to form connections between presented content (Leone et al., 2019; Wiemann, 2007). Similarly, this may also result in educators being able to quickly identify linear relationships between content and learning objectives whereas students cannot.

Lastly, the sampled medical student perceptions of communication from their instructor regarding learning objectives reflects trends observed in other student populations (Osueke et al., 2018). This includes descriptions of both general communication wherein the instructor encouraged the use of learning objectives and specific communication wherein the instructor describes detailed ways to interact with learning objectives to aid learning. Given that each cohort in this study shared the same environment and instructors, further investigation is necessary to identify what factors may have contributed to discrepancies in student perception of communication from instructors.

### Limitations

The authors acknowledge several limitations of this study. The first is that these students were only sampled at one given time-point. Student opinions could have been biased by a recency effect, particularly if the given instructor may have specifically pointed out learning objectives that day. Students may have also interpreted and responded to questions specifically in reference to the course during which they were sampled (i.e., medical histology and cell biology learning objectives for first-year students and medical microbiology and immunology for second-year students) instead of with respect to all of their basic science courses. Second, the nature of the questionnaire limited the depth of response. Students were prompted to explain their ideas, but time and space limitations may have limited their responses. Future study could allow for interviews or focus groups to allow for probing questions and deeper responses. Finally, the authors limited this study to pre-clerkship basic science courses. They acknowledge that opinions on learning objectives will vary with the context and are careful not to generalize outside of the pre-clerkship population that was studied here.

*continued on next page*



### Future Directions

Further investigation into the perceptions of learning objectives by pre-clinical medical students is necessary to more accurately identify causative reasons for neglecting to use learning objectives. More specifically, parsing and analyzing data respective to cohort might reveal significant differences between or perceptions unique to each. Additional expansion to include other student populations and institutions would provide insight to developing more effective approaches to creating and implementing learning objectives. Comparing student perceptions to those held by teaching faculty would be valuable to identify potential miscommunications surrounding learning objectives. Finally, comparisons between medical student groups that use or do not use learning objectives and their respective performance on various assessments would lend insight to the practical value of learning objectives.

### Conclusion

This study suggests that pre-clerkship medical students may not use learning objectives for various reasons. By allowing these students to describe reasons for why they do not use learning objectives, the researchers have gained insight into potential areas of improvement regarding implementation of learning objectives in pre-clerkship medical education. This data can be used to explore other student populations (i.e., other health profession students) and compare experiences with learning objectives between disciplines. Additionally, this study found that pre-clerkship medical student perceptions of communication regarding learning objectives were similar to what has been found in other student populations. Further study is required to identify causative factors which contribute to students developing different perceptions of instructor communications.

### About the Authors

Kayla Pavlick is an Assistant Professor at the University of South Alabama and was a graduate student in an anatomical sciences education program at the University of Mississippi Medical Center at the time of this study. She was responsible for the conceptualization, methodology, data analysis, and writing of the manuscript in partial fulfillment of their dissertation. Casey Boothe is an Assistant Professor at the University of Mississippi Medical Center and was involved with the methodology, data analysis, and manuscript editing. Andrew Notebaert is an Associate Professor and Program Director at Northern Illinois University and contributed to the conceptualization, methodology, data analysis, and manuscript editing.

### Acknowledgements

The authors would like to thank all individuals willing to participate in this study. The authors would also like to thank the course directors, Kathy Yee, PhD and Stephen Stray, PhD, for allowing the researchers to collect data during their courses. Finally, the authors wish to thank Audra Schaefer, PhD, for her generosity in reviewing several drafts of this manuscript.

### Literature Cited

- Alsheikh, G. Y. M. (2014). Misjudgment and misuse of the learning objectives. *The Medical Journal of Basrah University*, 38(2), 1-7. <https://doi.org/10.33762/mjbu.2020.129154.1056>
- Association of American Medical Colleges (AAMC). (2022, December 31). *AAMC Faculty Roster*. <https://www.aamc.org/media/8496/download?attachment>
- Association of American Medical Colleges (AAMC). (2024). *Basic Science*. <https://www.aamc.org/what-we-do/mission-areas/medical-research/basic-science>
- Biggs, J., & Tang, C. (2007). *Teaching for quality learning at university: what the student does*. 3rd edition. McGraw-Hill.
- Bjork, E. L., & Bjork, R. (2011). Making things hard on yourself, but in a good way: creating desirable difficulties to enhance learning. In M. A. Gernsbacher, R. W. Pew, L. M. Hough, J. R. Pomerantz (Eds), *Psychology and the real world: Essays illustrating fundamental contributions to society*. 2<sup>nd</sup> edition. Worth. [https://bjorklab.psych.ucla.edu/wp-content/uploads/sites/13/2016/04/EBjork\\_RBjork\\_2011.pdf](https://bjorklab.psych.ucla.edu/wp-content/uploads/sites/13/2016/04/EBjork_RBjork_2011.pdf)
- Boud, D. (1995). *Enhancing learning through self-assessment*. Routledge. <https://doi.org/10.4324/9781315041520>
- Campbell, J. PL., & Campbell, R. J. (1988). *Productivity in organizations: New perspectives from industrial and organizational psychology*. Jossey-Bass.
- Chatterjee, D., & Corral, J. (2017). How to write well-defined learning objectives. *Journal of Education in Perioperative Medicine*, 19(4), Article e610.
- Ferguson, L. M. (1998). Writing learning objectives. *Journal of Nursing Staff Development*, 14(2), 87-94.
- Filippello, P., Buzzai, C., Costa, S., & Sorrenti, L. (2019). School refusal and absenteeism: Perception of teacher behaviors, psychological basic needs, and academic achievement. *Frontier in Psychology*, 10, Article e1471. <https://doi.org/10.3389/fpsyg.2019.01471>

continued on next page

- Fincham, F. D., Hokoda, A., & Sanders, R. Jr. (1989). Learned helplessness, test anxiety, and academic achievement: A longitudinal analysis. *Child Development*, 60(1), 138-145. <https://doi.org/10.2307/1131079>
- Floyd, K. S., Harrington, S. J., & Santiago, J. (2009). The effect of engagement and perceived course value on deep and surface learning strategies. *Informing Science: The International Journal of an Emerging Transdiscipline*, (12), 181-190. <http://doi.org/10.28945/3354>
- Husmann, P.R., Hoffman, L. A., & Schaefer, A. F. (2018). Unique terms or are we splitting hairs? Clarification of self-directed versus self-regulated learning and related terms. *Medical Science Educator*, 28, 777-783. <https://doi.org/10.1007/s40670-018-0626-2>
- Kassebaum, D. G. (1992). Origin of the LCME, the AAMC-AMA partnership for accreditation. *Academic Medicine*, 67(2), 85-87. <https://doi.org/10.1097/00001888-199202000-00005>
- Kiger, M. E., & Varpio, L. (2020). Thematic analysis of qualitative data: AMEE Guide No. 131. *Medical Teacher*, 42(8) 846-854. <https://doi.org/10.1080/0142159X.2020.1755030>
- Kuhn, K-A. L., & Rundle-Thiele, S. R. (2009). Curriculum alignment: Exploring student perception of learning achievement measures. *International Journal of Teaching and Learning in Higher Education*, 21(3), 351-361.
- Lachlan-Haché, L., Cushing, E., & Bivona, L. (2012, November). Student learning objectives: Benefits, challenges, and solutions. In *Performance management, advantage evaluation & professional growth at American Institutes for Research*. <https://www.air.org/sites/default/files/2021-06/Student-Learning-Objectives-Benefits-Challenges-Solutions.pdf>
- Leone, E.A., Salisbury, S., Nolen, Z. L., Idema, J.L., Parsley, K., Stefanik, K. L., & Daniel, K. L. (2019). Identifying the breakdowns in how students and faculty interpret course objectives. *Bioscene: Journal of College Biology Teaching*, 45(1), 16-23.
- Maher, A. (2004). Learning outcomes in higher education: Implications for curriculum design and student learning. *Journal of Hospitality, Leisure, Sport and Tourism Education*, 3(2), 46-54.
- McMahon, T., & Thakore, H. (2006). Achieving constructive alignment: Putting outcomes first. *Quality of Higher Education*, 3, 10-19.
- Osueke, B., Mekonnen, B., & Stanton, J. D. (2018). How undergraduate science students use learning objectives to study. *Journal of Microbiology & Biology Education*, 19(2). <https://doi.org/10.1128/jmbe.v19i2.1510>
- Orr, R. B., Csikari, M. M., Freeman, S., & Rodriguez, M. C. (2022). Writing and using learning objectives. *CBE Life Sciences Education*, 21(3). <https://doi.org/10.1187/cbe.22-04-0073>
- Paliokas, I. (2009). Reinforcing metacognition in CAD education using video tutorials. *Computer-Aided Design and Applications*, 6(5), 613-623.
- Pavlick, K., Boothe, C., & Notebaert, A. (2024). A qualitative study on instructor experiences with learning objectives in the basic sciences. *HAPS Educator*, 28(1), 22-35. <https://doi.org/10.21692/haps.2024.004>
- Stipek, D. (1996). Motivation and instruction. In *Handbook of Educational Psychology*. Simon and Schuster/McMillan, 85-113.
- Tanner, K. D. (2012). Promoting student metacognition. *CBE-Life Sciences Education*, 11(2), 113-120. <https://doi.org/10.1187/cbe.12-03-0033>
- Wang, X., Su, Y., Cheung, S., Wong, E., & Kwong, T. (2013). An exploration of Biggs' constructive alignment in course design and its impact on students' learning approaches. *Assessment & Evaluation in Higher Education*, 38(4), 477-491. <https://doi.org/10.1080/02602938.2012.658018>
- Webb, E. M., Naeger, D. M., Fulton, T. B., & Straus, C. M. (2013). Learning objectives in radiology education: Why you need them and how to write them. *Academic Radiology*, 20(3), 358-363. <https://doi.org/10.1016/j.acra.2012.10.003>
- Wieman, C. E. (2007). APS News – The back page. The “curse of knowledge”, or why intuition about teaching often fails. *American Physical Society News*, 16(10).

continued on next page

## Appendix 1. Student Questionnaire

Please **CIRCLE** your answer choices for the following questions.

1. Please indicate your age range:

- a. 20-23
- b. 24-37
- c. 28-31
- d. 31-35
- e. Over 35

2. Please indicate your race:

- a. African American
- b. Asian
- c. Caucasian
- d. Hispanic
- e. Other (Please specify: \_\_\_\_\_)
- f. Prefer not to answer

3. Please indicate the highest level of education you have completed:

- a. Bachelor's Degree
- b. Master's Degree
- c. Doctoral Degree
- d. Other (Please specify: \_\_\_\_\_)

4. Are you familiar with the term "Learning Objective"?

- a. Yes
- b. No

5. What do you think a learning objective is?

---

---

6. Do you know if there are learning objectives available for your basic science courses?

- a. Yes
  - i. Where do you typically find them?

---

---

- b. Not sure (proceed to question 8)
- c. No (proceed to question 8)

7. Do you use the learning objectives in your basic science courses?

- a. Yes
  - i. Please describe how you use these learning objectives:

---

---

---

- b. No
  - i. Why not?

---

---

---

8. Prior to entering medical school, were learning objectives available for your typical courses?

- a. Yes
- b. No
- c. Not sure

continued on next page



9. Prior to entering medical school, did you know how to use learning objectives?

- a. Yes
- b. No
- c. Somewhat

10. Have your basic science instructors communicated how to use their learning objectives?

- a. Yes
- b. No (please omit questions 11, 12, and 13)

11. **WHEN** do your instructors communicate to you about learning objectives?

---

---

12. **HOW** do your instructors communicate to you about learning objectives?

---

---

13. How do your instructors tell you to **USE** their learning objectives?

---

---

Thank you for participating in this study. The researchers at UMMC value your contribution to the education research conducted at UMMC.

**Please DO NOT put your name on any part of this questionnaire when you turn it in.**



## Become a Member of HAPS Today!

The Human Anatomy & Physiology Society (HAPS) is dedicated to promoting excellence in the teaching of Anatomy and Physiology at colleges, universities and related institutions.

- **Connect with colleagues also pursuing success in teaching A&P**
- **Discounted rates for annual and regional conferences**
- **Access Teaching Tips for tough topics**
- **HAPS Institute short-courses for ongoing professional development**
- **Open access to our peer-reviewed journal, *The HAPS Educator***
- **Grants and scholarships for research and travel**
- **Additional member resources listed [here](#).**



For more information, contact HAPS at [info@hapsconnect.org](mailto:info@hapsconnect.org) or at 1-800-448-4277.

Follow [this link](#) to join and start benefiting from membership today!

# A Survey of Exam Methods in College A&P Courses

Benjamin L. Wiggins, PhD<sup>1</sup> and Gregory J. Crowther, PhD<sup>2</sup>

<sup>1</sup>Shoreline Community College, Shoreline, WA, USA

<sup>2</sup>Everett Community College, Everett, WA, USA

Corresponding author: [bwiggins@shoreline.edu](mailto:bwiggins@shoreline.edu)

## Abstract

Exams are a form of assessment that is ubiquitous in college STEM classrooms yet is infrequently studied from the experiential perspectives of instructors or students. To better understand the forms, methods, and experiences of college STEM exams, we conducted survey-based research with instructors in anatomy and physiology courses, a well-defined and popular subset of STEM courses. We used a combination of qualitative and quantitative questions to learn about exam methods in the classrooms of 63 instructors, through which many thousands of exam-student interactions happen each year. Our data suggest that exams are a significant, possibly onerous undertaking for instructors, including many forms of optional support for students, and that they have an outsized impact on students' grades (and thus their persistence towards STEM careers). Instructors' survey responses imply that sustainability of the methods they use for assessment is a key and pressing concern in their professional lives. This need for sustainability may lead to tradeoffs that impact students, such as decreasing the transparency of the exam experience, sometimes to an extent that exams may be perceived as highly secretive. The feasibility of instructors accommodating students' absences and of students challenging instructors' grading are discussed as exemplars of the complex communication that, for better or worse, is central to student-instructor relationships and the outcomes of STEM classrooms.

<https://doi.org/10.21692/haps.2024.016>

**Key words:** equitable testing, instructor workload, summative assessment

## Introduction

College STEM courses are a gateway to science careers and human progress, but also act in practice as strong barriers and filters that decide which students are allowed to continue forward. Certain introductory STEM courses such as A&P, calculus, and organic chemistry have reputations as "weed-out" courses, also known as gateway or barrier courses (Seymour et al., 2019). Courses develop these reputations in large part from their high rates of low or failing grades and withdrawals (DFW rates; Hatfield et al., 2022), which lead many students to abandon their plans to major in STEM subjects (Hunter, 2019) and/or start careers in STEM-related areas such as nursing (Tripp et al., 2024). While attitudes along the lines of "not everyone can be a scientist" remain prevalent among college faculty (Canning & Limeri, 2023), there also is increasing interest among science educators in ensuring broader, more equitable access to such academic and career options (Shukla et al., 2022).

Improving equity in STEM education is a complex challenge that must be tackled in part at broad levels (e.g., across departments and institutions) to address systemic structural biases (e.g., Denaro et al., 2022). However, within individual classes, the professors, faculty, teachers, and teaching assistants (TAs; hereafter, "instructors") have some agency and some responsibility to employ techniques to improve equity (Crowther & Wiggins, 2024; Tanner, 2013). Many of these classroom practices are elaborations of the general strategy of "active learning" (Freeman et al., 2014); to measure the extent of adoption of this strategy (Stains et al., 2018), there are validated research tools such as the Classroom Observation Protocol for Undergraduate STEM aka COPUS (Smith, 2013), Practical Observation Rubric To Assess Active Learning aka PORTAAL (Eddy et al., 2015), and Decibel Analysis for Research in Teaching aka DART (Asgari et al., 2021). This work is worthwhile and important, yet in and of itself does not directly address the low test scores that --

*continued on next page*

since test scores dominate the determination of final grades (Momsen et al., 2010; Uminski et al., 2024) -- contribute to the high DFW rates and their often-devastating consequences for students (Holland et al., 2019). We discern a relative dearth of research on how undergraduate science students are tested, as opposed to how they are taught. For example, the closest analogue of COPUS, PORTAAL, and DART in the realm of assessment may be the 3-Dimensional Learning Assessment Protocol (3D-LAP) (Lavery et al., 2016), which, while regularly discussed and cited, has not been implemented nearly as widely as the observation tools for classroom practice. We focus on exams as an under-researched but crucial aspect of STEM education, and therefore one that is potentially ripe for improvement.

Our understanding of exams as an important, underexplored aspect of college education is focused on the student experience. Students' lived experiences within college STEM courses are crucial to the ways in which they can be included, or prevented from participating, in the practices and careers of science (Aguillon et al., 2020; Bonous-Hammarth, 2005; Meaders et al., 2019, 2020; Olson & Riordan, 2012). The degrees to which students identify as scientists in these spaces is one aspect of the experience, and these experiences largely determine whether or not students have and successfully use opportunities to persist within a large, complicated, and historically marginalized community (Cimpian et al., 2020; Dewsbury, 2020; Estrada et al., 2016). It is through student experiences that power relationships play out, especially for assessments like exams, and these relationships can be motivating or can be barriers to success (Crowther & Wiggins, 2024; Delpit, 2003). Why do some exams increase motivation while others discourage students? What emotional challenges are included with a particular method of exam grading? Do some types of exam support help students to be either resilient or pressure them into anxiety? Studying the social practices of writing, giving, and grading exams through a lens on student experiences means focusing on a broad range of student outcomes instead of solely highlighting issues of scientific content or instrument validity or demonstrated learning, all of which should also be the subject of research into college STEM exams (Branchaw et al., 2020; Mor & Erşen, 2023; Pellegrino et al., 2023; Sireci, 2015). We are interested in how college students' lives are likely to be impacted, well or poorly and under what conditions, by the exam practices created in their STEM courses.

In addition to focusing on student experiences, any analysis of current college teaching practice must foreground the constraints and affordances of the instructors. Within a postsecondary education system that follows many of the original designs of the 19<sup>th</sup> century, college science instructors are tasked with maintaining multiple cross-

coordinated specialties in pedagogy and science while subject to mandates and incentives very different from those of their K-12 teaching counterparts (Beach & Grubb, 2011; Dudley-Marling & Burns, 2014). Any inspection or judgment of their teaching practice can only be meaningful or useful if it incorporates and understands the unique challenges in this teaching environment.

Large-scale study of exam practices in K-12 is primarily conducted on standardized assessments. While some college STEM exams (like those used as entrance exams for professional schools) are in widespread use, the vast majority of the exams in college STEM are within individual courses. This is a complicated ecology, and far too large in scope for any single investigation to characterize fully. To begin this research, we sought a scientific subfield that has relatively well-defined content, standardized learning goals, economic importance, and sufficient popularity to be found in a range of institution types and classroom sizes. Human Anatomy and Physiology (A&P) is an excellent fit; the science is within a single species, there is a national professional society (the Human Anatomy and Physiology Society) with a subscribed membership and published exemplar learning goals, A&P courses are widely required for advanced healthcare professional schools, and the importance for careers in medicine, nursing, therapy and research is clear. Even more usefully, the known membership of HAPS allows for some estimation of the extent to which our survey has reached instructors in the field. Survey-based research is an appropriate fit for this initial exploration of the state of exam practices in this scientific subfield.

Given this opportunity to better understand the diversity of exam methods used by college A&P instructors, we entered this work with the following research question (RQ):

**RQ1: Which aspects of exam practices are most and least prevalent in college A&P courses?**

For this general inquiry, we assumed that the survey responses would (at least indirectly) indicate these instructors' relative priorities, and the compromises they may make in defending those priorities. Therefore our second and final RQ was the following:

**RQ2: Based on college A&P instructors' implementation of exams, what can we infer about their primary goals for and tradeoffs with these exams?**

To begin to address these questions, we developed the Exam Methods Survey for data collection within the A&P teaching workforce.

## Methods

### *Survey Development*

The goal of the Exam Methods Survey was to systematically collect data on methods, trends, and practices within the population of college science courses on Anatomy and Physiology in the United States. This population was chosen as a delineated subfield within postsecondary STEM education for the relatively standardized curriculum compared to other common courses, the large impact on industry (primarily in the health care sector) and the availability of a central teaching-focused organization (the Human Anatomy and Physiology Society, hereafter HAPS) from which we could estimate the size and scope of the overall population. Focusing on the themes that were most prevalent in our own experiences with professional development and writing of exams, we developed an initial set of 9 fixed-choice (7 choose-all-that-apply, 2 single-best-answer) and 9 corresponding open-ended survey items through a short series of research group writing tasks and editing sessions (Dillman, 2014). To create an instrument that was likely to capture as many trends as possible from a complex human practice (i.e., the giving of exams), survey items had as many multiple-select answers as the authors had encountered or heard of in their careers. Corresponding open-ended questions provided opportunities for participants to follow up on each item with optional, unlimited text. A set of 8 context items (e.g., institution type) were added to the survey. The overall survey draft was built into Google Forms for ease of use and edited to balance collection of contextual information with instrument brevity to prevent survey fatigue. This project was approved by the Shoreline Community College IRB apparatus under IRB#STUDY000324 and informed consent was obtained from all participants as described.

### *Cognitive Testing*

Content validity of the initial questions was provided through individual think-alouds (Gubrium & Holstein, 2002) with five instructors who are actively involved in exam development for their own courses and/or as science education researchers. These participants read each survey item silently, then aloud, and then were asked to answer the survey items and to justify their answers. They were coaxed to explain or identify problematic items and to suggest alternative language if applicable. Items were then edited based on this instructor talk during the think-alouds, with the mutual goals of maintaining coherence of instructor language and fidelity to the original goals of the survey and research questions. Two contextual questions were removed during this testing process.

### *Recruiting and Sampling*

Our goal was to broadly and deeply sample from the entire population of people teaching college A&P courses in the United States. Because this population is difficult to estimate across a wide range of academic institutions, this initial survey was targeted to a known subset of motivated instructors who are members of HAPS. With permission from HAPS leadership, recruitment emails were sent to the HAPS listserv with links to the survey and (to promote snowball sampling) explicit encouragement to forward the survey widely. From HAPS leadership, we know that there are roughly 1,740 members of HAPS at any given time, and our goal was to receive participation from at least 2% of membership and at least 50 total full participants. To incentivize participation, two prizes of \$250 each were offered to participants who completed the survey and provided contact information expressly for this purpose. Over 8 weeks, further recruitment was attempted through posts on professional social media via LinkedIn, by personal emails to colleagues in A&P, by handing out fliers at the spring 2024 annual meetings of HAPS and the American Physiological Society (APS), and through an interview with the authors on a podcast series on A&P teaching. The resulting sample of 63 participants included 41 self-reported members of HAPS (~2.4% of membership). 47 of the 63 provided contact information to learn about the results of the survey and were subsequently sent an initial summary of findings as part of best practices in returning information to the community of participants.

### *Coding of Responses to Open-Ended Questions*

For the 9 open-ended questions, a total of 323 free responses were collected (~5.1 per participant). 12 participants left all open-ended items blank and 22 participants answered all of the optional questions. Each response was read by an author and double-checked to ensure that it did not indicate a response opposite to what was given in the corresponding fixed-response question (this occurred in less than 0.1% of all responses). All responses were read by authors to give background to the experiences within the study population. For several questions, further qualitative analysis was conducted, as follows:

- *Q1: How do you help students to prepare for your exams?* Participants provided a wide range of methods for supporting students. Methods were tabulated as an aid to understanding the workload that A&P instructors voluntarily take on to help students and also as a resource for instructors looking for new methods of student support.

*continued on next page*



- *Q2: How do you choose material for your exams?* To better understand the range of sources that instructors use to decide what material should be on an exam or not, authors mined these responses looking for sources that had not been previously selectable in the survey items. Seven new sources were noted that will be written into future versions of the survey instrument.
- *Q4: What feedback do students receive after your exams?* A discussion with reviewers had highlighted that the choices available might confound some responses in which instructors would return aspects of the exam to students but in a way that was temporary or otherwise unable to be used as a resource for study, challenge, or reflection. We mined the responses looking for examples of this complex combination of multiple-select and open-ended responses. The responses noted in this additional analysis, and their impact on the data, are discussed below.
- *Q5: Can (or, how do) students challenge the grading on your exams?* From prior discussions with students, the authors were aware that the ability to challenge an exam grade might be perceived differently between them and their instructors. Open-ended responses were iteratively coded into four final codes: "Instructors encourage challenges and/or review", "Instructors describe opportunities to review", "Instructors are open to review only with student completion of prior preparative work", and "Instructors discourage, or never receive requests to, review exam grades". The prevalence of responses in these four codes is discussed below.

#### *Synthesis of Responses to Fixed-Choice and Free-Response Questions*

Since each required fixed-choice question was paired with an optional free-response question, we sometimes considered each respondent's answers to both questions simultaneously in compiling data. For example, if a respondent did not check a fixed-choice response but provided equivalent information as a free-response comment, we credited the respondent with affirming that fixed-choice response.

## **Results**

### *Demographics of Survey Respondents*

Our survey was completed by a total of 63 A&P instructors, 41 of whom (65%) self-identified as current members of HAPS. All but two of these instructors indicated that undergraduate students in their first two years were a description of many of their students.

Fifty-one (81%) of the instructors self-identified as full-time instructors who were either tenured, on a tenure track, or on the functional equivalent with a title such as "Lecturer with Security of Employment". Seven (11%) instructors are Staff Instructors, and one each who identified as a Graduate Student and an Undergraduate Student. Only three instructors (4.7%) self-identified as part-time or adjunct faculty. HAPS membership overall is similar in the relative lack of temporary faculty, with only 4.6% specifically identifying as adjunct or part-time instructors (and another 2.6% identifying as graduate students, who are likely to have part-time teaching duties). While this indicates a relative match in titles and roles between our sample population and HAPS membership, it is notable that adjunct instructors are underrepresented compared to the likely overall distribution of all A&P instructors teaching in US higher education, assuming that general college-level trends (Culver & Kezar, 2020) apply to A&P.

Regarding surveyed instructors' institution types, 29 (46%) were at community or technical colleges, 13 (21%) were at R1 or research universities, 11 (17%) were at private liberal arts colleges, 4 (6%) were at regional or comprehensive universities, and several did not neatly fit within these classifications of postsecondary institutions. For HAPS membership as a whole, 22.1% of members are at community colleges, 39.7% are at universities, and 28.9% are at other colleges, with the remainder classified as High School or Other. Thus, our sample is enriched for instructors at community and technical colleges and under-samples those at universities compared to HAPS membership, and our sample is likely a reasonable match with the overall population of bachelor's-degree-obtaining students in the US, nearly half of whom have taken courses at community colleges (Fink et al., 2024).

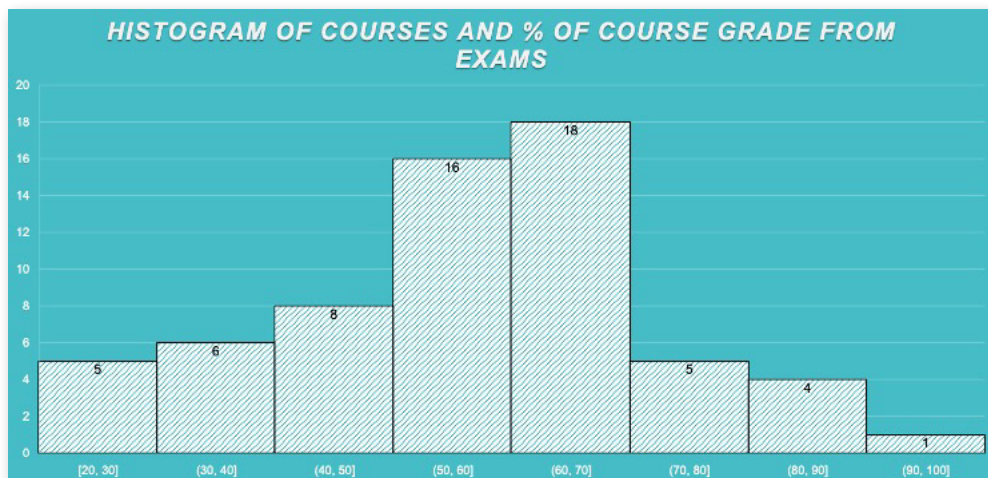
### *Numerical Impact of Exams*

The 63 survey respondents give an average of 4.8 exams per course, with the 54 instructors teaching on a semester schedule giving 4.98 exams per term and the 9 instructors teaching on a quarter schedule giving 4.00 exams per term. These instructors' courses varied from 5 to 1,400 students per class, with a median of 35 and an average of 93 students per term. If we assume that the data contributed to this survey is representative of a term by each professor, then by multiplying the exams per term by the number of exams given by the number of students per course, we can approximate that the students of these 63 instructors are collectively taking something on the order of 51,000 individual A&P exams in each academic year. Assuming that this study population is roughly representative of all of HAPS membership gives an estimate of more than 1.1 million individual exams taken by students given per academic year within this small society.

*continued on next page*

In computing final course grades, surveyed instructors weigh their exams to be worth an average of 61% of the final grade, exam weights ranging from as low as 20% to as much as 90% (Figure 1). There was no significant relationship that we could detect between exam weighting and class size, instructor type, or institution type.

**Figure 1.** The weighting of exams in the determination of A&P course grades given by surveyed instructors.



### Instructors' Training in Executing Exams

When instructors were asked to report the ways in which they developed the skills needed to build and implement exams, our mix of categorical responses and written comments indicated that 26 (41%) instructors used only knowledge ascertained from their own experiences as students themselves or in teaching their own courses. Nationally, there is no formal mandate that college instructors have training in exam-writing, so this was not surprising to us. An additional 9 instructors (14%) indicated that they drew upon informal experiences beyond their own courses. A further 13 (21%) indicated their training in exam methods came from professional development, and another 10 (16%) instructors indicated completion of specific coursework that guided their use of exams. Finally, 5 instructors (8% of the participants) hold a specific degree in teaching, education or a related field beyond their scientific credentials that they draw on when creating exams. Collectively, the non-overlapping count of the last three groups suggest that 42% of instructors have completed training in the writing of exams that extend beyond their own backgrounds as science students. However, our data did

not demonstrate a significant relationship between depth of training and any other aspect of exam experiences for students.

### Instructors' Effort in Executing Exams

Administering exams is an instructor responsibility that includes several subtasks addressed by our survey: selecting material for exams, writing/editing exams, helping students prepare for exams, and accommodating makeup exams and retakes. (Our survey did not specifically ask about grading exams.)

In selecting material for exams, most instructors said that they use learning goals that were specific to the course and/or specific to their view of the course (top two rows of Table 1). A sizable number (rows 3-5 of Table 1) relied on outside sources: the course textbook (generally written by someone other than the instructor), the department, and/or national/international societies, with 30-45% of instructors using each of those options. Relatively few instructors said that they selected exam topics/questions at random (25.4%) or specifically emphasized things that students have historically struggled with (19.0%). Aside from the options we provided

for instructors, the most popular "write-in" sources of inspiration for exam questions included textbook publishers (3 respondents), relevance to professional or graduate programs in health sciences (3 respondents), and conversations with former students (2 respondents).

Source of exam material (fixed-choice options)	Number of instructors:
"learning goals that are specific to my course"	49
"what I see as important for students in possible careers"	41
"nationally- or internationally-standardized learning goals"	27
"college- or departmentally-standardized learning goals"	25
"provided by a textbook or learning management system"	20
"the ideas I get from people in relevant careers"	19
"what will make the most interesting exam questions"	18
"random selection from course material"	16
"areas that students traditionally struggle with"	12

**Table 1.** Sources of material for exams. Percentages were compiled from each respondent's fixed-choice selections and free-response comments.

continued on next page

Instructors devote effort to having their exams reviewed for clarity, accuracy, and appropriateness. 45 (71%) of participants did this editing without enlisting anyone else in a review process. For those that used outside assistance to edit, that assistance came from colleagues for 13 instructors (21%), from Teaching Assistants or other staff for 3 instructors (5%), and from students for 6 instructors (9%), some of whom were given course credit for finding errors that would improve future exams or inform possible class-wide grading changes on the current exam.

Instructors spend significant effort to support and guide student studying by producing documents, resources, and practice opportunities. Based on fixed-choice and free-response answers, a sizable number of instructors (rows 3-6 of Table 2) generated documents or opportunities that could be optionally used by students to prepare for exams, with 50-80% of instructors providing each of these options. Relatively fewer instructors said that they provided old exams (32%), gave opportunities to work through practice questions in class (19%), provided a partial version of the upcoming exam (16%), or facilitated review sessions in class (11%). Aside from the options we provided for instructors, the most popular "write-in" types of pre-exam support were online practice quizzes (5 respondents indicated graded and 4 respondents indicated ungraded), in-class gamification of exam practice using Kahoot, Jeopardy, or other models (5 respondents), case studies (2), connections with outside tutoring (2), sample study calendars (2), and exam wrapper assignments (2) (Soicher & Gurung, 2017). In all, instructors reported an average of 4.8 extra tasks taken on (i.e., an average of 4.8 options checked for Q1, helping students prepare) to help students prepare for exams in their courses.

Every survey respondent reported using approaches that help students to overcome challenges with illness and absences. Of the instructors surveyed, 57 (90%) allow students to take rescheduled exams after the rest of the class; the other 6 instructors all gave relatively large numbers of exams and allowed students to drop individual exams. (Three instructors mentioned in comments that they allow ALL students to retake exams to improve scores.) Finally, a large number of instructors (34 of 63, or 54%) habitually spend time adjusting or rewriting exams as part of allowing late/makeup testing.

*Return of Exam Information to Students*

Table 3 summarizes the post-exam artifacts and information that instructors report giving to students. The most transparent and idealistic options were selected by relatively small numbers of instructors: less than 40% reported giving students answer keys or individualized written or oral feedback, and only 12.7% reported providing rubrics for exam answers (though this percentage may be low in part because some exams include only fixed-choice answers and thus do not require a rubric).

<b>Methods for supporting student preparation for exams:</b>	<b>Number of instructors:</b>
Provide information about the format of each exam	61
Provide practice questions	54
Provide summary study guides	45
Publish learning objectives for each exam	35
Publish learning objectives for each class session	33
Provide old exams for students to practice with	20
Provide and/or work through practice questions in class	12
Provide a partial or full copy of the actual exam	10
Facilitate an exam review session in class	7

**Table 2.** What instructors provide for students to help them prepare for exams, from combined non-overlapping results of surveys and comments.

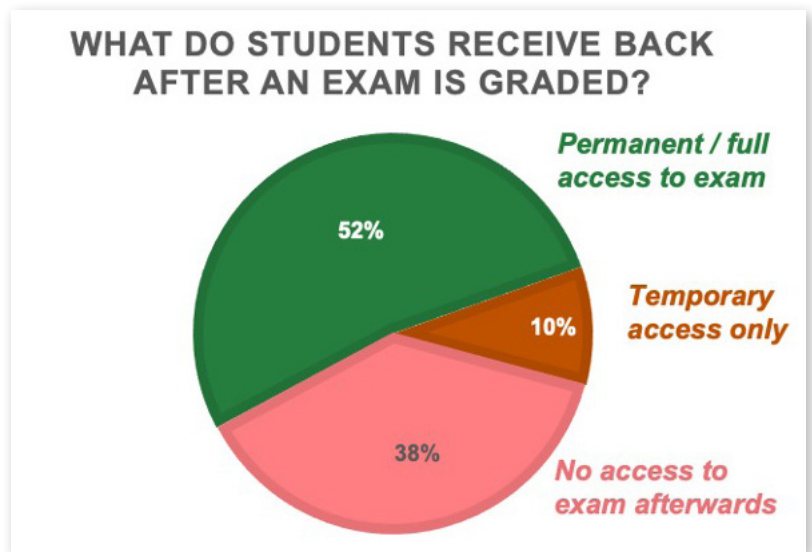
*continued on next page*

<b>What students receive after an exam is graded:</b>	<b>Number of instructors:</b>
Their own exam score	63
Class average and/or median	42
Scores on each individual exam problem	41
Their own exam (or a copy of their exam)	33
Key to the exam with correct answers	23
Individual written feedback	18
Rubric(s) for exam answers	8
Temporary access to their own exam	6
Individual verbal feedback	4
[No feedback of any kind is given]	1

**Table 3.** What students receive after an exam, from combined non-overlapping results of surveys and comments.

We were especially interested in the issue of whether students receive their own exam back. This facet of Table 3, which comes from combining instructor responses to the fixed-choice question and the open-ended question on this topic, is replotted as Figure 2. Overall, only 52% of students had what we would call “full access” to their graded exam (meaning that they could take it home and study it outside of class).

Students’ relatively limited access to their own exams (Fig. 2) might be less of a concern for cases where exams constitute a relatively small percentage of the total course grade. However, when the Fig. 1 data and Fig. 2 data were considered together, we saw evidence of the opposite, i.e., students were *less* likely to get their exams back in courses where exams constituted the bulk of the course grade (Table 4).



**Figure 2.** A&P instructors’ responses on whether students receive their exams after they are graded.

<b>Percentage of course grade determined by exams</b>	<b>Frequency of instructors in this category who DO return exams</b>
20-40%	8 out of 10 (80.0%)
50-70%	26 out of 42 (61.9%)
80-90%	4 out of 9 (44.4%)

**Table 4.** Likelihood of instructors returning exams to students is inversely related to exams’ weight in overall course grade.

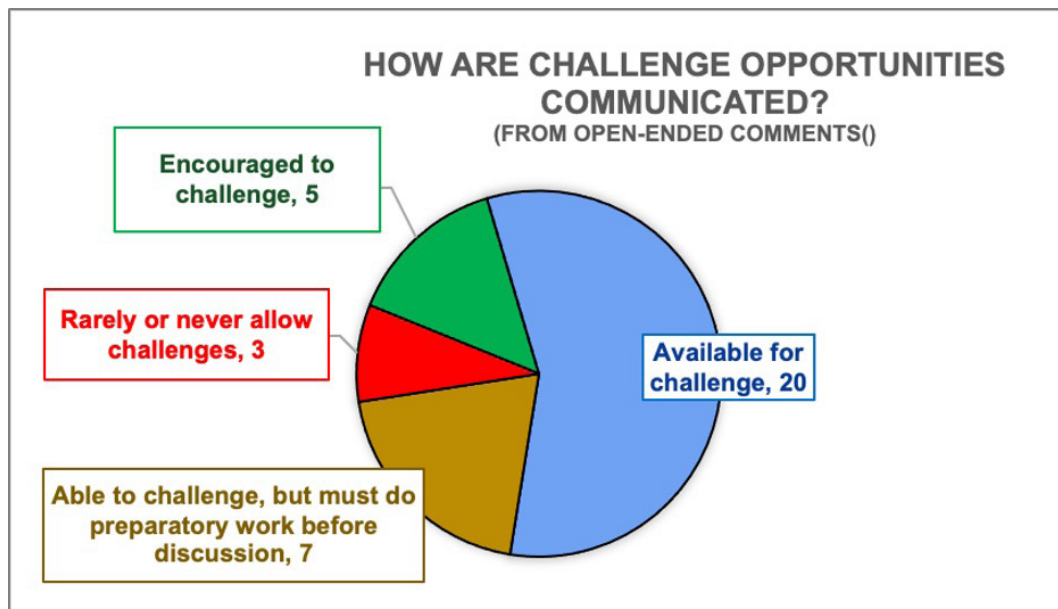


The relatively limited granting of access to graded exams (Fig. 2, Table 4) could, in theory, be explained by extensive reuse of exams from term to term, which would be less feasible if exams were kept by students. Consistent with this hypothesis, only ~5% of instructors (3 of 63) reported writing each exam from scratch (i.e., without reusing old questions), with all others (95%) reporting the reuse of some or all questions from previous exams.

*Student Challenges to Exam Grading*

Finally, we asked instructors whether students can challenge the grading of their exams. 86% (54 of 63) said that students could make such challenges; however, in most cases, instructors accept challenges on an informal ad-hoc basis rather than via an explicit procedure (Figure 3).

In addition, of the respondents who provided free-form answers about the nature of exam-grade challenges in their classes, only 14% (5 of 35) explicitly encouraged students to challenge questions that seemed questionable, with the remainder either simply allowing challenges or expressing some resistance or skepticism regarding challenges (Table 5).



**Figure 3.** Whether and how opportunities to challenge exam grades are communicated to students. Numbers shown are out of 35 respondents who answered the optional free-response question on this topic.

*Validity of “Choose-All-That-Apply” Data*

For the seven questions that asked respondents to “choose all that apply,” a possible concern is that, if some respondents misunderstood the question format, they might select only one answer per question, which would artificially lower the frequencies of individual selections (i.e., in Table 1, Table 2, etc.). To assess this possibility, we checked all 63 respondents’ patterns of answers; only one respondent selected only one choice for each of the seven multi-select answers, thus alleviating the general concern of artificially low selection frequencies.

<b>How can students challenge exam grades?</b>	<b>Number of instructors</b>
<b>Not allowed</b> to challenge exam grades	2
Can challenge <b>informally</b> (e.g. during office hours, email, or individual conversations)	41
Can challenge through a <b>formal</b> , publicly described mechanism	12
Can challenge, but unclear whether through a formal or informal process	8

**Table 5.** If and how students are allowed to challenge exam exams, from combined non-overlapping results of surveys and comments.

continued on next page

## Discussion

This study addressed the relative paucity of information about college-level STEM exams by surveying a well-defined subgroup of STEM instructors, i.e., teachers of anatomy and/or physiology (A&P) courses. Our data suggest that each instructor creates relatively unique exam experiences in the sense that they tend to prioritize personal and course-specific issues more often than broader departmental, institutional, or national guidelines (Table 1). Instructors also devote considerable effort to helping students with exams (Table 2). However, this effort often does *not* extend to giving students detailed feedback on exams, access to their own graded exams, or clearly articulated student-friendly procedures for challenging the grading of exam questions (Figs. 2-3 and Tables 3-5). As discussed below, these results collectively raise important questions about whether exams can be administered equitably without making instructors' workloads completely unmanageable.

### Limitations

Even for the limited goal of characterizing exam practices within the biology subfield of A&P, this study had sampling limitations that are common to most studies of uncompensated volunteers. Perhaps most notably, while about half of all college faculty are part-time (Culver & Kezar, 2020), our recruitment strategy targeted a professional society (HAPS) that (like most professional societies) consists largely of full-time faculty. Therefore our data are not necessarily representative of the A&P exam practices of part-time instructors, whose schedules may further limit the support they are able to provide to students. Relatedly, the pool of mostly full-time instructors who completed our survey might have been skewed toward those with especially stable and secure (i.e., tenured) positions. Therefore, due to under sampling of less secure faculty, our results may present an overly optimistic picture of exam practices.

In addition, our desire to limit the survey to less than 15 minutes also prevented us from interrogating some potentially important aspects of exam practices. For example, issues of time elapsed from initial content coverage to corresponding exams, exam question formats (e.g., multiple-choice vs. short-answer), exam retakes, and "curving" distributions of grades may all impact exam equity (Crowther & Wiggins, 2024), but the survey did not ask directly about these issues.

### Secrecy Versus Sustainability

While we did not directly ask instructors about balancing service to students with maintenance of a manageable workload, our data are consistent with the hypothesis that finding such a balance is challenging for many. Arguably, our most alarming finding was that almost half of instructors do not give students full access to their graded exams (Figure 2).

Such secrecy is problematic for equity (Crowther & Wiggins, 2024) and may promote perceptions that instructors are trying to weed students out, rather than trying to support them (Holland et al., 2019). Moreover, without good access to their graded exams, students may not get the feedback they need to iteratively navigate the cycle of performance, feedback, and improvement that underlies all significant learning (Clark & Talbert, 2023). The implication, as we see it, is that increasing the transparency of exam methods is likely to have both learning and emotional positive impacts for students.

Lest anyone accuse these instructors of laziness or ignorance, we find that they devote considerable creative energy to many aspects of exams. The participants in this survey reported their efforts to support students through a) utilizing ~3 sources for exam material, b) creating ~4.8 opportunities and documents for students preparation, c) supporting students in exam-based accommodations and rearrangements, and, in 42.8% of cases, and d) undertaking significant professional development related to exam methods. While this report is only an initial look at the experience of exam-based assessments, it is clear that these efforts to support students are taken up not as a tacked-on afterthought but as a complex core responsibility. Based on these data and other personal experiences, we propose that the constraints of instructors' schedules prevent them from further optimizing exams in ways that they (instructors and students) would prefer and that would maximize student learning. The implication, as we see it, is that efforts to make exam practices better for students must also be sustainable for instructors effort-wise.

This proposed tension between the support of students and the maintenance of some exam secrecy is not only suggested by the quantitative data but also by the comments of individual instructors. For example, one instructor described their exams as:

*Students receive their exam back, their answers, and the correct answers. They can ask questions and challenge questions in class at that time (it is rare that a student will do this, but I wish they did!). They do not get to keep their exam.*

This instructor is clearly focused on creating pathways for student learning and for openness in the process of assessment. From this and other written comments, we assume this instructor cares deeply for their students' well-being and learning. At the same time, students might interpret the fact that they must hand back their graded exams, and that they are only allowed to challenge grading at one particular moment, to mean that the instructor does not trust them and/or prioritizes personal (i.e., instructor) convenience over student learning and growth.

*continued on next page*

A similar conclusion can be reached for an instructor of 50-student classes, who wrote:

*I meet with each student individually. They sit with me, their exam, and the exam key. They can ask me questions, challenge how I scored them, etc. Students do not get to keep old exams.*

Again, exam secrecy is not simply the result of laziness. Rather, we perceive it as a symptom of the push and pull of busy lives that must somehow be balanced between saving time and negatively impacting students.

#### *The Importance of Exams*

The data reported here reinforce the centrality of exams in the college STEM experience, both as a professional practice for instructors and as a crucial hurdle for students to surmount. The specific act of producing a written assessment for an individual student in STEM is not only happening in all or nearly all of these courses, but goes beyond the historical stereotype of “one midterm and one final” to be happening 4.8 times per term. Students are likely to perceive these exams, constituting an average of 61% of their course grade, as the dominant arena in which they must both display their understanding of A&P and demonstrate their fitness for future STEM professional training. While the rough calculation of 51,000 exams collectively taken by our respondents’ students in a single academic year is notable, our data also underscore the complexity that exists in giving each one of those assessment experiences. Several methods for assessment that diminish or remove the need for exams (Clark & Talbert, 2023; Kohn & Blum, 2020; Krajcik, 2015; Pate et al., 2019), and we see significant value in these approaches, but the constraints and norms of college STEM (as well as the increasing focus on preparation for STEM fields) suggest to us that the outsized importance of exams is likely to remain.

#### *Exams as “Conversations,” for Better and Worse*

The simplest model of assessments is as a purely extractive instrument for collecting student-generated evidence of learning (G. Wiggins, 1998). As exemplified in many large-scale testing situations, information is thought to flow in one direction from students to evaluators and is packaged into simplified grades or marks that approximate student learning (Pellegrino, 2001). However, we find this simple model insufficient for capturing the risks and opportunities of exams in STEM courses. Students constantly collect data from their environments about the nature of science (Stroupe et al., 2024), the values held by experts in the fields, the likelihood of their own future successes, and their own changing identities and questions, and this data collection continues as they encounter exam-related artifacts ranging from study guides to scores and feedback (Malcom et al., 2016). For example, an exam with extremely difficult questions may be an excellent instrument for collecting data about learning, but may also convey erroneously to students

that their prior preparation is insufficient for future success. Cues in exams may also signal to students that they should learn and study in certain ways (Couchman et al., 2016; Tanner, 2012; Zhao et al., 2014) and/or that the content is or is not relevant to their desired careers. Thus, a more realistic view of exams is that they lead to bidirectional information flow (both to and from students) and represent a basis for a kind of “conversation” between students and instructors.

Our view of exams as substrates for two-way conversations is consistent with many open-ended comments from instructors who seem to use exams to instill values or norms of their classroom or scientific field. Various instructors stated or implied that exams are chances for them to help students think metacognitively, develop better study habits, and/or contribute to exam-taking practices (e.g., via pre-editing; Wiggins et al., 2023).

Like any important conversation, exams carry opportunities and risks depending on how the conversation is handled. Especially for students in large classes, the feedback around exams is likely to be the most personal and meaningful communication that individuals have with an authority figure to whom they spend a great deal of time and effort listening. However, such communications are at risk for being truncated prematurely, with cognitive and emotional consequences. For example, consider the act of a student challenging a grade on their exam. Even in a best-case scenario, a student who has recognized an error in grading must approach their instructor, constrained by perceived course norms and perceived risks of offending an authority figure who as a scientist/teacher is generally highly respected (Buffett, J, 2022) and, in challenging a score, must show understanding of complex material and offer reasoning for an alternative, just outcome. Now consider the additional burden on the student if the instructor has not explicitly welcomed such challenges or presented a protocol for making them. What could potentially be a fruitful exchange on nuances of content, instructor fallibility, and the limits of objectivity might never get off the ground due to student anxiety or uncertainty about where to begin. Alternatively, instructors that skillfully signal their openness to critical, evidence-based dialogue are actively representing how science at its best can be done. How much more about our values can we instill in the process of the exams that already have our students’ attention?

The impacts of exam-related conversations are likely to be profound far beyond the graded scores on that exam. We know that persistence in STEM is largely determined by factors other than grades per se, and these impacts are exacerbated for students who intake messages (often implicit and/or unintentional) from their instructors and institutions that they do not belong (J. Allen et al., 2021; Chen et al., 2021; Penuel et al., 2023). We suggest that exam-related conversations -- accidental or planned, truncated or extended, cryptic or direct, sympathetic or aloof -- may

*continued on next page*

critically affect whether students feel disenfranchised from college or professional STEM fields and how they persist over barriers to their success (Dika & D'Amico, 2016; Estrada et al., 2016; Graham et al., 2013). These conversations may be a key source for personalized beliefs around growth mindsets to take hold (Canning et al., 2024). Methods for improving exam experiences for students without increasing instructor workloads are, in our eyes, crucial to addressing this problem of persistence in STEM.

#### Future Research

This exploration of the ecology of exam methods within the subfield of A&P is by nature preliminary; we chose this subfield as a useful entry point for broad, shallow data collection to better inform the deeper research needed for true understanding. We hope that this future research can better describe the demographics of students and instructors alike. It will be important to go beyond rote percentages of points for indicating the grade importance of exams and instead collect data on the proportion of grade variation, as well as linking that variation to success in later professional school. Separation of the experiences provided by different types of challenges (e.g., multiple choice exams versus written exams) will be important. We hope that richer qualitative methods can be applied to help understand the thought processes (both for scientific content and emotion) that exams promote for students, and, similarly, that the goals and mental frameworks of exam-writing instructors can also be described. While we have personally undertaken studies of exam methods we believe may contribute to improving conversations and eventually persistence (Evans et al., 2023; B. L. Wiggins et al., 2023), change and improvement will be best informed by a combination of these data types from a wide range of classrooms.

#### Author Biographies

Ben Wiggins is an instructor in biology at Shoreline Community College, where he teaches human anatomy and physiology. Ben developed the methods collectively known as the Public Exam system during fifteen years of large courses at the University of Washington. He continues to focus on transforming college science exams from punitive barriers into the kind of complex challenges that motivate and drive personal growth.

Greg Crowther is a tenured biology instructor at Everett Community College north of Seattle, where he teaches human anatomy and physiology to pre-nursing students and others. Greg is the lead developer and researcher of the Test Question Templates (TQT) framework for making summative assessments more transparent, rigorous, and equitable.

#### Acknowledgments

Sixty-three hardworking instructors took time to answer our many questions about a potentially thorny professional and academic subject; we appreciate their bravery and hope to have done them justice. We appreciate the help and thoughtful advice from the leadership of the Human Anatomy and Physiology Society from the outset. This work was supported in part by NSF grant #2412708. Drs. Robin Altman, Kevin Patton, Mandy Schivell, and Crystal Uminski also deserve our thanks for provocative conversations. Most importantly, we appreciate the constant effort and struggle that our own A&P students undertake on a daily basis to someday reach their goals as therapists, nurses, doctors, PAs, and a wide range of other professionals who want to make us all healthier.

#### Literature Cited

- Aguillon, S. M., Siegmund, G-F., Petipas, R. H., Drake, A. G., Cotner, S., & Ballen, C. J. (2020). Gender differences in student participation in an active-learning classroom. *CBE—Life Sciences Education, 19*(2), ar12. <https://doi.org/10.1187/cbe.19-03-0048>
- Allen, J., Brown, E. R., Ginther, A., Graham, J. E., Mercurio, D., & Smith, J. L. (2021). Nevertheless, she persisted (in science research): Enhancing women students' science research motivation and belonging through communal goals. *Social Psychology of Education, 24*(4), 939–964.
- Asgari, M., Miles, A. M., Lisboa, M. S., & Sarvary, M. A. (2021). COPUS, PORTAAL, or DART? Classroom observation tool comparison from the instructor user's perspective. *Frontiers in Education, 6*, 740344. <https://doi.org/10.3389/feduc.2021.740344>
- Beach, J. M., & Grubb, W. N. (2011). *Gateway to opportunity?: A history of the community college in the United States*. Routledge.
- Bonus-Hammarth, M. (2005). Promoting student participation in science, technology, engineering and mathematics careers. In W. R. Allen, M. Bonus-Hammarth, R. T. Teranishi, & O. C. Dano (Eds.), *Higher Education in a Global Society: Achieving Diversity, Equity and Excellence* (Vol. 5, pp. 269–282). Emerald Group Publishing Limited. [https://doi.org/10.1016/S1479-358X\(05\)05013-8](https://doi.org/10.1016/S1479-358X(05)05013-8)
- Branchaw, J. L., Pape-Lindstrom, P. A., Tanner, K. D., Bissonnette, S. A., Cary, T. L., Couch, B. A., et al. (2020). Resources for teaching and assessing the vision and change biology core concepts. *CBE—Life Sciences Education, 19*(2), es1.

continued on next page



- Buffett, J. (2022). *Top most respected jobs 2022*. <https://zety.com/blog/most-respected-jobs>
- Canning, E. A., & Limeri, L. B. (2023). Theoretical and methodological directions in mindset intervention research. *Social and Personality Psychology Compass*, 17(6), e12758. <https://doi.org/10.1111/spc3.12758>
- Canning, E. A., White, M., & Davis, W. B. (2024). Growth mindset messages from instructors improve academic performance among first-generation college students. *CBE—Life Sciences Education*, 23(2), ar14. <https://doi.org/10.1187/cbe.23-02-0014>
- Chen, S., Binning, K. R., Manke, K. J., Brady, S. T., McGreevy, E. M., Betancur, L., et al. (2021). Am I a science person? A strong science identity bolsters minority students' sense of belonging and performance in college. *Personality and Social Psychology Bulletin*, 47(4), 593–606. <https://doi.org/10.1177/0146167220963616>
- Cimpian, J. R., Kim, T. H., & McDermott, Z. T. (2020). Understanding persistent gender gaps in STEM. *Science*, 368(6497), 1317–1319. <https://doi.org/10.1126/science.aba7377>
- Clark, D., & Talbert, R. (2023). *Grading for growth: A guide to alternative grading practices that promote authentic learning and student engagement in higher education*. Taylor & Francis.
- Couchman, J. J., Miller, N. E., Zmuda, S. J., Feather, K., & Schwartzmeyer, T. (2016). The instinct fallacy: The metacognition of answering and revising during college exams. *Metacognition and Learning*, 11, 171–185. <https://doi.org/10.1007/s11409-015-9141-x>
- Crowther, G. J., & Wiggins, B. L. (2024). Exam reform: An opportunity for the redistribution of academic power. *Journal of Microbiology and Biology Education*, e00119-24. <https://doi.org/10.1128/jmbe.00119-24>
- Culver, K. C., & Kezar, A. (2020). The impacts of 2020 on advancement of non-tenure track and adjunct faculty. Pullias Center for Higher Education, University of Southern California. Retrieved from <https://nap.nationalacademies.org/resource/26405/6> <https://nap.nationalacademies.org/resource/26405/6> [The Impacts of 2020 on Advancement of Contingent Faculty-Culver Kezar.pdf](https://nap.nationalacademies.org/resource/26405/6)
- Delpit, L. D. (2003). Other People's Children. *Education Policy and Practice: Bridging the Divide*. Harvard, 56(3), 11.
- Denaro, K., Dennin, K., Dennin, M., & Sato, B. (2022). Identifying systemic inequity in higher education and opportunities for improvement. *PLoS One*, 17(4), e0264059. <https://doi.org/10.1371/journal.pone.0264059>
- Dewsbury, B. M. (2020). Deep teaching in a college STEM classroom. *Cultural Studies of Science Education*, 15(1), 169–191. <https://doi.org/10.1007/s11422-018-9864-9>
- Dika, S. L., & D'Amico, M. M. (2016). Early experiences and integration in the persistence of first-generation college students in STEM and non-STEM majors. *Journal of Research in Science Teaching*, 53, 368–383. <https://doi.org/10.1002/tea.21301>
- Dillman, D. A. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method* (4th ed.). John Wiley & Sons. Dudley-Marling, C., & Burns, M. B. (2014). Two perspectives on inclusion in the United States. *Global Education Review*, 1(1), 14–31.
- Eddy, S. L., Converse, M., & Wenderoth, M. P. (2015). PORTAAL: A classroom observation tool assessing evidence-based teaching practices for active learning in large science, technology, engineering, and mathematics classes. *CBE Life Sci Educ*, 14. <https://doi.org/10.1187/cbe.14-06-0095>
- Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutiérrez, C. G., et al. (2016). Improving underrepresented minority student persistence in STEM. *CBE Life Sciences Education*, 15(3), Article 3. <https://doi.org/10.1187/cbe.16-01-0038>
- Evans, D. P., Jenkins, L. D., & Crowther, G. J. (2023). Student perceptions of a framework for facilitating transfer from lessons to exams, and the relevance of this framework to published lessons. *Journal of Microbiology & Biology Education*, 24(1), e00200-22. <https://doi.org/10.1128/jmbe.00200-22>
- Fink, J., Myers, T., Sparks, D., & Smith Jaggars, S. (2024). Toward a practical set of STEM transfer program momentum metrics. *Research in Higher Education*, 65(2), 259–282. <https://doi.org/10.1007/s11162-023-09692-8>
- Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, 111, 8410–8415. <https://doi.org/10.1073/pnas.1319030111>
- Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A. B., & Handelsman, J. (2013). Science education. Increasing persistence of college students in STEM. *Science*, 341, 1455–1456. <https://doi.org/10.1126/science.1240487>
- Gubrium, J. F., & Holstein, J. A. (2002). *Handbook of interview research: Context and method*. Sage Publications.
- Hatfield, N., Brown, N., & Topaz, C. M. (2022). Do introductory courses disproportionately drive minoritized students out of STEM pathways? *PNAS Nexus*, 1(4), pgac167. <https://doi.org/10.1093/pnasnexus/pgac167>

- Holland, D. G., Harper, R. P., Hunter, A.-B., Weston, T. J., & Seymour, E. (2019). The processes and consequences of switching, including the loss of high-performing STEM majors. *Talking about Leaving Revisited: Persistence, Relocation, and Loss in Undergraduate STEM Education*, 329–369. [https://doi.org/10.1007/978-3-030-25304-2\\_12](https://doi.org/10.1007/978-3-030-25304-2_12)
- Hunter, A.-B. (2019). Why undergraduates leave STEM majors: Changes over the last two decades. *Talking about Leaving Revisited: Persistence, Relocation, and Loss in Undergraduate STEM Education*, 87–114. [https://doi.org/10.1007/978-3-030-25304-2\\_5](https://doi.org/10.1007/978-3-030-25304-2_5)
- Kohn, A., & Blum, S. D. (2020). *Ungrading: Why rating students undermines learning (and what to do instead)*. West Virginia University Press.
- Krajcik, J. (2015). Project-based science: Engaging students in three-dimensional learning. *The Science Teacher*, 82(1), Article 1.
- Laverty, J. T., Underwood, S. M., Matz, R. L., Posey, L. A., Carmel, J. H., Caballero, M. D., et al. (2016). Characterizing college science assessments: The three-dimensional learning assessment protocol. *PLOS ONE*, 11(9), Article 9. <https://doi.org/10.1371/journal.pone.0162333>
- Malcom, S., Feder, M., in Completing, O., of Engineering, N. A., & National Academies of Sciences, E. (2016). The culture of undergraduate STEM education. In *Barriers and opportunities for 2-year and 4-year STEM degrees: Systemic change to support students' diverse pathways*. National Academies Press.
- Meaders, C. L., Lane, A. K., Morozov, A. I., Shuman, J. K., Toth, E. S., Stains, M., et al. (2020). Undergraduate student concerns in introductory STEM courses: What they are, how they change, and what influences them. *Journal for STEM Education Research*, 3(2), 195–216. <https://doi.org/10.1007/s41979-020-00034-8>
- Meaders, C. L., Toth, E. S., Lane, A. K., Shuman, J. K., Couch, B. A., Stains, M., et al. (2019). "What will I experience in my college STEM courses?" An investigation of student predictions about instructional practices in introductory courses. *CBE—Life Sciences Education*, 18(4), ar60. <https://doi.org/10.1187/cbe.19-05-0097>
- Momsen, J. L., Long, T. M., Wyse, S. A., & Ebert-May, D. (2010). Just the facts? Introductory undergraduate biology courses focus on low-level cognitive skills. *CBE—Life Sciences Education*, 9(4), 435–440. <https://doi.org/10.1187/cbe.10-01-0001>
- Mor, E., & Erşen, R. K. (2023). Implications of current validity frameworks for classroom assessment. *International Journal of Assessment Tools in Education*, 10(Special Issue), 164–173.
- Olson, S., & Riordan, D. G. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Executive Office of the President.
- Pate, A., Lafitte, E. M., Ramachandran, S., & Caldwell, D. J. (2019). The use of exam wrappers to promote metacognition. *Currents in Pharmacy Teaching and Learning*, 11(5), 492–498. <https://doi.org/10.1016/j.cptl.2019.02.011>
- Pellegrino, J. W. (2001). *Rethinking and Redesigning Education Assessment. Preschool through Postsecondary*.
- Pellegrino, J. W., Grover, S., Harris, C. J., & Wiebe, E. (2023). Classroom assessment in STEM education: An introduction to the report. *Classroom-Based STEM Assessment*, 4.
- Penuel, W. R., Krumm, A. E., Pazera, C., Singleton, C., Allen, A.-R., & Deverel-Rico, C. (2023). Belonging in science classrooms: Investigating their relation to students' contributions and influence in knowledge building. *Journal of Research in Science Teaching*.
- Seymour, E., Hunter, A.-B., & Weston, T. J. (2019). Why we are still talking about leaving. In E. Seymour & A.-B. Hunter (Eds.), *Talking about Leaving Revisited: Persistence, Relocation, and Loss in Undergraduate STEM Education* (pp. 1–53). Springer International Publishing. [https://doi.org/10.1007/978-3-030-25304-2\\_1](https://doi.org/10.1007/978-3-030-25304-2_1)
- Shukla, S. Y., Theobald, E. J., Abraham, J. K., & Price, R. M. (2022). Reframing educational outcomes: Moving beyond achievement gaps. *CBE—Life Sciences Education*, 21(2), es2. <https://doi.org/10.1187/cbe.21-10-0287>
- Sireci, S. G. (2015). A Theory of action for test validation. *The next Generation of Testing: Common Core Standards, Smarter-Balanced, PARCC, and the Nationwide Testing Movement*, 253–272.
- Smith, M. K. (2013). The Classroom Observation Protocol for Undergraduate STEM (COPUS): A new instrument to characterize university STEM classroom practices. *CBE—Life Sciences Education*, 12, 618–627. <https://doi.org/10.1187/cbe.13-08-0154>
- Soicher, R. N., & Gurung, R. A. (2017). Do exam wrappers increase metacognition and performance? A single course intervention. *Psychology Learning & Teaching*, 16(1), 64–73. <https://doi.org/10.1177/1475725716687164>
- Stains, M., Harshman, J., Barker, M. K., Chasteen, S. V., Cole, R., DeChenne-Peters, S. E., et al. (2018). Anatomy of STEM teaching in North American universities. *Science*, 359(6383), 1468–1470. <https://doi.org/10.1126/science.aap8892>
- Stroupe, D., Suárez, E., & Scipio, D. (2024). Epistemic injustice and the "Nature of Science." *Journal of Research in Science Teaching*.

continued on next page

Tanner, K. D. (2012). Promoting student metacognition. *CBE—Life Sciences Education*, 11(2), 113–120.  
<https://doi.org/10.1187/cbe.12-03-0033>

Tanner, K. D. (2013). Structure matters: Twenty-one teaching strategies to promote student engagement and cultivate classroom equity. *CBE Life Sci Educ*, 12, 322–331.  
<https://doi.org/10.1187/cbe.13-06-0115>

Tripp, B., Cozzens, S., Hrycyk, C., Tanner, K. D., & Schinske, J. N. (2024). Content coverage as a persistent exclusionary practice: Investigating perspectives of health professionals on the influence of undergraduate coursework. *CBE—Life Sciences Education*, 23(1), ar5.

Uminski, C., Burbach, S. M., & Couch, B. A. (2024). Undergraduate biology lecture courses predominantly test facts about science rather than scientific practices. *CBE—Life Sciences Education*, 23(2), ar19.  
<https://doi.org/10.1187/cbe.23-12-0244>

Wiggins, B. L., Lily, L. S., Busch, C. A., Landys, M. M., Shlichta, J. G., Shi, T., et al. (2023). Public exams may decrease anxiety and facilitate deeper conceptual thinking. *Journal of STEM Education: Innovations and Research*, 24(2).

Wiggins, G. (1998). *Educative assessment: Designing assessments to inform and improve student performance*. Jossey-Bass.

Zhao, N., Wardeska, J. G., McGuire, S. Y., & Cook, E. (2014). Metacognition: An effective tool to promote success in college science learning. *Journal of College Science Teaching*, 43(4), 48–54.

### Supplemental Materials

- The "A&P Exam Methods Survey" can be found on the next pages.
- The survey results, in excel form, are available upon request from the corresponding author.

## Become a Member of HAPS Today!

The Human Anatomy & Physiology Society (HAPS) is dedicated to promoting excellence in the teaching of Anatomy and Physiology at colleges, universities and related institutions.

- **Connect with colleagues also pursuing success in teaching A&P**
- **Discounted rates for annual and regional conferences**
- **Access Teaching Tips for tough topics**
- **HAPS Institute short-courses for ongoing professional development**
- **Open access to our peer-reviewed journal, *The HAPS Educator***
- **Grants and scholarships for research and travel**
- **Additional member resources listed [here](#).**



For more information, contact HAPS at [info@hapsconnect.org](mailto:info@hapsconnect.org) or at 1-800-448-4277.

Follow [this link](#) to join and start benefiting from membership today!

### **A&P Exam Methods Survey**

Writing science exams is hard. Exams soak up free time, test our communication skills, and provide stress for everyone involved. In this survey, we want to better understand the methods that A&P faculty are using to maintain quality, inform students, and (perhaps most importantly) stay as efficient as possible.

**For the 9 multiple-choice questions here, and for the optional written questions afterwards, we want to hear about your experiences with writing, giving and grading exams.** What do you do? What works? What are the challenges?

Please take this exam with your own classes in mind, and focus on the course(s) in which you write exams the most.

0. The course(s) I have in mind while taking this survey is/are: [open-ended]

The choices here are all based on existing college STEM courses.  
For each question, you'll be able to explain more on the next page if you want.

Q1) How do you help students to prepare for your exams?

*[Choose all that apply]*

- Publish learning objectives for each class session
- Publish learning objectives for each exam
- Provide study guides that summarize the material on each exam
- Provide practice questions
- Provide information about the format of each exam
- Provide old exams for students to practice with
- Provide a partial or full copy of the actual exam
- Encourage students to study together
- Encourage students to study creatively
- Encourage students to study daily or regularly
- Encourage students to work with Teaching Assistants or Peer Learning Assistants
- Facilitate study group formation
- Facilitate a particular method of studying
- Give class points for doing a particular method of studying
- Give class points for studying in groups
- Give class points for feedback from students on the exam
- I don't help students to prepare for exams.

Q2) I choose material for my exams based on...

*[Choose all that apply]*

- ...nationally- or internationally-standardized learning goals
- ...college- or departmentally-standardized learning goals

*continued on next page*



## A&P Exam Methods Survey

Writing science exams is hard. Exams soak up free time, test our communication skills, and provide stress for everyone involved. In this survey, we want to better understand the methods that A&P faculty are using to maintain quality, inform students, and (perhaps most importantly) stay as efficient as possible.

**For the 9 multiple-choice questions here, and for the optional written questions afterwards, we want to hear about your experiences with writing, giving and grading exams.** What do you do? What works? What are the challenges?

Please take this exam with your own classes in mind, and focus on the course(s) in which you write exams the most.

0. The course(s) I have in mind while taking this survey is/are: [open-ended]

The choices here are all based on existing college STEM courses.

For each question, you'll be able to explain more on the next page if you want.

Q1) How do you help students to prepare for your exams?

*[Choose all that apply]*

- Publish learning objectives for each class session
- Publish learning objectives for each exam
- Provide study guides that summarize the material on each exam
- Provide practice questions
- Provide information about the format of each exam
- Provide old exams for students to practice with
- Provide a partial or full copy of the actual exam
- Encourage students to study together
- Encourage students to study creatively
- Encourage students to study daily or regularly
- Encourage students to work with Teaching Assistants or Peer Learning Assistants
- Facilitate study group formation
- Facilitate a particular method of studying
- Give class points for doing a particular method of studying
- Give class points for studying in groups
- Give class points for feedback from students on the exam
- I don't help students to prepare for exams.

Q2) I choose material for my exams based on...

*[Choose all that apply]*

- ...nationally- or internationally-standardized learning goals
- ...college- or departmentally-standardized learning goals

- ...learning goals that are specific to my course
- ...questions provided by a textbook or learning management system (LMS)
- ...what I see as important for students in possible careers
- ...the ideas I get from people in relevant careers
- ...what will make the most difficult exam questions
- ...what will make the most interesting exam questions
- ...areas that students traditionally struggle with
- ...random selection from course material

Q3) How do you edit your exams?

*[Choose all that apply]*

- I edit my own exams.
- I have colleagues who teach the same course edit my exams.
- I have colleagues who do NOT teach this same course edit my exams.
- I have staff (like TAs or other non-faculty) who edit my exams.
- I compensate an outside professional specifically to edit my exams.
- I involve students in the editing of my exams.
- I reuse exams so they do not need editing.
- My exams are not edited.

Q4) After my exams, students receive...

*[Choose all that apply]*

- ...their own exam score
- ...the class average and/or median
- ...their scores on each individual exam problem
- ...their own exam (or a copy of their exam)
- ...a key to the exam with correct answers
- ...a rubric or rubrics for exam answers
- ...individual verbal feedback
- ...individual written feedback

Q5) Can students challenge their grade on the exam?

*[Choose all that apply]*

- Yes, they can challenge the grading of any parts of the exam.
- Yes, they can challenge but are limited to challenging a small part of the exam.
- Yes, they can challenge but only one part of the exam.
- Yes, they can challenge through a formal procedure within the class.
- Yes, they can challenge through a formal procedure outside of the class.
- Yes, they can challenge on an informal or case-by-case basis.
- Yes, they can challenge verbally during office hours.
- No, students cannot challenge exam grading.

Q6) Feedback on the difficulty of an exam that would impact course grades includes...

*[Choose all that apply]*

- ...my own sense for the difficulty of the exam
- ...informal feedback or complaints from students on the difficulty of the exam
- ...formal, graded feedback that I require from students on the difficulty of the exam
- ...the class average or median on the exam grade
- ...the class distribution (including the high or low scores) of the exam grade
- Once an exam is written, I do not adjust grading based on difficulty.

Q7) If a student is unable to attend an exam due to illness, then I typically...

*[Choose all that apply]*

- ...give a different version of the exam as a later makeup
- ...give the same version of the exam as a later makeup
- ...allow the student to complete a makeup exam from home
- ...allow the student to do an oral exam in person
- ...don't allow for makeup exams, because I drop one or more of the exam scores from the final grade
- I don't allow for makeup exams in my class.

Q8) After I give an exam...

*[Choose the single best answer] \**

- ...I never use the questions again (I write all my exams new)
- ...I reuse all of the questions on future exams
- ...I reuse a few of the questions on future exams
- ...I reuse the entire exam for a future class
- My exams are the same in each iteration of the class.

Q9) Roughly how much of the final grade in your course is determined by exams?

*[Choose the single best answer]*

- ~100% of the final grade is from exams
- ~90% of the final grade is from exams
- ~80% of the final grade is from exams
- ~70% of the final grade is from exams
- ~60% of the final grade is from exams
- ~50% of the final grade is from exams
- ~40% of the final grade is from exams
- ~30% of the final grade is from exams
- ~20% of the final grade is from exams
- ~10% of the final grade is from exams
- None of the final grade is from exams

If you would like to explain any of your prior answers, you can do so on these follow-up questions. **These are completely optional; answers are NOT required**, but we wanted to provide a place to explain your methods if you want. Anything you write here will be read (many times!) by our team as we try to understand the myriad of exam methods that exist across college A&P courses.

10. How do you help students to prepare for your exams? *[Optional, open-ended]*
11. How do you choose material for your exams? *[Optional, open-ended]*
12. In what way(s) do you edit your exams? *[Optional, open-ended]*
13. What feedback do students receive after your exams? *[Optional, open-ended]*
14. Can (or, how do) students challenge the grading on your exams? *[Optional, open-ended]*
15. What feedback (if any) do you use to decide if the exam was too easy or too difficult? *[Optional, open-ended]*
16. For illnesses, do you allow makeups for your exams, and if so: how? *[Optional, open-ended]*
17. How much of your exams do you reuse from course to course? *[Optional, open-ended]*
18. How do exams contribute to the final course grade? *[Optional, open-ended]*

This last section is for information that will help us to better understand the context of exam methods. As a reminder: All data in this survey will be anonymized before any summary is generated, and no individual data will be made public outside of summary.

19. At what type of institution do you primarily give exams?

*[Choose the single best answer]*

- R1 or research university
- Private liberal arts college
- Regional or comprehensive college
- Community or technical college
- High school
- Graduate school
- Other: *[open-ended response]*

20. Do you typically teach a schedule on quarters or semesters?

*[Choose the single best answer]*

- Quarters
- Semesters
- Asynchronously outside of a term schedule
- Other: *[open-ended response]*

21. Roughly how many exams do you give in a typical course?

*[Choose the single best answer]*

- 0



- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

22. What level of students do you primarily teach?

*[Choose all that apply]*

- 1st-year college students
- Undergraduates in their 2nd or 3rd year
- Undergraduates in their last year
- Graduate students
- K-12 students
- Other: *[open-ended response]*

23. Where did you learn the most about exam writing?

*[Choose the single best answer]*

- I have taken coursework in exam writing methods
- I have done professional development for exam writing
- I have researched exam writing on my own
- I use knowledge from past instructors that I taught with
- I use knowledge from courses in which I was a student
- I use knowledge from observing the courses of other instructors
- I have only used my own ideas for exam writing
- Other: *[open-ended response]*

24. For the course you had in mind on earlier questions: What is your typical number of students per course?

*[open-ended response]*

25. Which of these is closest to your academic title?

*[Choose the single best answer]*

- Full-time (tenure-track or equivalent)
- Part-time or adjunct faculty
- Staff instructor
- Graduate student
- Post-doc

- Other: *[open-ended response]*

26. Are you a member of HAPS?

*[Choose the single best answer]*

- Yes
- No
- Other: *[open-ended response]*



# An Unconventional Cadaveric Prosection for Neuroanatomy Education: Extraction of the Central and Peripheral Nervous Systems with Anatomical Landmarks

Madeline M. Damjanovic MSc<sup>1\*</sup>, Isabella G. Damjanovic MSc<sup>1\*</sup>, Christine A. Major MS, DC<sup>2</sup>, Logan S.W. Bale MSc<sup>1</sup>

<sup>1</sup>Queen's University, Department of Biomedical and Molecular Sciences, Kingston, Ontario, Canada

<sup>2</sup>University of Western States, Department of Basic Sciences, Portland, Oregon, USA

\*These authors contributed equally to this work

Corresponding author: [madeline.damjanovic@queensu.ca](mailto:madeline.damjanovic@queensu.ca)

## Abstract

The aim of this project was to create a prosected specimen that demonstrates the integration of the central and peripheral nervous system with the maintenance of key anatomical landmarks for use as an educational resource. In this dissection, the brain, brainstem, spinal cord, eyes, and optic nerves and tracts were removed along with spinal roots and peripheral nerves so that the majority of the nervous system can be appreciated. Select landmarks were preserved to illustrate key anatomical relationships and provide context to peripheral nerve pathways. Here we describe the educational significance and value of this specimen for various levels of neuroanatomy education. <https://doi.org/10.21692/haps.2024.015>

**Key words:** anatomy; dissection; medical education; nervous system; neuroanatomy

## Introduction

Neuroanatomy, often taught as a stand-alone course or integrated with gross anatomy in medical curricula, is perceived as one of the most difficult anatomical disciplines to learn. Challenges in student learning typically arise as a result of the overwhelming complexity and interconnectedness of the nervous system (Arantes et al., 2018; Venter et al., 2022). In a relatively short time frame, students are expected to understand detailed neuroanatomical structures, challenging nomenclature, topographical and spatial relationships, and relevant clinical applications (Arantes et al., 2018). This often leads to decreased ability to utilize and integrate neuroanatomy concepts in the patient care environment (Arantes et al., 2018; Venter et al., 2022). In most undergraduate medical programs nervous system dissection is limited and time spent in the laboratory is declining. As a result, educators are developing supplementary resources to support student learning, such as prosections, 3D-printed brain structures, clay modeling, and digital representations of complex spatial relationships (Arantes et al., 2018; Estevez et al., 2010). Despite the continued development of innovative resources and advancements in technology-based teaching tools, the

debate as to the most effective method of neuroanatomy education continues.

Dissection of cadaveric specimens in neuroanatomy curriculum has been shown to increase motivation and improve academic performance (Shell et al., 2020). Hands-on learning through dissection allows students to appreciate spatial relationships of anatomical structures, fostering a deeper understanding of the material and reducing extraneous cognitive load (Henssen et al., 2020). However, dissection is considered to be one of the most time consuming and labor-intensive pedagogical strategies in anatomical education (Chang & Molnar, 2015). Moreover, factors such as increasing student enrollment, rapidly changing curricula, reduction in the time dedicated to anatomy as well as budgetary concerns introduce a unique challenge for anatomy educators (Drake et al., 2015; Henssen et al., 2020; Ahmed et al., 2021). As such, when dissection is included in neuroanatomy curriculum, it typically involves dissecting isolated structures of the central nervous system (CNS) or peripheral nervous system (PNS) rather than utilizing a systems-based approach. For example, students

*continued on next page*

typically remove the brain to learn cranial nerves and cerebral vasculature, and in some cases perform a partial laminectomy to view a small segment of the spinal cord (Long et al., 2014). Thus, the opportunity to view the entire CNS and follow spinal nerves peripherally is rare. A systems-based prosected specimen could enhance an integrated medical curriculum by enabling students to bridge concepts in the CNS and PNS while addressing the limitations of dissection in neuroanatomy curriculum.

Existing literature describing dissection methods for a systems-based approach to the nervous system is limited. A 19th century dissection named “Harriet” demonstrated the complete human nervous system with the exception of the terminal branches of the intercostal nerves (Nwaogbe et al., 2018), however, there are no methods available in the literature to replicate this dissection. Although documentation pertaining to the removal of the entire nervous system is lacking, there are sources that describe the extraction of the CNS. An approach described by Riepertinger outlines the detailed process of removal of the brain and spinal cord ventrally following post-mortem examination, with the goal of maintaining suitability for plastination (Riepertinger 1989). Additionally, in a study conducted by Hlavac et al. (2018), the authors developed a detailed dissection approach and step-by-step guide for an en bloc removal of the brain, spinal cord, dorsal root ganglia, cauda equina, and optic nerves, tracts, and eyes to demonstrate the complete CNS. Currently, to our knowledge, no publication has described the technique for extraction of the CNS and PNS with the maintenance of anatomical landmarks for use as an educational resource. The purpose of this work is to document the development of a novel educational resource with the goal of supporting the integration of the CNS and PNS in neuroanatomy and medical education.

## Materials and Methods

A formalin-fixed donor was dissected to demonstrate the CNS and PNS with key anatomical landmarks to contextualize nerve pathways and innervation. Prior to being dissected further for this project, the donor was prepared and prosected for use as a full body demonstration cadaver for the purpose of anatomical education.

In this dissection, the brain, spinal cord, and eyes with the optic nerves and tracts were removed along with peripheral nerves and select anatomical landmarks (Figure 1). The total preparation time for the specimen was approximately 30 hours. Anatomical landmarks and their role in neuroanatomy education are summarized in Table 1. The specimen was wrapped in linen saturated with moistening solution and stored in a refrigerator at four degrees Celsius in a body bag when not in use. The specimen was wrapped in linen saturated with moistening solution (potassium acetate (150 ml), ethanol (250 ml), Dettol (750 ml), and glycerol (1500 ml) and stored in a refrigerator at four degrees Celsius in a body bag when not in use.



**Figure 1a.** anterior view and **b.** posterior view of the dissected CNS and PNS with associated anatomical landmarks.

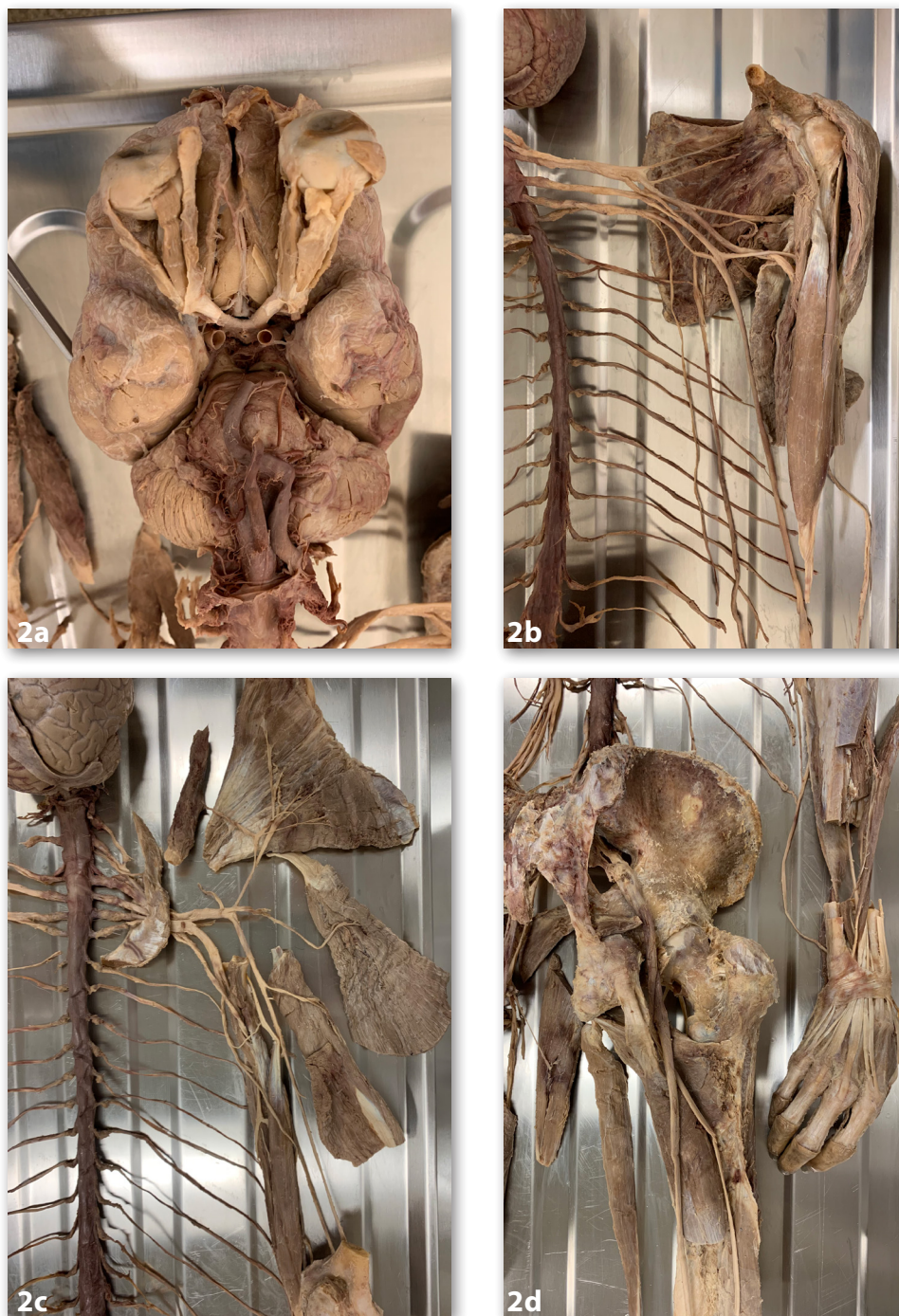
continued on next page



## Results

The current project aimed to create an educational resource demonstrating the CNS and PNS. Specific anatomical landmarks were maintained for the purpose of providing context to nerve pathways and visualizing the innervation of various muscles. For example, the right upper limb of the donor demonstrates the path and innervation of the nerves of the brachial plexus via landmarks such as the interscalene triangle, isolated muscles of the arm and shoulder, the

elbow joint and associated musculature, as well as the wrist and hand. The lower limbs demonstrate the path and innervation of the nerves of the lumbar and sacral plexuses with landmarks including the sacrum, obturator and greater sciatic foramina, isolated muscles of the thigh and leg, as well as the foot. Examples of select anatomical landmarks and associated nervous system structures can be viewed in Figure 2. This specimen will likely be able to be used for 5-15 years with proper moistening and care.



**Figure 2a.** inferior view of the brain and orbital contents **b.** anterior view of the left shoulder with associated nerves **c.** posterior view of the right hip joint **d.** anterolateral view of the left side of the pelvis demonstrating the pathways of the sciatic, femoral, and obturator nerves.

continued on next page

## Discussion

Developing a foundational knowledge and understanding of the nervous system is an integral component of many undergraduate and postgraduate programs in health sciences and is viewed as an essential component of medical curriculum. Although the importance of neuroanatomy education is widely accepted, the significant decrease in the amount of time devoted to anatomical sciences in modern medical curricula has led to the use of alternative teaching tools, such as prosected specimens (Hortsch & Mangrulkar, 2015; Sugand et al., 2010). Cadaveric prosections are valuable learning resources that may be used to supplement, or in some cases replace, the time-consuming dissection process making them an ideal learning tool for a condensed curriculum (Aziz et al., 2019).

Prosected specimens often demonstrate specific anatomical regions rather than complete systems. However, systems-based educational resources could provide learners with the opportunity to develop foundational knowledge in one system while enhancing understanding of previously learned material (Arslan, 2014). For example, although this specimen is focused on structures of the nervous system, the musculoskeletal system can be revisited in the context of innervation and relationships of nerve pathways to musculoskeletal structures. Viewing the nervous system as a whole could help improve understanding of anatomical relationships, functional significance, and clinical relevance of neuroanatomical structures.

This prosected specimen can be utilized as an educational resource to supplement and enhance various levels of teaching and learning that take place in the Anatomy Learning Center (ALC) at Queen's University. In addition to dissection-based curriculum for select programs, the ALC offers a wide variety of educational resources for neuroanatomy education, including: jarred museum specimens, wet prosected specimens, plastinated prosected specimens, plastic anatomical models, and anatomy review videos. Interaction with the unique specimen described here could supplement learning by providing students with the unique opportunity to view the complete CNS, contextualize complex plexuses and peripheral nerve pathways with maintained anatomical landmarks, and visualize the intricate relationships between anatomical structures and systems. A variety of programs supported by laboratory sessions in the ALC could benefit from interaction with this specimen. This includes undergraduate programs in life sciences, health sciences, kinesiology, nursing, and medicine; graduate programs in physical therapy, occupational therapy, neurosciences, and anatomical sciences; and lastly, postgraduate medical residency programs in orthopedic

surgery, anesthesiology, physical medicine and rehabilitation, and ophthalmology. For example, physical therapy students can utilize this specimen to learn and integrate the CNS and PNS while contextualizing relationships to musculoskeletal structures. Ophthalmology residents can review and trace the nerves of the orbit without compromising structural relationships of orbital contents. This specimen offers the unique opportunity to visualize complete nerve pathways. The axillary nerve, for example, is often demonstrated in small segments in typical cadaveric prosections of the upper limb, whereas this specimen allows for the pathway of the axillary nerve, from roots to terminal branches, to be studied in its entirety while maintaining key anatomical relationships.

### Limitations

We recognize that our project has limitations, such as the time constraints that come with the complex dissection process and the delicate nature of the final specimen. Furthermore, the donor used in this project was previously dissected for educational purposes, and therefore not all nerves were able to be preserved. A future specimen of a similar nature may include a more extensive range of neuroanatomical structures such as cranial nerves, the cervical plexus, phrenic nerves, and the sympathetic chain with associated anatomical landmarks. Another limitation of this project was that it did not collect student perception nor related academic assessment performance data, which could provide further insight into the effectiveness of the specimen as an educational resource.

## Conclusion

For the past several years higher education anatomy instruction has been undergoing a variety of changes due to ever increasing constraints on time and resources. Prosected specimens such as this can be used to preserve the learning benefits of utilizing cadaveric models while reducing costs and instructor time. Additionally, unique prosected specimens demonstrating the CNS and PNS with anatomical landmarks can be used to illustrate complex neuroanatomical concepts for various educational levels and programs. The present communication aims to encourage learners and educators to create innovative educational resources that have the potential to enhance anatomy and neuroanatomy education.

*continued on next page*

Anatomical Landmark	Educational Significance
<b>Central Nervous System</b>	
Brain	Visualize: <ul style="list-style-type: none"> <li>- Sulci and gyri</li> <li>- Right and left cerebral hemispheres</li> <li>- Lobes of the cerebral cortex: frontal lobe, parietal lobes, temporal lobes, occipital lobe</li> <li>- Longitudinal fissure, transverse fissure</li> <li>- Central sulcus, lateral sulcus, parieto-occipital sulcus, calcarine sulcus</li> <li>- Superficial cerebral veins</li> </ul>
Dural folds (falx cerebri, tentorium cerebelli, falx cerebelli)	Visualize: <ul style="list-style-type: none"> <li>- Falx cerebri: separates the two cerebral hemispheres along the longitudinal fissure</li> <li>- Tentorium cerebelli: separates the cerebral hemispheres posteriorly from the cerebellum along the transverse fissure</li> <li>- Falx cerebelli: separates two cerebellar hemispheres</li> </ul>
Eyeballs with associated muscular and neurovascular structures	Visualize relationships between: <ul style="list-style-type: none"> <li>- Optic nerve, optic chiasm, optic tract</li> <li>- Extraocular eye muscles (superior rectus, inferior rectus, medial rectus, lateral rectus, superior oblique, inferior oblique, levator palpebrae superioris)</li> <li>- Lacrimal gland</li> <li>- Branches of the ophthalmic nerve (V1): frontal nerve, nasociliary nerve, lacrimal nerve</li> </ul>
Brainstem	Visualize: <ul style="list-style-type: none"> <li>- Midbrain</li> <li>- Pons</li> <li>- Medulla</li> <li>- Cranial nerves</li> </ul>
Cerebellum	Visualize: <ul style="list-style-type: none"> <li>- Horizontal fissure</li> <li>- Vermis</li> <li>- Right and left cerebellar hemispheres</li> <li>- Lobes: anterior lobe, posterior lobe, flocculonodular lobe</li> </ul>
Spinal cord/spinal meninges	Visualize: <ul style="list-style-type: none"> <li>- Spinal nerves</li> <li>- Dura mater</li> <li>- Filum terminale externum</li> </ul>
<b>Peripheral Nervous System</b>	
<b>Thorax</b>	Visualize intercostal nerves and dorsal root ganglia
<b>Right Axilla &amp; Upper Limb</b>	
Interscalene triangle: middle scalene, anterior scalene, segment of first rib	Visualize the roots of the brachial plexus passing through the interscalene triangle
Latissimus dorsi	Visualize innervation via the thoracodorsal nerve
Deltoid and teres minor	Visualize innervation via the axillary nerve
Coracobrachialis	Contextualize pathway of musculocutaneous nerve (pierces coracobrachialis prior to innervating anterior compartment of arm)
Biceps brachii	Visualize innervation via the musculocutaneous nerve

continued on next page

Triceps brachii	Visualize innervation via branches of the radial nerve
Elbow joint (distal humerus, proximal ulna and radius) with associated musculature (supinator, pronator teres, reflected extensor digitorum)	Visualize: <ul style="list-style-type: none"> <li>- Path of the median nerve through the cubital fossa between the humeral and ulnar heads of pronator teres</li> <li>- Path of the ulnar nerve through the cubital tunnel</li> <li>- Deep branch of the radial nerve piercing supinator</li> </ul>
Hand	Visualize common palmar and proper palmar digital branches of the median and ulnar nerves
<b>Left Upper Limb</b>	
Glenohumeral joint (scapula, proximal humerus) with associated musculature (supraspinatus, infraspinatus, subscapularis, deltoid, teres minor)	Visualize: <ul style="list-style-type: none"> <li>- Innervation of supraspinatus and infraspinatus via the suprascapular nerve (and associated pathway)</li> <li>- Innervation of subscapularis via the upper and lower subscapular nerves</li> <li>- Pathway of the axillary nerve through quadrangular space to innervate teres minor and deltoid</li> </ul>
Biceps brachii, brachialis, coracobrachialis attached to proximal humerus	Visualize innervation via musculocutaneous nerve
Triceps brachii (long head reflected)	Visualize proximal branches of the radial nerve
Latissimus dorsi	Visualize innervation via the thoracodorsal nerve
<b>Pelvis</b>	
Sacrum	Visualize: <ul style="list-style-type: none"> <li>- Lumbar and sacral plexuses and formation of the sciatic nerve from L4, L5, S1, S2, S3 spinal nerves</li> </ul>
Right side of pelvis (ilium, ischium, pubis) and hip joint	Visualize: <ul style="list-style-type: none"> <li>- Sciatic nerve passing through the greater sciatic foramen</li> <li>- Obturator nerve passing through the obturator foramen</li> <li>- Femoral nerve exiting the pelvis</li> </ul>
<b>Right Lower Limb</b>	
Vastus intermedius, vastus lateralis, vastus medialis	Visualize innervation via branches of the femoral nerve
Adductor longus, adductor brevis, adductor magnus	Visualize: <ul style="list-style-type: none"> <li>- Division of obturator nerve into anterior and posterior divisions</li> <li>- Anterior branch traveling between adductor brevis and adductor longus</li> <li>- Posterior branch traveling between adductor brevis and adductor magnus</li> </ul>
Proximal tibia and fibula	Visualize branches of the tibial nerve

continued on next page



<b>Left Lower Limb</b>	
Adductor longus, adductor brevis	Visualize innervation via the obturator nerve
Sartorius, biceps femoris (long head)	Visualize innervation via the femoral nerve
Proximal tibia and fibula with associated musculature (reflected gastrocnemius and soleus, reflected fibularis longus)	Visualize: - Path of the tibial nerve as it travels between the medial and lateral heads of gastrocnemius and passes anterior to soleus to supply muscles of the deep posterior compartment of the leg - Path of common fibular nerve as it branches into the superficial and deep fibular nerves to supply the lateral compartment of the leg and anterior compartment of the leg, respectively
Ankle joint and foot	Visualization of the tibial nerve passing through the tarsal tunnel prior to dividing into the medial and lateral plantar nerves to supply the plantar surface of the foot

**Table 1.** Summary of anatomical landmarks and associated educational significance.

## Acknowledgments

The authors sincerely thank those who donated their bodies to science so that anatomical research and teaching could be performed. Results from such research may increase scientific knowledge and improve patient care. Therefore, these donors and their families deserve our highest respect. The authors would also like to thank Andrew Butterfield for his assistance.

## About the Authors

Madeline Damjanovic, MSc, is an anatomical prosector and demonstrator in the Department of Human Anatomy and Cell Science at the University of Manitoba. Isabella Damjanovic, MSc, is an instructional resource assistant in the Education Program in Anatomy at McMaster University. Logan Bale, MSc, is the laboratory and educational coordinator of the Anatomy Learning Centre at Queen’s University. He teaches specimen preparation techniques in anatomical sciences. Christine Major, MS, DC, is an associate professor at the University of Western States and teaches in the Basic Sciences and Clinical Sciences Departments. She primarily teaches neuroscience and neurology courses.

## Literature Cited

- Ahmad, K., Khaleeq, T., Hanif, U., & Ahmad, N. (2021). Addressing the failures of undergraduate anatomy education: Dissecting the issue and innovating a solution. *Annals of Medicine and Surgery*, 61, 81–84. <https://doi.org/10.1016/j.amsu.2020.12.024>
- Arantes, M., Arantes, J., & Ferreira, M.A. (2018). Tools and resources for neuroanatomy education: a systematic review. *BMC Medical Education*, 18(1), 94. <https://doi.org/10.1186/s12909-018-1210-6>
- Arslan, O.E. (2014). Region vs. system-based anatomy: efficacy and implementation. *American International Journal of Biology and Life Sciences*, 2(3), 1-23. <http://dx.doi.org/10.15640/aijb.v2n3-4a1>
- Aziz, M., Kernick, E.T., Beck Dallaghan, G.L., & Gilliland, K.O. (2019). Dissection versus prosection: a comparison of laboratory practical examinations. *Medical Science Educator*, 30(1), 47–51. <https://doi.org/10.1007/s40670-019-00839-6>
- Chang, B.S., & Molnár, Z. (2015). Practical neuroanatomy teaching in the 21st century. *Annals of Neurology*, 77(6), 911–916. <https://doi.org/10.1002/ana.24405>
- Drake, R.L., McBride, J.M., Lachman, N., & Pawlina, W. (2015). 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>
- Estevez, M.E., Lindgren, K.A., & Bergethon, P.R. (2010). A novel three-dimensional tool for teaching human neuroanatomy. *Anatomical Sciences Education*, 3(6), 309–317. <https://doi.org/10.1002/ase.186>

continued on next page

Henssen, D.J., van den Heuvel, L., De Jong, G., Vorstenbosch, M.A., & van Cappellen van Walsum, A.M. et al. (2020). Neuroanatomy learning: augmented reality vs. cross-sections. *Anatomical Sciences Education*, 13(3), 353-365. <https://doi.org/10.1002/ase.1912>

Hlavac, R.J., Klaus, R., Betts, K., Smith, S.M., & Stabio, M.E. (2018). Novel dissection of the central nervous system to bridge gross anatomy and neuroscience for an integrated medical curriculum. *Anatomical Sciences Education*, 11(2), 185-195. <https://doi.org/10.1002/ase.1721>

Hortsch, M., & Mangrulkar, R.S. (2015). When students struggle with gross anatomy and histology: A strategy for monitoring, reviewing, and promoting student academic success in an integrated preclinical medical curriculum. *Anatomical Sciences Education*, 8(5), 478-483. <https://doi.org/10.1002/ase.1519>

Long, J., Roberts, D.J., & Pickering, J.D. (2014). Preservation of cranial nerves during removal of the brain for an enhanced student experience in neuroanatomy classes. *Clinical Anatomy*, 27(1), 20-24. <https://doi.org/10.1002/ca.22356>

Nwaogbe, C., Schmidt, C., Tubbs, R.S., & Rufus, B. (2018). Dr. Rufus B. Weaver and his intriguing dissection of Harriet Cole. *Translational Research in Anatomy*, 10, 7-9. <https://doi.org/10.1016/j.tria.2017.12.002>

Riepertinger, A. (1989). Plastination of the brain with attached spinal cord. *Journal of Plastination*, 3, 22-28. <https://doi.org/10.56507/JGJS6881>

Shell, K., Holt, E., Kington, A., Mohammed, K., Black, A., Troup, C., et al. (2020). Motivation to learn neuroanatomy by cadaveric dissection is correlated with academic performance. *Clinical Anatomy*, 33(1), 128-135. <https://doi.org/10.1002/ca.23500>

Sugand, K., Abrahams, P., & Khurana, A. (2010). The anatomy of anatomy: a review for its modernization. *Anatomical Sciences Education*, 3(2), 83-93. <https://doi.org/10.1002/ase.139>

Venter, G., Lubbe, J.C., & Bosman, M.C. (2022). Neurophobia: a side effect of neuroanatomy education? *Journal of Medical Systems*, 46(12), 99. <https://doi.org/10.1007/s10916-022-01885-1>



## Become a Member of HAPS Today!

The Human Anatomy & Physiology Society (HAPS) is dedicated to promoting excellence in the teaching of Anatomy and Physiology at colleges, universities and related institutions.

- Connect with colleagues also pursuing success in teaching A&P
- Discounted rates for annual and regional conferences
- Access Teaching Tips for tough topics
- HAPS Institute short-courses for ongoing professional development
- Open access to our peer-reviewed journal, *The HAPS Educator*
- Grants and scholarships for research and travel
- Additional member resources listed [here](#).



For more information, contact HAPS at [info@hapsconnect.org](mailto:info@hapsconnect.org) or at 1-800-448-4277.

Follow [this link](#) to join and start benefiting from membership today!

# Interlacing and Unweaving the Brachial Plexus: A Visual Demonstration Highlighting Form and Function

Lindsay Renee Dresang, PhD<sup>1,2</sup>

<sup>1</sup>Department of Biology, College of Letters and Science, University of Wisconsin-Stevens Point, Stevens Point, Wisconsin, USA

<sup>2</sup>Doctor of Physical Therapy Program, School of Health Sciences and Wellness, College of Professional Studies, University of Wisconsin-Stevens Point, Stevens Point, Wisconsin, USA

Corresponding author: [LDresang@UWSP.edu](mailto:LDresang@UWSP.edu)

## Abstract

What happens when an individual spinal nerve is damaged or severed? The loss of function upon nerve damage is a straightforward concept to understand. But what if that spinal nerve contributes to the brachial plexus? The brachial plexus can be an intimidating structure for students, but this structure is also rich in regional anatomy connotations with physical redistribution related to its function. Thus, teaching the parts of the brachial plexus and how it gives rise to its five main terminal nerves innervating different regions of the upper limb has great utility in undergraduate human anatomy education taught with a regional approach. Low-fidelity models, while being limited in their comprehensive utility, are effective tools to help convey essential concepts in the form and function of select structures. Presented here is a demonstration which uses strings and shoelaces to be braided in class to engage students, trigger responses to posed questions, and convey the importance of spinal nerve redistribution within a nervous plexus. After performing this short activity, students voluntarily responded to a questionnaire and provided qualitative one-word descriptions or short reflection statements for assessment. Overall, this activity was highlighted as “visual”, “helpful”, and that they “understand” the brachial plexus structure with positive agreement in recognizing the importance of redistributing spinal nerves within the brachial plexus—to prevent full paralysis of a given limb region upon individual spinal nerve damage. <https://doi.org/10.21692/haps.2024.017>

**Key words:** undergraduate education, anatomy models, active learning, brachial plexus, low-fidelity models

## Introduction

Low-fidelity models have been part of human anatomy instruction for centuries (or possibly millennia), dating well back to periods when gross dissection was highly limited and wax, wooden, or plastic models became important for training in various health professions (Marković & Marković-Živković, 2010). Low-fidelity models in use today have been successfully implemented to convey anatomical development or the final structure of several complex anatomical features using an incredible variety of materials and methods, including crocheted embryonic germ layers (McConnell & Mooney, 2021), aprons for highlighting mesentery position (Chan, 2010; Noël, 2013) or abdominal organ peritoneal placement (Chan, 2010), cut boxes with strings simulating the inguinal canal (Hindmarch et al., 2020), hair bands and gloves to map tendons and muscles along

the digits (Cloud et al., 2010; Lisk et al., 2015), and clay used in anything from cross-sections to heart vasculature (Oh et al., 2009). Low-fidelity models can still be highly complex and involve large scale modeling like equine anatomy reconstruction (Bietzk et al., 2019; Leandro et al., 2019), highly personalized, as with body painting (McMenamin, 2008; Cookson et al., 2018), or highly intricate, as in pipe cleaner tying approaches used to model the brachial plexus (Lefroy et al., 2011; Yu & Husmann, 2021).

While some points have been raised regarding the use of only high-fidelity models (Nayak & Soumya, 2020), several studies have supported the use of adding low-fidelity instruction to aid programs already providing multiple resources as a means to supplement learning and incorporate active learning strategies with observable

*continued on next page*

benefit (Chan & Cheng, 2011, 2020; Chytas et al., 2022; Collins, 2008; Sugand et al., 2010). Furthermore, the greater the variety of teaching strategies and tools utilized beyond lecturing alone, from model demonstration to dissection, the greater the enhancement of overall student engagement and learning (Collins, 2008; Sugand et al., 2010). This article describes a demonstrative activity for the brachial plexus intended for an undergraduate class; the materials and time allotment are minimal as the students also require review of high-fidelity models for later examination.

The textbook used for undergraduate instruction at the University of Wisconsin–Stevens Point, refers to the brachial plexus as the “anatomy student’s nightmare” (Marieb et al., 2016, p. 447). Explaining the spinal nerve contributions, overall position, and function of the brachial plexus with its five main terminal branches can be challenging. These structures were reviewed in the laboratory using high-fidelity models (i.e., SOMSO® models BS3, BS31, or NS15) in addition to reading assignments provided to students in the aforementioned textbook. Additional use of a low-fidelity model with an active learning demonstration augmented this instruction by highlighting a critical component otherwise often missed – that redistribution of spinal nerves prevents full paralysis of a given limb region when an individual spinal nerve becomes damaged.

All spinal nerves were assembled using a set of shoelaces and corrugated ribbons taped onto the front board in the classroom; anterior and posterior divisions were delineated per nerve by making dark and light sets per spinal nerve. These nerves were then braided together into the different trunks, cords, and five main terminal nerve branches: the axillary, radial, musculocutaneous, median, and ulnar nerves. Using this string-based model over the past ten years has consistently led to in-class engagement with the correct answers when posing questions about what happens if individual spinal nerves are severed or damaged. Similar models have been frequently made by others using pipe cleaners (Lefroy et al., 2011; Yu & Husmann, 2021), which do have great utility in conveying how spinal nerves are distributed within the brachial plexus. However, there is a key to this demonstration, in both form and function, using a string-based analogy and model that pipe cleaner-based models lack – a quick visualization of spinal nerve damage.

At the end of assembling the five main terminal nerves arising from the brachial plexus, select spinal nerves were “severed.” While some terminal nerve branches were impacted more than others, there was a lack of total loss for any one of these five nerves. Thus, this string-based modeling activity not only conveys the structural features of the brachial plexus, but also provides a visual analogy for one

of its most important functions: prevention of full paralysis to the different regions of the upper limb (or other areas innervated by a plexus), even if there is spinal nerve damage. At this stage, a greater discussion of common forms of nerve damage can take place.

Pathologies commonly involving individual cervical spinal nerves include impingement due to inflammation or intervertebral foramen stenosis. The cervical vertebral column can present with age-related degenerative disc pathologies such as cervical spondylolisthesis with subsequent narrowing from disc height loss (Iyer & Kim, 2016). The vulnerability of cervical nerve roots can also be highlighted as they lack significant protection from the dura mater or epineurium, but that tractional injuries would likely involve multiple nerves (Rubin, 2020). Clavicular crushing or other traumatic injuries influencing overall plexus function should also be impressed upon students (Rubin, 2020), and this could provide an opportunity to remind students to evenly distribute one’s back-pack weight or select roller bag options.

#### *Learning Objectives of the Brachial Plexus Demonstration*

- Recognize how spinal nerves are redistributed within a plexus.
- Distinguish between anterior and posterior divisions of spinal nerves, including the placement of cords along the axillary artery.
- Explain how nerve divisions segregate into different functional muscle compartments and innervate muscles of similar function.
- Evaluate the impact of individual spinal nerve damage versus plexus damage on limb function.
- Recall the specific spinal nerve distributions to the individual five terminal branches of the brachial plexus.

#### *Aims of the Data Collected Post-Demonstration*

- Assess if the demonstration provided an added benefit beyond other available resources.
- Assess if the demonstration promoted understanding of the brachial plexus structure and its five main terminal nerve branches.
- Evaluate if students understood the importance of spinal nerve redistribution within a plexus and how this structural rearrangement can prevent full paralysis to a given area upon individual spinal nerve damage.

*continued on next page*





**VIDEO:**  
**Brachial Plexus Demonstration**  
**Prof. Lindsay Dresang**

## Materials and Methods

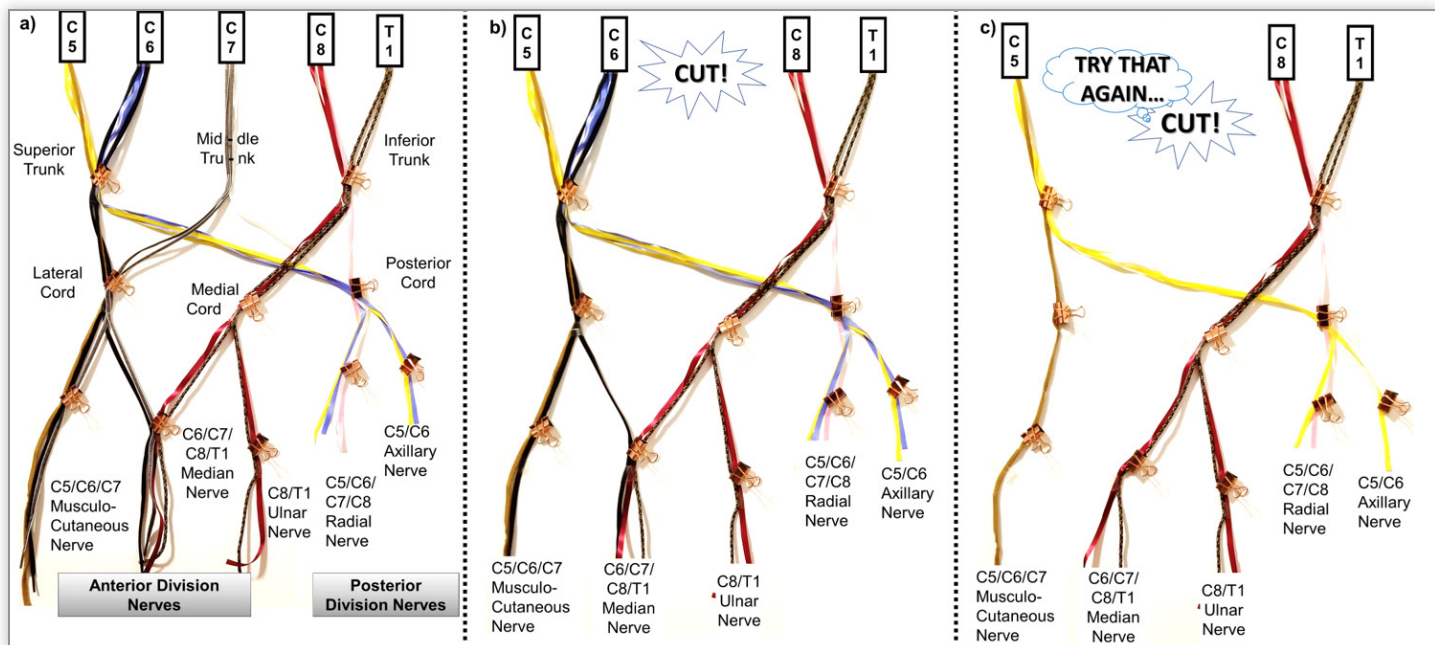
In addition to the information provided below, in the video shown above that can be accessed at this link (<https://www.youtube.com/watch?v=rNZleeFkPs4>), I describe important points to consider when reproducing this demonstration in class.

Briefly, gather the following materials, with assembly as shown in Figure 1A.

- A multi-colored pack of shoelaces (with at least 5 different, preferably darker, colors)
- A multi-colored pack of corrugated/ribbed ribbons commonly used in gift wrapping (with at least 4 different lighter colors, preferably matched to the color combinations obtained in the pack of shoelaces)
- Clear tape, packing tape, scissors, ~8-10 small binder clips (15-20 mm)
- Markers and/or chalk (depending upon one's classroom set-up), and
- An undergraduate student audience (preferably in a lab setting) with volunteers willing to provide anonymous feedback to a questionnaire.
  - This demonstration was performed in front of two lab sections taught in the same term. A total of 34 students were retained through the topics involving upper limb regional anatomy when this demonstration was given. Both lab sections and the corresponding lecture were taught by the same instructor (the author).

- The students who watched the demonstration and who were asked to provide anonymous feedback for the term in which data was collected included students majoring in: health sciences (56%), biochemistry or biology (26%), or other fields (3-6% for all other individual majors). Of these students, 24% had additionally self-identified as being on a pre-medicine, pre-physicians assistant, or pre-nursing professional track. Most students (41%) were seniors, while the remaining 59% of students were evenly split between juniors and sophomores based upon class standing at the start of the term. However, no specific ages or other demographics were collected. Given the anonymity involved, it is unknown what proportions of the students having declared different pre-professional tracks or majors provided feedback.
- The institutional review board (IRB) assessed the experimental design. Student anonymity was maintained throughout the data collection process and all feedback was provided voluntarily without incentive (not even extra credit). Also, students were given the option to declare permission (or not) to have their feedback used for publication purposes; no student selected the option to have their feedback rescinded for publication purposes. Therefore, the IRB designated this study as exempt from a formal human subject research protocol.

*continued on next page*



**Figure 1.** (A) Assembled brachial plexus. (B) Removal of the C7 spinal nerve. (C) Severance of a second contributing spinal nerve (C6).

#### Instructions, in Brief

Assemble the spinal nerves with dark and light color combinations (delineating anterior and posterior divisions, respectively) as shown in Figure 1A. Braid together the laces and strings to form the trunks, cords, and five main terminal nerve branches of the brachial plexus (Figure 1A). “Sever” a spinal nerve, like C7 (Figure 1B) and ask the class, “What just happened?”. Carefully pull the corresponding lace/string bundle for that nerve out of the assemblage to reveal that all five terminal branches remain. Repeat as desired, as shown for C6 (Figure 1C). Take this opportunity to discuss differences between injury to individual spinal nerves, common forms of individual cervical spinal nerve injury (i.e., cervical radiculopathy including age-related cervical spondylolisthesis), and compare these injuries to damage of the brachial plexus as a whole and/or damage to the five main terminal branches after they have formed (Iyer & Kim, 2016; Rubin, 2020).

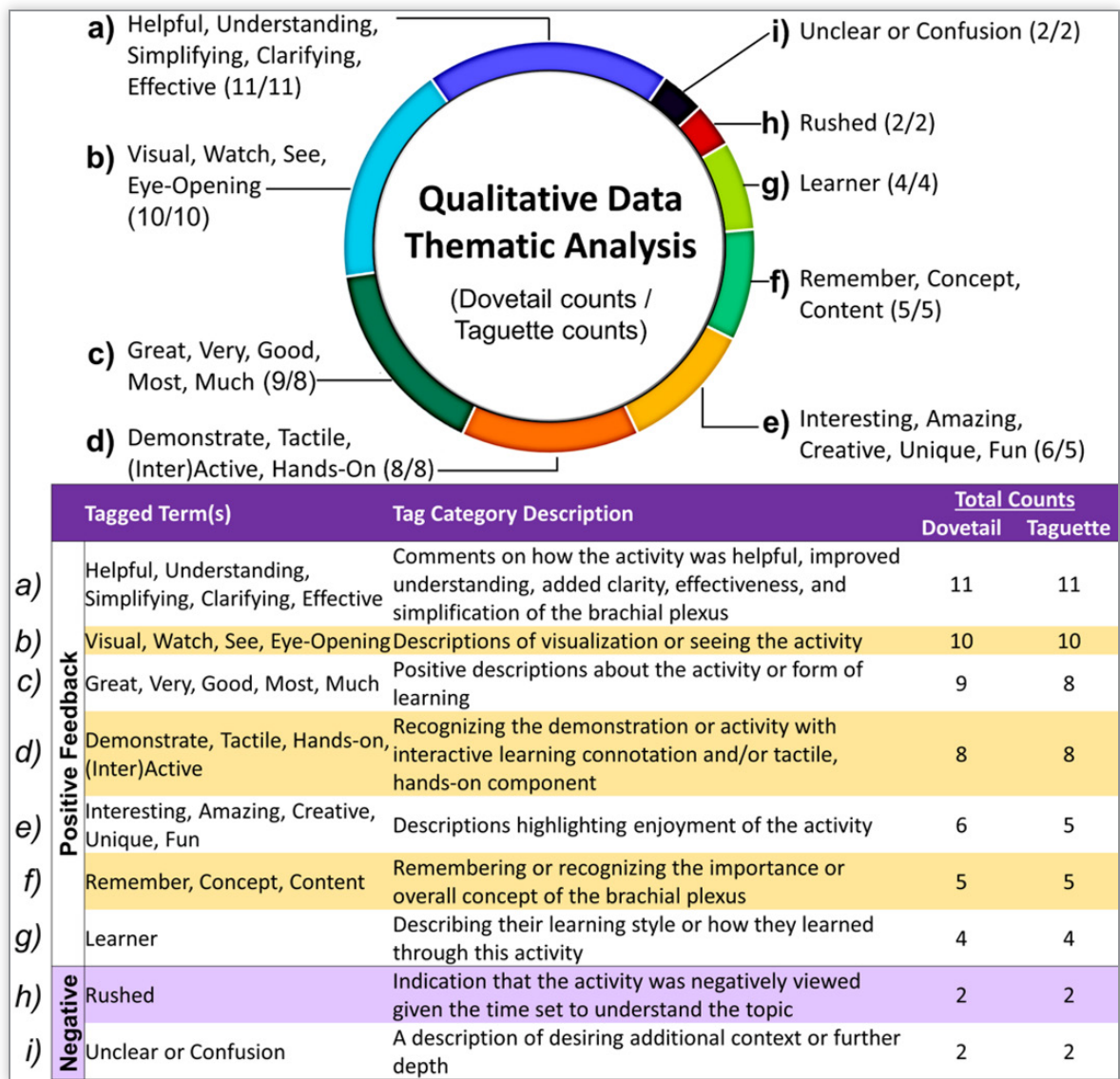
#### Assessment

Students were provided with a questionnaire (Appendix 1) to complete in a purely anonymous and voluntary manner (no incentives were provided for participation). Students whose responses indicated that they were both present for this demonstration, and that they consented to provide feedback for potential publication of results (100% of volunteers who

identified as being present for this demonstration), were assessed further. Likert-scale responses to the questions are reported with averages and standard deviations using the data from 18 qualifying respondents. Short descriptive feedback and elaboration with additional comments were further assessed to assemble key terms in a word cloud (<https://www.wordclouds.com/>). Words or phrases appear in proportion to their occurrence in the assembled graphic (depending upon word length, letter height, and fit to the cloud-form graphic chosen). A comparable word cloud was generated by a colleague using the same software to confirm that similar results were obtained without the introduction of bias.

Additional qualitative data thematic analysis was conducted (Guest et al., 2012). Terms were tagged by theme, as shown in Figure 2, using both Dovetail 3.0 (<https://dovetail.com/#recruit>) and Taguette (Rampin and Rampin, 2021) qualitative thematic software platforms. Similar results with slight variation were obtained using the indicated coded tags; graphical information was generated using the Dovetail 3.0 platform, while tabular information was modified from Taguette platform output files.

continued on next page



**Figure 2.** Tagging of student written responses according to the categories listed in the associated table. The frequency of these terms relative to total tag counts are shown in the ring graphic generated using Dovetail platform 3.0. Tabular information was generated with modification to incorporate results of both platforms using Taguette.

Since both Dovetail 3.0 and Taguette still analyze data with user-defined codes, this data was also uploaded to the YesChatGPT40 platform for artificial intelligence analysis (<https://www.yeschat.ai/blog-gpt4-free>), allowing an overall thematic summary to be generated.

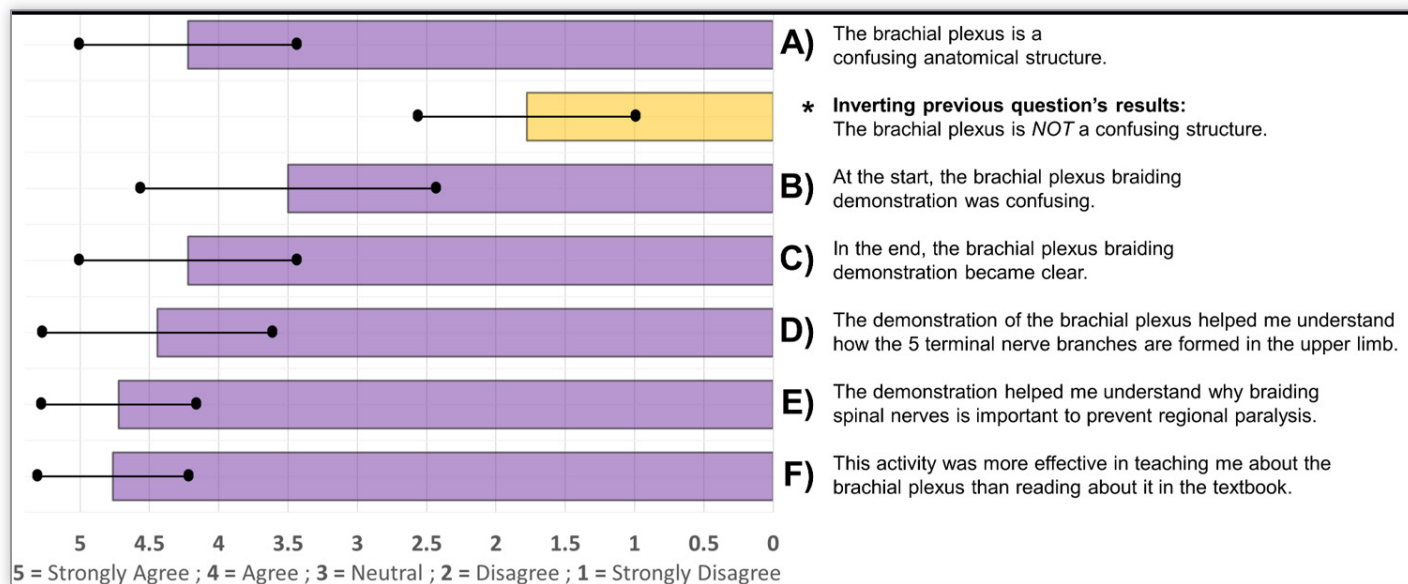
## Results

A total of 18 students provided feedback on the brachial plexus demonstration (Figure 3). Their responses to the Likert-based questions indicated that they found the brachial plexus to be, in general, a complex anatomical structure ( $4.22 \pm 0.79$ ). Meanwhile, their feedback indicated that the demonstration helped them in their understanding of how a plexus can redistribute nerves to prevent full paralysis to a particular region ( $4.72 \pm 0.56$ ) and that this activity was more effective in teaching them about the brachial plexus than the corresponding reading in the textbook ( $4.76 \pm 0.55$ ). If the results of the first question are “inverted” (Figure

3, orange bar), then those results could serve as a baseline for a rough comparison to observed improvements in student understanding. Thus, if students strongly disagreed that the brachial plexus was *not* a complex anatomical structure ( $1.78 \pm 0.79$ ), then clarity of the brachial plexus after the demonstration improved roughly 2.5-to-2.7-fold. Since the first question, however, was not originally asked in this manner, it remains unclear if this perceived relative improvement would be appropriately assessed using further statistical analysis.

*continued on next page*





**Figure 3.** Students were requested to provide responses to the indicated questions on a purely voluntary basis. Their answers were tabulated using the indicated Likert scale under strict anonymity. Average scores ( $\pm$  SD) on Likert-based questions from 18 participants (purple bars). The results of students' impression of the brachial plexus were inverted for comparison (orange bar) to assess shifts in clarity after the demonstration.

One-word descriptive responses and short additional comments were assessed for key words and phrases as a word cloud (Figure 4A). Altogether, 33 words or short phrases with descriptive assessment were collated to 22 words. The most frequently occurring terms were “visual” (used 7 times), “helpful” (used 4 times), “understand”, and “great” (each used twice). All remaining words appeared once in

the provided feedback. Of the terms provided, only “rushed” (used 1 time, and described as “more time” being requested) was considered negative feedback. To eliminate assessment bias, the written results of these questionnaires were independently assessed by a colleague and a second, fairly similar word cloud was obtained (Figure 4B).



**Figure 4.** (A) Word cloud generated in which words sizes are proportional to their occurrence in student feedback. (B). A separate word cloud was generated by a colleague to verify that similar results were obtained using scanned copies of the anonymized questionnaires.

continued on next page



Overall, of the highlighted tags using Dovetail and Taguette platforms, there were 53 and 51 positive feedback tags, respectively, and only 4 negative feedback attributes for either platform (Figure 2). The largest category tagged involved descriptions of being either helpful, (improving) understanding, and simplifying/clarifying the brachial plexus. Differences in the exact totals are attributed to how terms/codes could be highlighted using each interface. Codes were still formally defined by the researcher.

To evaluate themes coded using artificial intelligence and further reduce potential bias, all text from the questionnaire results was uploaded onto the YesGPT40 platform. The summary generated was consistent with the associated tags, including both summarized positive feedback, some suggestions for improvement, and included an overall summary of the merits of this activity (Figure 5).

**Figure 5.** The raw, written feedback data from the questionnaires was uploaded to an artificial intelligence platform to assess a non-user generated thematic analysis (YesChatGPT40). The positive feedback, suggestions for improvement, and overall impact are consistent with the results of other qualitative analyses.

## Discussion

Altogether the results of the questionnaire indicate student appreciation of this low-fidelity model and in-class activity. Responses indicate that the demonstration was helpful in understanding both the anatomical form of the brachial plexus as well as its function to prevent full paralysis to a particular region of the upper limb. Routes of “severing” or otherwise damaging a spinal nerve, while not formally evaluated in this questionnaire, have repeatedly triggered recognition of plexus function during and after the demonstration. Students will often recognize or even volunteer responses in class regarding the problem-solving aspect of this activity, namely a request of what would happen should one or two spinal nerves become damaged.

### Written Feedback Thematic Analysis using Artificial Intelligence

- All written text from evaluated questionnaires were loaded into the YesChatGPT40 platform.
- The summary output in its raw form is indicated below.

#### YesChatGPT4o

It seems like you've provided a series of reflections or feedback, possibly on a learning activity or demonstration related to the brachial plexus. Here's a summary of the key points and themes:

#### Positive Feedback:

- **Effective for Visual Learners:** Multiple mentions of how the demonstration was clarifying, helpful, and allowed concepts to “click” for visual learners.
- **Interactive and Engaging:** Described as fun, creative, and interactive, making the learning experience unique and memorable.
- **Tactile Learning Benefits:** Highlighted as effective for tactile learners, emphasizing the value of hands-on activities.

#### Suggestions for Improvement:

- **More Detail on Nerves:** Some feedback suggests a need for more time or focus on the nerves, especially their arrangement and connection.
- **Pacing:** Noted that the session felt rushed, particularly toward the end, which may have impacted comprehension.

#### Overall Impact:

- The activity was described as eye-opening, simplifying, and a great way to visualize and understand the brachial plexus's structure and function.

*continued on next page*

While this demonstration is less robust than the pipe cleaner-based demonstrations described by Lefroy et al. (2011) or Yu & Hussmann (2021), it does provide an in-class critical thinking framework with minimal class-time use (usually under 15 minutes) as well as inexpensive materials which can be reused for multiple future demonstrations. This approach, while not intended to be a replacement altogether of the high-fidelity models subsequently studied in the human anatomy laboratory, is an inexpensive way to highlight a complex anatomical structure in both its form and function while also driving home the key features of the terminal nerves and the importance of braiding/redistributing spinal nerves when they develop. This demonstration further sets up the class to recall these concepts in later units, discussing the importance of the phrenic nerve arising off of the cervical plexus, as well as in upper-level courses involving cadaveric dissection (not formally evaluated at present).

#### *Limitations of the Study*

This demonstration is intended for an upper-level, undergraduate human anatomy course taught in a regional manner. It is likely too advanced for a systems-based, introductory-level undergraduate human anatomy course, which would likely neither discuss brachial plexus components like the roots, trunks, or cords, nor discuss the regional positioning relative to the axillary artery. This demonstration has some limited utility for an advanced undergraduate human anatomy course involving gross dissection, as the median nerve of the model closely resembles the formation of the median nerve anteriorly along the axillary artery with medial and lateral cord contributions. However, this activity concurrent with dissection labs was not assessed in the more advanced undergraduate or graduate courses also provided at UWSP.

It should also be noted that this demonstration does not incorporate more intricate detailing of the brachial plexus, as its intent is to highlight the “what-if” scenario of severing (or otherwise damaging) an individual cervical spinal nerve. Namely, it does not incorporate possible communication of the C7 spinal nerve to the ulnar nerve, it does not include branches arising from roots or trunks (i.e., the long thoracic nerve or the suprascapular nerve), it does not readily provide for additional spinal nerve contributions which are variably reported (i.e., the C5 spinal nerve may also contribute to the median nerve depending upon the individual assessed in dissection), nor does it provide the three-dimensional relationships the way that other models might (Lefroy et al., 2011; Yu & Husmann, 2021).

While this demonstration highlights how multiple spinal nerves braided together contribute to multiple terminal nerve branches of the brachial plexus and prevent full paralysis to a region should one of the spinal nerves become damaged, it is far more frequent to observe

injury to components past these brachial plexus roots (Iyer & Kim, 2016; Rubin, 2020). Discussing other forms of injury of terminal nerve branches (i.e., humeral fractures, cubital and/or carpal tunnel syndromes), impingement or traumatic impact associated with divisions and/or cords (i.e., compression injuries or advanced lung/breast neoplastic growth impinging upon the plexus), injuries involving multiple spinal nerves, (i.e., stretching/traction injuries), or specific trunk injuries (i.e., thoracic outlet syndrome) are warranted for comparison (Marieb et al., 2016; Rubin, 2020). Despite these limitations, the “severing” aspect of the demonstration still holds utility, provided these caveats are acknowledged along with specific examples of how individual spinal nerves could be damaged (i.e., age-related cervical radiculopathy from intervertebral disc compression, spondylolisthesis, and intervertebral foramina stenosis, as well as increased risk of lung cancer or breast cancer malignant growths regionally) (Iyer & Kim, 2016; Rubin, 2020).

Additionally, this demonstration, while used multiple times over the years, has only formally been assessed recently by one cohort in an assessment not correlated to post-demonstration performance in brachial plexus component recognition. Likewise, the discussions with students completing an advanced human anatomy section relating to this string-based demonstration are anecdotal at present, as it has not had the opportunity for uniform assessment since the hiatus taken during the pandemic between 2020 up to 2022. It will be useful to assess the utility of this demonstration if repeated for students who had previously seen it and those who did not previously see it (either due to transfer circumstances or to a prior class absence), and then see if there are noted differences in appreciation for how a brachial plexus is formed, as well as whether or not students can readily identify its contributing parts.

## **Conclusions**

Altogether, the interlacing and subsequent unweaving of the brachial plexus using shoelaces and corrugated/ribbed ribbons demonstrates utility in teaching the brachial plexus components and their functions. This low cost, minimal time-requiring activity is a useful supplement to readings and high-fidelity models also employed in class. Additional evaluation is of interest to explore retention pre- and post-demonstration regarding terminal nerve’s anterior/posterior division correlation, spinal nerve contribution, and other possible critical thinking scenarios involving severing of nerves. Assessment of this demonstration’s utility at the level of gross dissection is also warranted.

*continued on next page*

## Acknowledgements

The author wishes to acknowledge and thank Chris Yahnke for his support and his recommendation that this demonstration be submitted for publication. The author would also like to thank Sarah Jane Alger, who independently analyzed questionnaire results, validating that the original findings lacked bias. Both Sarah Jane Alger and Jennifer Bray are also acknowledged for having helped review aspects of this demonstration and manuscript. The author also would like to thank Roberta White for securing the anonymized data set until after grades had been submitted. Further, the students at UWSP who provided this feedback, as well as those who also provided interest in seeing pedagogical assessment of these learning strategies, have provided immeasurable support. The author reports no conflict of interest.

## About the Author

Lindsay R. Dresang, Ph.D., is an associate professor in the Department of Biology, College of Letters and Science, and an affiliated faculty member of the Doctor of Physical Therapy Program, College of Professional Studies at the University of Wisconsin-Stevens Point, Stevens Point, Wisconsin. She mainly teaches one graduate and three different undergraduate human anatomy courses, as well as classes in cancer biology, virology, and others. Her research interests include teaching as research with a diversity, equity, and inclusion emphasis, novel chemotherapeutics, and liver metastasis.

## Literature Cited

- Bietzk, E., Weller, R., Simons, V., & Channon, S. B. (2019). Anatomy teaching, a “model” answer? Evaluating “Geoff”, a painted anatomical horse, as a tool for enhancing topographical anatomy learning. *Anatomical Sciences Education*, 12(5), 529–540. <https://doi.org/10.1002/ase.1823>.
- Chan, L. K., & Cheng, M. M. (2011). An analysis of the educational value of low-fidelity anatomy models as external representations. *Anatomical Sciences Education*, 4(5), 256–263. <https://doi.org/10.1002/ase.239>.
- Chan, L. K. (2010). Pulling my gut out – Simple tools for engaging students in gross anatomy lectures. *Anatomical Sciences Education*, 3(3), 148–150. <https://doi.org/10.1002/ase.154>.
- Chytas, D., Piagkou, M., Skandalakis, G. P., & Natsis, K. (2022). Can low-fidelity models be effective anatomy teaching tools? *Surgical and Radiologic Anatomy*, 44:3–4. <https://doi.org/10.1007/s00276-021-02818-2>.
- Cloud, B. A., Youdas, J. W., Hellyer, N. J., & Krause, D. A. (2010). A functional model of the digital extensor mechanism: Demonstrating biomechanics with hair bands. *Anatomical Sciences Education*, 3(3), 144–147. <https://doi.org/10.1002/ase.143>.
- Collins, J. P. (2008). Modern approaches to teaching and learning anatomy. *The British Medical Journal*, 337, Article e1310. <https://doi.org/10.1136/bmj.a1310>.
- Cookson, N. E., Aka, J. J., & Finn, G. M. (2018). An exploration of anatomists’ views toward the use of body painting in anatomical and medical education: An international study. *Anatomical Sciences Education*, 11(2), 146–154. <https://doi.org/10.1002/ase.1698>.
- Guest, G., MacQueen, K. M., & Namey, E. E. (2012). *Applied thematic analysis*. SAGE Publications, Inc. <https://doi.org/10.4135/9781483384436>.
- Hindmarch, J., Bazzi, K., Lahoud, J., Malik, A., & Sinha, S. (2020). Evaluating a low-fidelity inguinal canal model. *Surgical and Radiological Anatomy*, 42, 1323–1328. <https://doi.org/10.1007/s00276-020-02553-0>.
- Iyer, S., Kim, H. J. Cervical radiculopathy. (2016). *Current Reviews in Musculoskeletal Medicine*, 9, 272–280. <https://doi.org/10.1007/s12178-016-9349-4>.
- Leandro, R. M., Filho, R. P. P. F., De Silvio, M. M., Quilici, A. P., Sattin, M. M., Paretsis, B. F., & Souza, V. A. (2019). Construction of the equine digestive system: A tool for teaching topographical anatomy. *Journal of Veterinary Medical Education* 46, (1), 108–115. <https://doi.org/10.3138/jvme.0317-043r>.
- Lefroy, H., Burdon-Bailey, V., Bhangu, A., & Abrahams, P. (2011) A novel technique for teaching the brachial plexus. *The Clinical Teacher*, 8(3), 196–199. <https://doi.org/10.1111/j.1743-498X.2011.00448.x>.
- Lisk, K., McKee, P., Baskwill, A., & Agur, A. M. R. (2015). Student perceptions and effectiveness of an innovative learning tool: Anatomy glove learning system. *Anatomical Sciences Education*, 8(2), 140–148. <https://doi.org/10.1002/ase.1459>.
- Marieb, E. N., Wilhelm, P. B., & Mallatt, J. B. (2016). *Human anatomy, 8<sup>th</sup> edition*. Pearson Education Inc.
- Marković, D., & Marković-Živković, B. (2010). Development of anatomical models – Chronology. *Acta Medica Medianae*, 49(2), 56–62.
- McConnell, S. E. A., & Mooney, C. J. (2021). A crocheted model activity for teaching embryonic lateral folding to medical students. *Anatomical Sciences Education*, 14(5), 666–674. <https://doi.org/10.1002/ase.2062>.
- McMenamin, P. G. (2008). Body painting as a tool in clinical anatomy teaching. *Anatomical Sciences Education*, 1(4), 139–144. <https://doi.org/10.1002/ase.32>.

continued on next page

Nayak, S. B., & Soumya, K.V. (2020). Flawless, accurate models only can help in deeper learning of anatomy. *Surgical and Radiologic Anatomy*, 43, 529-530. <https://doi.org/10.1007/s00276-020-02623-3>.

Noël G. P. J. C. (2013). A novel patchwork model used in lecture and laboratory to teach the three-dimensional organization of mesenteries. *Anatomical Sciences Education*, 6(1), 67–71. <https://doi.org/10.1002/ase.1309>.

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>.

Rampin, R., & Rampin, V. (2021). Taguette: Open-source qualitative data analysis. *Journal of Open Source Software*, 6(68), 3522. <https://doi.org/10.21105/joss.03522>.

Rubin, D. I. (2020). Brachial and lumbosacral plexopathies: A review. *Clinical Neurophysiology Practice*, 5, 173–193. <https://doi.org/10.1016/j.cnp.2020.07.005>.

Sugand, K., Abrahams, P., & Khurana, A. (2010). The anatomy of anatomy: A review for its modernization. *Anatomical Sciences Education*, 3(2), 83-93. <https://doi.org/10.1002/ase.139>.

Yu C. I., & Husmann, P. R. (2021). Construction of knowledge through doing: A brachial plexus model from pipe cleaners. *Medical Science Educator*, 31, 1053–1064. <https://doi.org/10.1007/s40670-021-01274-2>.

## Become a Member of HAPS Today!

The Human Anatomy & Physiology Society (HAPS) is dedicated to promoting excellence in the teaching of Anatomy and Physiology at colleges, universities and related institutions.

- **Connect with colleagues also pursuing success in teaching A&P**
- **Discounted rates for annual and regional conferences**
- **Access Teaching Tips for tough topics**
- **HAPS Institute short-courses for ongoing professional development**
- **Open access to our peer-reviewed journal, *The HAPS Educator***
- **Grants and scholarships for research and travel**
- **Additional member resources listed [here](#).**



For more information, contact HAPS at [info@hapseconnect.org](mailto:info@hapseconnect.org) or at 1-800-448-4277.

Follow [this link](#) to join and start benefiting from membership today!



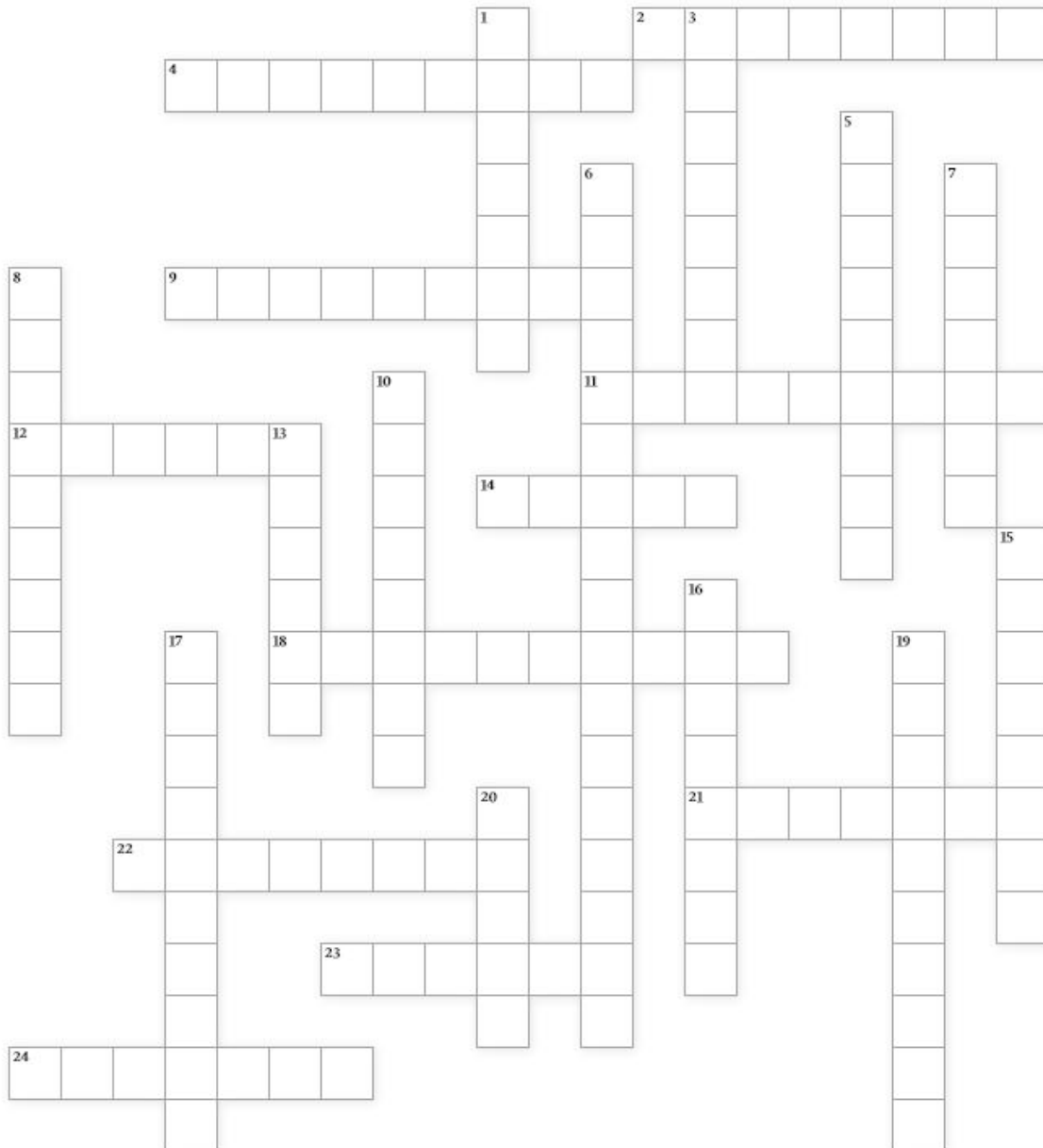
## Appendix 1. Brachial Plexus Questionnaire

You are not required to complete this questionnaire. Your answers to the following questions and your comments are entirely voluntary. If you choose to provide feedback regarding the brachial plexus demonstration, I will incorporate your responses into a teaching methods publication. Please provide feedback anonymously. Circle numbers or terms as needed and fill in comments if you have any.

- 1) Do you consent to provide feedback for the brachial plexus demonstration, which will be used in a teaching methods publication? YES / NO
- 2) Did you see the brachial plexus demonstration? YES / NO
- 3) Did you enjoy watching the brachial plexus demonstration? YES / NO
- 4) Please respond to the following statements using a scale of 1-5 (1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree):
  - a) The brachial plexus is a confusing anatomical structure. 1 / 2 / 3 / 4 / 5
  - b) At the start, the brachial plexus braiding demonstration was confusing. 1 / 2 / 3 / 4 / 5
  - c) The demonstration of the brachial plexus helped me understand how the 5 terminal nerve branches are formed in the upper limb. 1 / 2 / 3 / 4 / 5
  - d) The demonstration helped me understand why braiding spinal nerves is important to prevent regional paralysis. 1 / 2 / 3 / 4 / 5
  - e) This activity was more effective in teaching me about the brachial plexus than reading about it in the textbook. 1 / 2 / 3 / 4 / 5
  - f) In the end, the brachial plexus braiding demonstration became clear. 1 / 2 / 3 / 4 / 5
- 5) Please provide a word or phrase to describe the brachial plexus demonstration as a teaching tool.  
\_\_\_\_\_
- 6) Please provide any additional comments you may have:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

# HAPS Educator Crossword 3: The Skeleton

(For an online version [CLICK HERE.](#))



## ACROSS

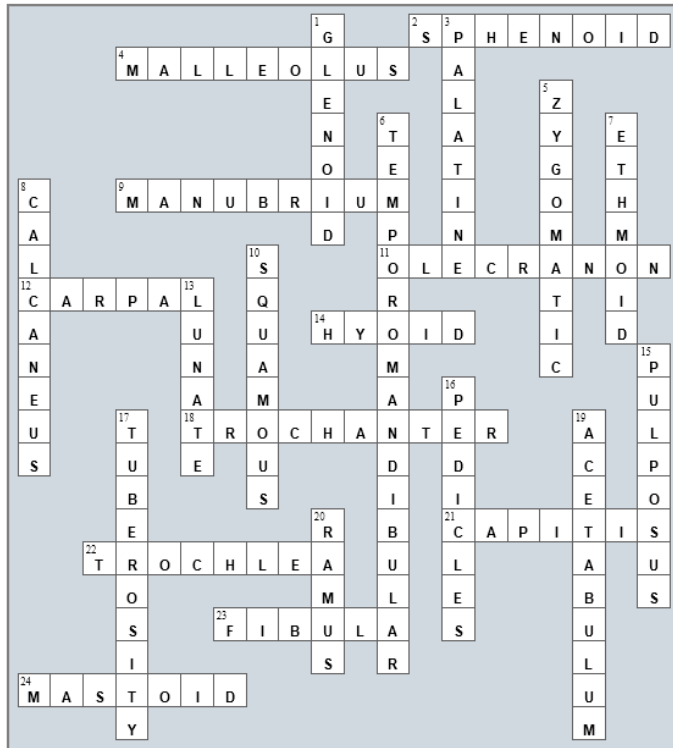
2. The ..... bone has greater and lesser wings.
4. The lateral ..... forms a bulge that you can feel at the level of the ankle.
9. The ..... of the sternum is the site of attachment of the clavicles and the first pair of ribs.
11. Process extending from the ulna that forms the elbow.
12. The 8 bones of the wrist are referred to as ..... bones.
14. The ..... bone is anchored by neck muscles and does not connect directly to any skull bones.
18. Equivalent to a tubercle of the humerus, but found on the femur.
21. Fovea ..... of the head of the femur means "pit of the head".
22. Name of the condyle of the humerus that articulates with the ulna.
23. Lateral bone of the leg that is not weight bearing.
24. The ..... process is a rounded bony projection of the temporal bone that can be felt immediately behind the ear.

## DOWN

1. The ..... cavity of the scapula receives the head of the humerus.
3. The hard palate is formed by the maxillary and the ..... bones.
5. The ..... bones are more commonly known as the cheekbones.
6. The condylar process of the mandible inserts into the mandibular fossa of the temporal bone to form the ..... joint.
7. The middle nasal concha is part of the ..... bone.
8. Anatomical name for the heel bone.
10. This suture links the temporal and parietal bones on each side of the skull.
13. The scaphoid and ..... bones of the wrist articulate with the radius.
15. The central region of each intervertebral disc is called the nucleus ..... .
16. Except for the first cervical vertebra, each vertebral arch is formed by two ..... and two laminae .
17. While working on this crossword puzzle, you are sitting on your ischial ..... .
19. Socket of the pelvic bone that articulates with the head of the femur.
20. The body and the ..... of the mandible meet at the mandibular angle.

[CLICK HERE for Answer Key](#)

**Answer key for: Crossword 3. The Skeleton** (from previous page)



**GO BACK  
to the  
puzzle**

## Become a Member of HAPS Today!

The Human Anatomy & Physiology Society (HAPS) is dedicated to promoting excellence in the teaching of Anatomy and Physiology at colleges, universities and related institutions.

- Connect with colleagues also pursuing success in teaching A&P
- Discounted rates for annual and regional conferences
- Access Teaching Tips for tough topics
- HAPS Institute short-courses for ongoing professional development
- Open access to our peer-reviewed journal, *The HAPS Educator*
- Grants and scholarships for research and travel
- Additional member resources listed [here](#).



For more information, contact HAPS at [info@hapsconnect.org](mailto:info@hapsconnect.org) or at 1-800-448-4277.

Follow [this link](#) to join and start benefiting from membership today!

# HAPS COMMITTEES AND BOARDS

---

## Standing Committees:

---

### 2025 ANNUAL HOST COMMITTEE

[Furhan Garaibeh & Natasha Baker](#)

This committee is in charge of coordinating the 2025 Annual Conference to take place in Pittsburgh, Pennsylvania

### ANATOMICAL DONOR STEWARDSHIP

[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.

### AWARDS & SCHOLARSHIPS

[Chasity O'Malley](#)

### COMMUNICATION

[Caitlin Burns](#)

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

[Abbey Breckling](#)

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

### DIVERSITY, EQUITY, AND INCLUSION

[Jennifer Stokes](#)

### FUNDRAISING

[Stacey Dunham](#)

[Click here to visit the HAPS committees webpage.](#)

## Special Committees and Programs:

---

### WELCOMING AND BELONGING

[Larry Young & Rachel Hopp](#)

### STEERING

[Larry Young](#)

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

### 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.

### EXAM PROGRAM LEADS

[Valerie O'Loughlin](#)

[Dee Silverthorn](#)

[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.

### EXECUTIVE

[Melissa Quinn](#)

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

### FINANCES

[Ron Gerrits](#)

### NOMINATING

[Rachel Hopp](#)

This committee recruits nominees for HAPS elected offices.

### PRESIDENTS EMERITI ADVISORY COMMITTEE

[Eric Sun](#)

This committee consists of an experienced advisory group including all Past Presidents of HAPS. The committee advises and adds a sense of HAPS history to the deliberations of the BOD