A&P Communities of Practice

Combined Muddiest Point and Peer Instruction Activities

3-D Digital Models for A&P Instruction during COVID

Case Study on Cortical Plasticity

Guidance Regarding Teacher Empathy

Multi-Dimensional Learning Modalities for Anatomy
EDUCATIONAL RESEARCH

What makes Communities of Practice Persist? Lessons from Anatomy and Physiology Instructors Communities of Practice.

https://doi.org/10.21692/haps.2023.021
Audrey Rose Hyson, PhD, Chasity B. O’Malley, PhD, Kamie K. Stack, MA, MEd, Megan C. Deutschman, PhD, Megan Bernier, B.Sc., and Murray Jenson, PhD ................................................................. 4

How Delivery Method Impacts Student Perceptions of Anxiety and Learning with Combined Muddiest Point and Peer Instruction Activities in Community College Anatomy and Physiology Classes: Lessons for Faculty, Higher Education Academic Leaders, and Educational Technology Leaders.

https://doi.org/10.21692/haps.2023.023
Anthony C. Edwards, PhD, Suzanne Hood, PhD, Murray Jenson, PhD, Ron Gerrits, PhD, Melaney Farr, MS, and Chasity O’Malley, PhD ........................................................................................................... 19

PERSPECTIVES ON TEACHING

Utilizing 3-D Digital Models in Synchronous Blended Anatomy & Physiology Courses During the COVID-19 Pandemic.

https://doi.org/10.21692/haps.2023.019
Luis D. Rosado, PhD ...................................................................................................................................................... 29

Sally’s Phantom: A Case Study on Plasticity of Cortical Representation.

https://doi.org/10.21692/haps.2023.022
Scott E. Dobrin, PhD ...................................................................................................................................................... 39

Teacher Empathy: A Personal View on Approaching Compassion Satisfaction, Avoiding Compassion Fatigue.

https://doi.org/10.21692/haps.2023.020
Tracy L. Ediger, MD, PhD .................................................................................................................................................. 47

From Cadaver Dissection to Digital Anatomy: Benefits of Multi-Dimensional Learning Modalities.

https://doi.org/10.21692/haps.2023.024
Kathleen G. Tallman, PhD, Grace Matsuda, PT, DPT, and Susan Shore, DPT, PhD .................................................................................. 53

HAPS Committees and Boards .............................................................................................................................. 60
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, 2023 All rights reserved.
What makes Communities of Practice Persist? Lessons from Anatomy and Physiology Instructors Communities of Practice

Audrey Rose Hyson, PhD*,1, Chasity B. O’Malley, PhD*2, Kamie K. Stack, MA, MEd3, Megan C. Deutschman, PhD1, Megan Bernier, BSc4, Murray Jensen, PhD5

*co-first authors
1University of Minnesota Medical School, Minneapolis, MN, USA
2Wright State University Boonshoft School of Medicine, Dayton, OH, USA
3University of Minnesota College of Education and Human Development, Minneapolis, MN, USA
4Bishop’s University, Sherbrooke, Quebec, Canada
5University of Minnesota College of Biological Sciences, Minneapolis, MN, USA.

Corresponding Author: Chasity.OMalley@wright.edu

Abstract

While there has been a recent focus on developing programs to support educational research by community college anatomy and physiology instructors, there is not yet an established long-term community of practice (CoPs) in this particular area. Studies of long-term CoPs, particularly in STEM education, are few and far between. This study examines College in the Schools (CIS), a long-term community of practice for high school anatomy and physiology (A&P) educators in Minnesota and Wisconsin. In addition, this study highlights the factors that attract high school A&P teachers to CIS and the possibility of creating a similar CoP for community college (CC) A&P instructors focused on educational research. It was discovered that despite their varying reasons for joining, members of CIS and CC instructors tend to participate in CoPs similarly. As a result, A&P instructors from CC who are interested in educational research could benefit from a CoP structure similar to CIS over a longer period of time.

https://doi.org/10.21692/haps.2023.021

Key words: community of practice, educational research, high school, community college, anatomy and physiology

Introduction

As higher education institutions continue to face issues with student learning, grit, and graduation in science, technology, engineering, and mathematics (STEM) programs, STEM educators in post-secondary institutions are being called upon to adopt evidence-based instructional practices (EBIPs) in order to improve student outcomes (Kezar et al., 2017; Ma et al., 2019). However, more than mere encouragement is needed to facilitate instructional change. Faculty encounter both internal and external barriers to implementing EBIPs, including limited access to professional development opportunities, little time to implement changes to teaching, and conflicting personal beliefs about teaching and learning (Andrews & Lemons, 2015; Edwards et al., 2015; Hyson et al., 2021; Ma et al., 2019; Schinske et al., 2017; Seithers et al., 2020).

Theoretical Framework

Lave and Wenger (1991) defined Communities of Practice (CoP) as “a set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice” (p. 98). The concept originated in Lave and Wenger’s 1991 book Situated Learning and is further elaborated on by Wenger in a 1998 book entitled Communities of Practice: Learning, Meaning, and Identity. Researchers have based the theory of situated learning on studies of apprenticeship learning models focusing on practice in relationships. In the apprenticeship model, all members teach internal norms and discourses through organic participation. The emphasis is on learning through practice. As newcomers enter a community, they reach a point of legitimate peripheral participation where all participants learn and engage through a community of practice. They observe, identify, and emulate standards modeled by masters or old-timers. Within the CoP model, old-timers are the more experienced peers facilitating newcomers’ learning through example and interaction. At the same time, the leaders are learning from the fresh perspectives and experiences new members bring to the community.

continued on next page
A typical example of situated learning theory and communities of practice is the Alcoholics Anonymous program. According to Lave and Wenger (1991), more experienced members in that program provide “counter exemplary stories” in response to newcomers’ initial stories without directly criticizing or correcting them (p. 106). Instead, the experienced members continue telling their stories using the tropes and techniques familiar to that community. As new members gain appropriate storytelling skills, they are validated for them, eventually developing into exemplary storytellers. Experienced members do not explain storytelling to newcomers by sitting down with them. Instead, newcomers learn by listening and telling stories themselves.

Similarly, situated learning theory is central to the student-teaching model in teacher education programs. Pre-service K-12 teachers learn through practice and mentorship in supervised practicum and clinical student-teaching placements. Given the argument that teachers learn by doing, we extend the situated learning theory and CoPs to investigate teacher practices in higher education.

Communities of Practice in STEM Education

For this paper, we applied Barab and colleagues’ definition of a community of practice (2002) as a network of individuals focused on a common practice who share experiences, beliefs, values, history, and knowledge. CoPs focused on STEM education reform provide interested faculty with the support and engagement necessary to adopt EBIPs or conduct educational research despite institutional barriers (Kezar et al., 2017; Ma et al., 2019; Nadelson, 2016; Olitsky, 2015; Townley, 2020). Unlike the K-12 pre-service teachers who learn through a structured and rigorous apprenticeship, instructors in higher education rarely have direct support in pedagogical practices. Specific challenges are associated with building and maintaining long-term CoPs in higher education. Through their study of four long-term STEM education research CoPs, Bernstein-Sierra and Kezar (2017) have identified five central challenges and solutions for creating sustainable, long-term Biology Education Research (BER) CoPs, (1) funding, (2) leadership, (3) staleness, (4) perceived threats of legitimacy, and (5) maintaining integrity.

The majority of these CoPs began with short-term National Science Foundation (NSF) grants as a funding source, which made it challenging to hire and retain permanent staff, recruit new members, develop and train new leaders, hold face-to-face events, or continue developing new materials after the grant was complete (Bernstein-Sierra & Kezar, 2017). The original leaders of these CoPs were charismatic people hand-picked by the primary investigator to embody the mission of the CoP; however, these leaders tended to leave a void when they stepped down (Bernstein-Sierra & Kezar, 2017). As these CoPs continued to grow, the original learning parameters were at risk of becoming stale through repetition over time and reliance on similar ideas (Bernstein-Sierra & Kezar, 2017). Bernstein-Sierra and Kezar (2017) discussed that STEM education reform CoPs often lack acceptance from the broader academic community due to their focus on teaching and pedagogy rather than biology, which is more rewarded in academia. To prove their legitimacy, the CoPs in this study validated their practices through educational research (Bernstein-Sierra & Kezar, 2017). Finally, the needs of the academic community, funders, and STEM fields may diverge from those of the CoP, therefore testing the integrity of the CoPs in their focus on specific learning parameters (Bernstein-Sierra & Kezar, 2017).

Long-Term Support for CoPs

For these CoPs to persist over the long term, they established sustainable funding models and hired professionalized staff rather than relying primarily on volunteers (Gehrke & Kezar, 2018; Kezar & Gehrke, 2017; Kezar et al., 2017). They also created flexible leadership development and succession plans and encouraged members to step into leadership positions (Gehrke & Kezar, 2018; Kezar et al., 2017; Kezar & Gehrke, 2017). The long-term CoPs provided transparent goals and clear mission statements and integrated new opportunities with scheduled and predictable opportunities for participation (Gehrke & Kezar, 2018; Kezar et al., 2017; Kezar & Gehrke, 2017). The communities also adapted the CoPs to participants’ needs by building checks and balances into the flexible organizational structure and allowing for self-reflection and criticism within the community (Bernstein-Sierra & Kezar, 2017).

To further support long-term STEM education reform CoPs, it is vital to consider the strong learning abilities of STEM faculty and identify ways of supporting them in the shift between research norms, methods, and practices within STEM fields and education research and emphasize that, while different, both types of research are rigorous (Nadelson, 2016). Generally speaking, faculty engagement in and design of CoPs results in learning and improving pedagogical practices, developing leadership skills, and increased networking among educators (Gehrke & Kezar, 2018). Members often consult with each other in peer-learning or brainstorming settings about teaching methods, problems in their classroom, and so on and these consultations often lead to more formal mentoring relationships (Kezar et al., 2017).

We hypothesize that the importance of personal interactions also relates to the fact that these are distance communities of practice. Typically, CoPs have regular interactions as part of an organization. Instead, individuals in STEM communities often find themselves part of a larger enterprise where their engaged reforms may receive only some support from colleagues. As a result, having colleagues to learn from, get advice from, and be mentored by was extremely important because they needed help to get this in their local departments and institutions (Kezar et al., 2010). Members of the CoP may benefit from deliberately developed public
and private community spaces where they can learn from each other and share experiences that they do not have the opportunity to share within their departments (Gehrke & Kezar, 2018; Kezar et al., 2017; Kezar & Gehrke, 2017). Several projects within the Biology Education Research (BER) space, including the Community College Anatomy and Physiology Education Research Project (CAPER) and the Community College Biology Instructor Network to Support Inquiry Into Teaching and Education Scholarship (CC Bio INSITES), are working to create CoPs with a culture of mutual learning and mentorship, while also encouraging engagement in BER. Connecting project participants, particularly instructors in community colleges and college-level high school environments, to long-term BER communities of practice could make these projects more sustainable. To that point, this study analyzes how two groups of anatomy and physiology educators participate in long-term communities of practice to answer the following questions:

1. **How do College in the Schools (CIS) and Community College Anatomy and Physiology Education Research (CAPER) instructors describe their participation in communities of practice?**

2. **How could CIS serve as a model for a long-term CAPER community of practice?**

The overarching goal of this study is to better envision how to create a long-term CoP for CC A&P instructors engaging in EBIPs and conducting educational research using the CIS CoP as a model.

**College in the Schools (CIS)**

The CIS program is a dual-enrollment program that provides college credits through the University of Minnesota to students taking the course in their high school. High school teachers teach CIS courses classified as teaching specialists in both public and private schools across Minnesota and Wisconsin (Jensen et al., 2013). This program only accepts licensed high school teachers as instructors, who must complete an application process to participate (Jensen et al., 2013). The instructors foster an environment of active learning by designing a student-centered course (Jensen et al., 2013). The requirements for teaching the CIS Anatomy and Physiology course include three professional development sessions per year, the weekly use of cooperative quizzes, and inquiry-based instructional methods. Over the past decade, CIS has formed its own CoP, including an active listserv and open discussion during professional development days. In addition, CIS instructors attend workshops focused on EBIPs and how to implement them in the classroom and science content before and during the academic school year.

**Refinement and Expansion of the Community College Anatomy and Physiology Education Research Program (CAPER)**

Community college (CC) instructors are essential in education in the United States, teaching 50% of Latinx and Indigenous students and 40% of Black and Asian students at post-secondary levels (Twombly & Townsend, 2008). CC A&P instructors often teach people preparing for nursing or other health professions programs. However, CC instructors often need more access to professional development or support for engaging in active learning and performing educational research (Edwards et al., 2015; Flynn et al., 2017; Parker et al., 2016).

The current CAPER program (IUSE Award #2111119) is a multi-layered program focused on researching the efficacy of EBIPs in Community College (CC) Anatomy and Physiology (A&P) Classrooms. It is a continuation of the previous CAPER program (IUSE Award #1829157) (see [https://hapsblog.org/2021/10/15/caper-is-back/](https://hapsblog.org/2021/10/15/caper-is-back/) for an explanation of names). CC A&P was selected to join the program after an application process that assessed familiarity with active learning and the diversity of the students at their institutions. Most CAPER participants are recruited through the Human Anatomy and Physiology Society (HAPS) and often indicate membership in HAPS during their interviews. Through the program, CAPER participants attend two semester-long courses on pedagogy and educational research methods and design and implement classroom research projects to evaluate the impacts of EBIPs on student success and classroom engagement. The program’s overarching goal is to expose CC A&P instructors to EBIPs and encourage the adoption of one or more of the EBIPs in their classrooms. The program integrates the EBIPs into the participants’ coursework and provides them with didactic sessions on the history and structure of the EBIPs. CC A&P instructors also evaluate the effectiveness of their EBIPs, fostering a culture of educational research.

**CIS and CAPER encourage using EBIPs in the Classroom to teach Anatomy and Physiology**

Additionally, both programs provide instructor support for understanding the history and usefulness of various EBIPs and comradery to troubleshoot their implementation. The two programs differ in three main ways:

1. **High school students use CIS, while community college instructors who teach learners from various age groups use CAPER.**

2. **Unlike CIS, CAPER includes educational research as a component.**

3. **CAPER has a relatively short-term CoP, a five-year NSF-funded program, while CIS does not rely on external funding.**

This study highlights the importance of a CoP for community college faculty using a long-term CoP for high school anatomy and physiology (A&P) educators (CIS) as its model.
It also highlights the factors that attract high school A&P teachers to CIS and the possibility of creating a similar CoP for community college (CC) A&P instructors focused on educational research. Long-term communities of practice for STEM at the community college level need to be better documented and can provide a wealth of knowledge sharing and community for those faculty.

**Methods**

This comparative study draws together interview data from two projects approved by the University of Minnesota Institutional Review Board: STUDY00012877 and STUDY00011020. All participants willingly agreed to participate after receiving sufficient information about the study’s purpose, procedures, potential risks, benefits, and other relevant details, giving informed consent.

**Participants and Sampling**

The data for this study includes qualitative interviews with two groups of A&P instructors, those from CIS and CAPER. We used a random number generator to randomly select seven CIS instructors from the group of approximately twenty-five educators. We interviewed all twelve participants in the CAPER study and documented their anonymized names in Table 1.

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nina</td>
<td>CIS</td>
</tr>
<tr>
<td>Jason</td>
<td>CIS</td>
</tr>
<tr>
<td>Lowery</td>
<td>CIS</td>
</tr>
<tr>
<td>Sandy</td>
<td>CIS</td>
</tr>
<tr>
<td>Marj</td>
<td>CIS</td>
</tr>
<tr>
<td>Allie</td>
<td>CIS</td>
</tr>
<tr>
<td>Jeremy</td>
<td>CIS</td>
</tr>
<tr>
<td>Tom Smith</td>
<td>CAPER</td>
</tr>
<tr>
<td>Kim</td>
<td>CAPER</td>
</tr>
<tr>
<td>Esry</td>
<td>CAPER</td>
</tr>
<tr>
<td>DJ Nemzer</td>
<td>CAPER</td>
</tr>
<tr>
<td>Borealis</td>
<td>CAPER</td>
</tr>
<tr>
<td>Yara</td>
<td>CAPER</td>
</tr>
<tr>
<td>Bulldog</td>
<td>CAPER</td>
</tr>
<tr>
<td>Wheeler</td>
<td>CAPER</td>
</tr>
<tr>
<td>Charles Darwin</td>
<td>CAPER</td>
</tr>
<tr>
<td>Heather</td>
<td>CAPER</td>
</tr>
<tr>
<td>Monica</td>
<td>CAPER</td>
</tr>
<tr>
<td>Professor Humerus</td>
<td>CAPER</td>
</tr>
</tbody>
</table>

**Data Collection**

In June 2021, we interviewed seven CIS instructors via Zoom for one hour each, and in September 2021, we conducted one-hour Zoom interviews with the twelve CAPER instructors (Figure 1). We recorded and transcribed all interviews using Otter.ai (https://otter.ai/).

CIS and CAPER instructors use significantly different interview protocols due to differences in their research questions. The CIS interviews aimed to answer whether educators can use guided inquiry and small group learning in the classroom effectively with the help of a long-term professional development program. Therefore, in addition to questions from Luft and Roehrig’s (2007) Teacher Beliefs Interview, the CIS interview protocol included specific questions about aspects of CIS and instructors’ experiences in the program. The CAPER interview protocol had a broader focus on teacher beliefs (Luft & Roehrig, 2007), self-efficacy (Manduca et al., 2017), and pedagogical discontentment (Southerland et al., 2011). Both interview protocols are included in Appendices 1 and 2.

**Figure 1. Data collection and analysis.**
Data Analysis

One of the authors (ARH) conducted qualitative open coding to identify initial themes across several interviews (Miles et al., 2014). Then, she conducted selective coding to analyze the data against the initial themes and refine these themes to better represent the data (Corbin & Strauss, 1990; Miles et al., 2014). At that point, ARH read literature on communities of practice to identify how the findings might blend with or diverge from the CoP literature. Finally, she did a separate round of open coding using Excel without reviewing previous codes to verify the themes and findings against her original coding. The codebook (Appendix 3) further explains the final themes and include isolation driving instructors towards communities of practice, collegiality within institutions leading to less active membership in communities of practice, the impacts of communities of practice on teaching, collaboration, and knowledge sharing in CoPs, and positive and negative aspects of solid leadership in CoPs. To add another layer of trustworthiness, the researchers asked MD and participants from CIS and CAPER to read and edit the article as a form of member checking (Guba, 1981; Schwandt et al., 2007).

Trustworthiness

Guba (1981) and Schwandt, Lincoln, and Guba (2007) set out four overarching criteria for trustworthiness in qualitative work: credibility, transferability, dependability, and confirmability. Credibility can be established in several ways, including research using multiple data collection forms, having multiple people code the data, member checking, and including negative cases in the study (Guba, 1981; Schwandt et al., 2007). While only one researcher coded the data for this study, ARH attempted to increase the credibility of her findings by re-coding the data four months after the initial coding process to verify her findings. She included counterexamples of her findings to show the degree to which the data represents all participants. In addition, she had the MD and study participants review the article and mark any areas in which the researcher’s interpretation diverged from the participants’ experiences as a form of member checking before finalizing the manuscript.

To fulfill the requirements of transferability, the researcher has provided detailed descriptions of CIS and CAPER to provide readers with a clear idea of whether or not the findings of this study may transfer to CoPs that they are involved with (Guba, 1981; Schwandt et al., 2007). She has also clearly described the interview and analysis methods used to collect the data, providing the readers with the resources necessary to conduct a similar study to confirm the findings (Guba, 1981; Schwandt et al., 2007). Regarding dependability, she had the opportunity to conduct interviews with CIS and CAPER participants and identify how their experiences are similar or different.

Results

This section describes the findings of this study by theme, divided into CIS and CAPER sections, with a comparison of the two at the end of each theme. The themes include isolation driving instructors towards communities of practice, collegiality within institutions leading to less active membership in communities of practice, the impacts of communities of practice on teaching, collaboration, and knowledge sharing in CoPs, and positive and negative aspects of solid leadership in CoPs.

Isolation Leads Instructors to Find Communities of Practice Outside of Institutions

CIS and CAPER instructors have unique difficulties finding space for professional development and growth as educators within their institutions. CIS instructors are distinct from other A&P instructors in that they are licensed high school educators who may or may not have advanced degrees. They are teaching in high schools where they may be the only educators teaching A&P. Generally speaking, CAPER instructors work in community college settings where time, institutional support, and funding often limit their opportunities for professional development and educational research (Andrews & Lemons, 2015; Edwards et al., 2015). While they may have colleagues also teaching A&P, they may not support integrating educational research or active learning into their teaching practice (Andrews & Lemons, 2015; Edwards et al., 2015).

CIS Instructors are the Only Teachers of Anatomy and Physiology at Secondary Schools

As discussed previously, CIS instructors are teaching college-level courses in high school. They are often the only A&P instructors at the school and cope with the demands of the CIS program and struggles specific to teaching A&P in isolation. Therefore, CIS A&P instructors often turn to each other for support. As Nina described:

“So one of the things I will just say is working with 30 other high school teachers… During the school year, if I am thinking I’m gonna start this new unit, I can just jump on and send an email to everybody in our group and say, “I want to start teaching this topic. Does anybody have any suggestions?” Alternatively, “I cannot find this POGIL we all wrote four years ago on vaccinations. Does anybody have it?” And, you know, within half an hour, three people have written back, “Here is the link, here it is.” It is wonderful to have that collegiality. Four people are in my science department…but only one other teaches life science. So I just don’t have a lot of other people as resources. College in the schools has given me a huge pool of like-minded educators.”

continued on next page
Nina and several other CIS instructors discussed how they interact throughout the school year and draw on each other’s experiences and materials to address classroom issues or develop lesson plans.

The Human Anatomy and Physiology Society (HAPS) Provides a Sense of Community for CAPER Instructors who Aspire to Improve as Educators and Feel Isolated

Several researchers found that STEM instructors who hope to grow as educators and researchers in CC environments are often limited by their work environments (Andrews & Lemons, 2015; Edwards et al., 2015). While this is not true for all instructors participating in CAPER, two instructors precisely pinpointed how they felt limited by their colleagues and turned to HAPS as a CoP. Charles Darwin described his experiences with his department.

“You know, the administration is very supportive. I’ve got administrative support. I get pushback from colleagues. I think they are the biggest downers… They get threatened by people who are showing success and trying to do things differently because they feel it directly makes them look bad as an instructor. So they don’t want you to do it. Because it makes them look bad. So I think fighting back on that, and just being like, ‘Listen, you’ve got your classroom. Do what you do in your room and run your course the way that you’re going to run it and respect my ability to do the same thing. I won’t pass judgment on you, don’t pass judgment on me. And we’ll see what happens.’ If there was a hurdle, I would say that’s the hurdle.”

He described his membership in HAPS as a group of like-minded individuals who are not threatened by pursuing opportunities for growth as educators.

“HAPS has really been my support system for going in and looking at how can we engage students differently. Where else can you get into a conversation with Mark Nielsen and some of the other textbook authors on current teaching trends, that directly affect how they’re gonna write their textbooks? I think there’s such power in looking at what other people are doing and knowing that you’re not alone and you’ve got a network of professionals teaching the same thing, that you are having the same struggles, and then being able to sit down and say, “Okay, what are we going to do about it?” and not be threatened by the new ideas?”

Wheeler similarly described HAPS as her professional community that makes up for a lack of collaboration in her local space.

“Yeah, HAPS is definitely my professional community. And I feel a connection to those humans that is far beyond colleagues. I definitely… we talk about it all the time in HAPS. We talk about each other like family, and it feels that way. I feel like I have mentors all over the country, all over the world, because of my relationship with HAPS. And I give a lot to the organization. And I know that that’s a big part of why I feel as connected as I do. But I also feel like I... you know, most people who we connect in are... just feel that same like, “Wow, this is a really supportive, amazing group.” My local colleagues are more conservative and traditional. They have learned to not try to tell me I can’t do something. Nobody tells me, “Oh, you shouldn’t do that.” But they definitely go “Dude, what are you doing now?” There’s not an “Oh, I am interested in that. Let’s brainstorm. Let’s work together.” You know, there isn’t that kind of collaboration in my local space. But yeah, the HAPS scene is just pure golden.”

Wheeler and Charles Darwin have found the supportive learning environment they need through HAPS. 

CIS and CAPER Instructors and Isolation

While the causes of the isolation experienced by CIS and CAPER instructors differ, they seem to find solidarity in similar remote CoPs. The CIS instructors, as the only A&P instructors in their schools, have created a network of peer learning and sharing among themselves to share information, lesson plans, and materials through email. CAPER instructors experiencing isolation within their institutions due to a lack of support in their pursuits of active learning and educational research engage with the HAPS community online and through in-person conferences.
**CAPER Instructors Who Experience Collegiality within Educational Institutions may be Less Connected to External CoPs**

Several CAPER instructors described collegial teaching and learning environments within their institutions. For instance, Bulldog described how his previous role as a college professional development fellow encouraged the development of an institutional CoP.

“I was actually a professional development fellow at my college for a while. I had all the faculty getting together during brown lunches where we had everyone from chemistry, physics, biology, and health sciences in the same room sharing. So we had this little community of scholars, we’re learning about the limitations of each other’s disciplines, and how we could kind of look at how we teach that particular part, like A&P, when you get into partial pressures, that’s math. And students immediately shut down, and the math help us a lot with little signals on how they would teach that type of stuff. So I miss my own colleagues in a way when we were getting together. And now we’ve kind of lost that component because we can’t fund that [professional development fellow] position anymore. So mostly, it’s just interacting with my peers.”

When describing his membership in HAPS, Bulldog defined himself as a “lurker type” who used to be more active but has begun to engage more with high school resources and educators since they “structure stuff much better than college people do.”

Yara also described finding her colleagues within the college and school to be particularly helpful for her growth as an A&P instructor.

“**My colleagues. We have amazing people in our department and within our college and school, and I’ve been so lucky from day one that they just kind of took me under their wing. As an adjunct, it was very isolating. It was extremely isolating. I had no idea what I was doing. But my colleagues here have been beyond supportive... Just this stuff that takes so much time that you don’t even have time to prepare your course or think about pedagogy. These people have supported and allowed me to grow so much as an instructor. So that’s a huge resource. “Hey, I have this student who behaved this way.” Snap a picture of an email from a student, “Hey, what do I do here?” We have a group text message just for biology. We have a group text message with faculty from different departments. So much support from colleagues is a huge one.”**

Similarly to Bulldog, Yara talked about communication networks within the department and also between different departments. She mentioned that she has yet to find a CoP outside her institution.

As a counterpoint, Borealis tended to turn to colleagues when he has questions about teaching or runs into issues with students.

“**Generally, colleagues that have been here before, done this before, colleagues that do this better than I do it. I think we all have our strengths and weaknesses, too.”**

In addition to turning to colleagues to address questions, Borealis is an active member of HAPS and finds motivation to keep trying new things by attending HAPS conferences.

“**The people in HAPS, I think, are the special sauce for it. It’s has benefited from amazing leadership for a very long time, and people who want to really advance HAPS...When I come back from HAPS, I’m like ‘This is great. I have all these ideas.’ So it’s really a very useful thing.”**

Borealis’ experiences working with his colleagues and participating actively in HAPS illustrate that some people like Bulldog and Yara find their colleagues supportive and do not need to look beyond their institutions. Other people engage with their colleagues and CoPs simultaneously. The varying levels of participation in HAPS described by Bulldog and Borealis also indicate that HAPS has a flexible membership model welcoming different types of participants (Gehrke & Kezar, 2018; Kezar et al., 2017; Kezar & Gehrke, 2017).

**CAPER and CIS Instructors and Collegiality Within the Institution**

While CAPER participants discussed their relationships with other instructors in their departments, colleges, and institutions more broadly, CIS instructors focused much more on their relationships with each other in their interviews. CIS instructors shared process-oriented guided inquiry learning (POGIL) activities and cooperative quizzes within their science departments but needed to discuss interactions with other teachers. This general lack of discussion about other teachers may be related to their relative isolation as A&P instructors or may be due to the nature of the interview questions asked of CIS instructors, as most of these teachers work closely with other teachers in the school, just not around the topic of A&P.

**Professional Development from CoPs Revitalizes Teaching for A&P and Other Subjects.**

Instructors in both CIS and CAPER described how CoPs revitalize their teaching through professional development and knowledge-sharing among members. While CIS members tended to discuss CIS and POGIL, CAPER instructors are often members of more than one CoP, with all CAPER instructors including HAPS and other pedagogy-focused organizations.

---

*continued on next page*
CIS, Revitalization of Teaching, and Collaboration.

Several instructors in CIS described how professional development opportunities helped them improve their teaching. Jason, for example, explained how CIS offers professional development related to pedagogy and content.

“With CIS... it revitalized my teaching. I’ve been teaching for almost 20 years. And I needed a challenge. I needed something new, and CIS did exactly that. Also, with the CIS program, with staff development, the professional development is some of the best we’ve had - everything from when we had the people from POGIL come in and we met... to having speakers like we had today. It’s like, ‘Wow, this is so cool. How can I bring this information back to my students?’” Because as teachers, oftentimes we don’t get the science PD portion of it. We get methods, we get the assessment, and we get technology when we don’t necessarily get the content PD. So getting that content PD plus still getting the methods of using inquiry, again, has really revitalized my teaching. I think it’s made me a better teacher. I think my students have benefited from it. I think I challenge my students a lot more than I probably did in the early years of my career.”

We questioned all CIS instructors during the interviews, and just like Jason, we recorded and analyzed their responses. We discussed the impacts of learning POGIL and developing POGIL materials within the CIS program to varying extents. This development of prepared and shared materials ties directly in with the processes necessary to create long-term communities of practice (Bernstein-Sierra & Kezar, 2017).

Most CIS interviewees described collegiality and knowledge-sharing among members of the CoP and Lowery discussed how the leader of the CIS A&P program (co-author MJ) encourages CIS members to discuss everything from the highs and lows of teaching to specific methods.

“But it’s truly... it’s kind of like a family, you know, you have a bad day, you know, you had a bad school year. And everyone’s like, ‘It’s okay, we did too’, or you know, these are highs, these are lows, and you can feel like you can tell them everything. Like, ‘I do not know how to do this.’ And everyone’s like, ‘Here, I’ve got this lab, I’ve got this activity.’ And it’s so cool. I love that. And Murray encourages us to do that. He encourages us to share things with people and get together and do things. You know what I mean? Today, we just shared a folder, because I had a really cool lab that someone wanted and she had an idea for something for me. And so we just shared it. And I love that opportunity that we can do that.”

CIS participants have developed spaces for sharing and collaborating during professional development days and through the networks that instructors have created amongst themselves, yet another indicator of a sustainable community of practice (Gehrke & Kezar, 2018; Kezar et al., 2017; Kezar & Gehrke, 2017).

CAPER, CoPs, and Knowledge Sharing.

Eight out of twelve (which we define as most) participants in CAPER are members of more than one organization focused on STEM education or pedagogy more generally, with all of them being members of HAPS. DJ Nemzer, an active member of several CoPs, described how these organizations have led her to a network of colleagues across the US.

“I have colleagues all over the United States that I feel like, give me more inspiration and give me more ideas and more opportunities than you’re going to get from just directly in your own department or your own surroundings.”

Cross-pollinating with instructors around the US opened DJ Nemzer’s eyes to more possibilities than what she can find in her institution alone. Esry described her experiences as a peer reviewer for Quality Matters, where she contributes to and learns from other instructors’ online course designs.

“Especially in an online setting, one of the big influences, I think is Quality Matters. And I’ve had one of my courses actually go through that process, and to kind of look at the different standards. And plus, I’ve been a peer reviewer, and I still am the peer reviewer, for Quality Matters. So I’ve actually gotten a chance to look at other people’s courses. And so because of that, I could see ideas that other online instructors have used. And sometimes I’ve stolen a few of those ideas and adapted them.”

While Esry focused on online learning and pedagogy, Kim interacted with a STEM education professional development community similar to CAPER.

“I have been interacting with EDU-STEM. It’s a science education collaborative network with the University of Minnesota. So for the last couple of years, [I’ve] kind of been interacting with them. We’ve been working on a couple of papers, and just kind of intermingling and discussing amongst science faculty ways in which we can improve student learning, diversify our teaching styles, and then also be able to deal with students, or I guess, assist student grit, or their ability to persist through these science courses.”

Kim has found a CoP of science faculty who are sharing ideas for how to support students as they take challenging science courses such as A&P. While some participants are involved

continued on next page
What makes Communities of Practice Persist? Lessons from Anatomy and Physiology Instructors Communities of Practice

with several organizations or find support and development opportunities within their institutions, several participants are deeply involved with HAPS as both a source of professional development and knowledge-sharing. Heather, for instance, described HAPS as a safe space to continue learning and asking questions, no matter how long a person has been teaching A&P.

“I think HAPS is the main one. I see in that community a bunch of people who are lifelong learners and educators who continue to want to learn, and I think that’s really encouraging. They’re always asking each other questions. I love that on the message boards... there’s a range of questions that I’m like, ‘Whoa, I hadn’t even thought of that.’ And ‘Oh my gosh, I knew that 10 years ago.’ And so it just feels like a really comfortable place to sort of open yourself up and not be afraid to ask us questions. And then, even textbook authors are on there asking questions. That’s super encouraging to feel like it’s okay to be like, “Hey, I don’t understand this thing.” I think that has been really beneficial.”

Tom Smith has been deeply involved with HAPS, serving on multiple committees. He also indicated that he finds the online networking aspect of HAPS informs his teaching practice.

“I spend a lot of time on social media with them. And so... we get to know each other and our different teaching strategies. And so that’s been really helpful in terms of perspective on inclusion in the classroom, as well as just overall teaching strategy.”

As discussed throughout this paper, CAPER participants have found supportive CoPs in several spaces that allow them to focus on specific teaching and professional development aspects. These CoPs often provide professional development opportunities and spaces for sharing and collaboration among members (Gehrke & Kezar, 2018; Kezar et al., 2017; Kezar & Gehrke, 2017).

CIS and CAPER on Professional Development and Knowledge Sharing.

While CIS members rely predominantly on CIS as their CoP, most CAPER participants are often active in two or more CoPs, focusing on different types of STEM education, online education, or pedagogy. These educators find professional development opportunities and networks of like-minded educators who share tips and discuss ideas outside the formal CoP spaces.

Leadership in CoPs

Focusing on CIS as a CoP allows us to look more closely at the nature of leadership in STEM education CoPs. As with many CoPs in the STEM education space, the CIS A&P program benefits from a strong and charismatic leader, Murray Jensen, who has been a part of the CIS A&P program since the beginning. Several participants highlighted the freedom that Murray allows them in their classes, emphasizing that they can teach any A&P content as long as they integrate cooperative quizzes and inquiry into their courses. Sandy explained several aspects of how Murray leads CIS A&P.

“Well, I like I mean, Murray’s amazing since day one, once you’re in the program. He makes you work to get into the program, or at least he made me work to get into it. I feel like he loves being a teacher and teaching high school. You can tell he values high schoolers, which is kind of cool. So he values education and has your back and he gives you all the support you need. And I love that he gives you the freedom to go deep on certain subjects if you’re really into something, and as long as you’re doing the few things that he wants to make sure you have done, which I think align with what I talked about at the beginning with critical thinking study skills, Co-Ops, working in teams, as long as you’re hitting that stuff, preparing kids for the world, the actual content that you teach isn’t as huge, which I think is really refreshing. So I really like that aspect.”

CIS instructors like Sandy appreciated Murray’s structured pedagogical requirements and the freedom in terms of content. They also recognized Murray’s love of teaching and respect for high school students as essential to his leadership.

However, some CIS instructors also found him “a bit random” as they switched between projects without necessarily completing them. For instructors, this occasionally made them feel that the professional development could be more cohesive when they wished to continue with projects they liked for a longer time.

continued on next page
As the CIS A&P CoP develops, some instructors felt they could organize and share more. Nina explained that community members can step up at this point and take more leadership roles within the CoP.

“I realize we’ve had COVID and but even before that, I feel like our time could be better utilized with the people in this group. There are 30 people, there’s one Murray. I don’t think Murray has to do everything. But that maybe with the 30 of us, we can bring things now to the party and share. This is something that I have done, and it’s worked really well. It’s worked really well and just a lot more sharing of ideas from the 30 of us who work together... We should probably revisit all the good things that we have and that many of us use and kind of bring that to the forefront. Because even Murray told us yesterday, ‘Hey, you’re my kids, but you’re kind of grown-up now. And I got some other things going on. So you know, take it away.’... There are so many people here who are great teachers and just to have a forum where we could share some of the time-tested and high-quality educational materials, labs, models, and investigations that we’ve really polished in our teaching...with our colleagues so that everybody can gain from that. That’d be my one thing. Let’s take a look at our format for professional development and revisit that.”

Nina clearly stated that it is time for CIS A&P to look at the current leadership structure and format of professional development and knowledge sharing and adjust it to fit members’ needs. Taking on leadership positions and adjusting professional development days can increase the longevity of CIS A&P (Bernstein-Sierra & Kezar, 2017; Gehrke & Kezar, 2018; Kezar et al., 2017; Kezar & Gehrke, 2017).

Discussion

While most CAPER participants are members of more than one CoP, none of these groups focus on A&P educational research, and CIS participants did not indicate involvement with other CoPs. The theoretical framework supports this as the CIS teachers are K-12 educators engaged in an apprenticeship/mentor CoP throughout their professional training (Lave & Wenger, 1991; Wenger, 1998). In contrast, the CAPER participants, as higher educators, typically receive little pedagogical training and, therefore, need to seek those CoPs in other areas (Edwards et al., 2015; Flynn et al., 2017; Parker et al., 2016). Recognizing existing long-term CoPs, such as CIS and HAPS, and their impact on educators, can inform how short-term BER projects, such as CAPER, can become long-term communities of practice. CIS and CAPER participants emphasized the importance of physical or online conferences and continued engagement through listservs within their CoPs (Kezar et al., 2017). Therefore, the CAPER research team should consider creating and maintaining a listserv and, potentially, a blog-style website and webinar space to support the continued sharing of information about A&P educational research. A vibrant listserv already exists for the CIS community, although a blog-style website and webinar space could be practical additions to continue the CoP for CIS.

Reflecting on the current shifts in CIS instructors’ perspectives toward the balance of power within the CoP as it matures, both CIS and the CAPER research team should think carefully about how to structure leadership within the long-term CoP. Assuming that the CAPER CoP will not find a consistent funding source, the CAPER research team and CC instructors may want to select volunteers to maintain the listserv and website, organize occasional webinars, and make blog posts (Kezar et al., 2017). Within CIS, those conversations have begun to examine the current leadership structure to make improvements. Given that the CAPER research team has provided the initial digital infrastructure for educational anatomy and physiology (A&P) research to begin, it will likely naturally form a community of practice (CoP) similar to the structure for CIS.

Seeing as CAPER recruited most participating instructors through HAPS, it is likely that creating an education research branch and listserv within HAPS would overcome funding and infrastructural barriers to the development of a long-term CoP. By integrating with HAPS, A&P educators interested in educational research could join HAPS conferences to reinforce their community and reinvigorate online engagement throughout the year.

In terms of faculty mentoring, both CIS and CAPER could potentially benefit from the faculty mentoring described to be used by Project Kaleidoscope (a STEM CoP centered on educational reform), which provides a framework for mentoring, including building relationships and establishing formal mentor relationships (Kezar et al., 2017; American Association of Colleges and Universities, 2023). There is a layer of this within the current CAPER project, with each participant having a formal mentor during the project time that could become a longer-term mentor relationship. The CAPER program also utilizes former participants as mentors, providing more opportunities for building relationships as mentors. Within CIS, as the discussions regarding leadership structure continue, formal mentoring should be considered a leadership opportunity for some longer-standing members.

continued on next page
Conclusion

This study of two unique STEM education spaces - one for high school A&P instructors teaching a college-level course and one for CC A&P instructors engaging in educational research - reveals that long-term CoPs like CIS and HAPS share many of the characteristics described by Gehrke, Kezar, and Bernstein-Sierra in their studies from 2017 through 2018. While their isolation forms differ, members of CIS and CAPER find CoPs outside of their institutions to get the support they need to continue growing as educators (Kezar et al., 2017). CIS and the CoPs that CAPER participants are involved with provide them with professional development opportunities and informal networks of peer teaching and mentorship (Kezar et al., 2017). Several CAPER participants described their progression through different committees in HAPS and other leadership roles in pedagogy-focused CoPs (Gehrke & Kezar, 2018; Kezar et al., 2017; Kezar & Gehrke, 2017). CIS has thrived under a strong leader and is on the brink of evolving, with some participants hoping for leadership opportunities and shifts in the organization of professional development programming (Gehrke & Kezar, 2018; Kezar et al., 2017; Kezar & Gehrke, 2017).

Acknowledgments

The work with the CAPER program was funded by the National Science Foundation (Award #2111119) Improving Undergraduate STEM Education: Education and Human Resources.

About the Authors

Audrey Rose Hyson, PhD, currently works as a Research Project Manager for Hennepin Healthcare Research Institute, where she manages studies on opioid use disorder and type 2 diabetes among people who have experiences with incarceration or housing insecurity. She was previously a graduate research assistant and then a postdoctoral fellow in the College of Biological Sciences at the University of Minnesota. She has worked on multiple iterations of the Community College Anatomy and Physiology Education Research (CAPER) project. Chasity O’Malley, PhD is an Associate Professor of Medical Education and Physiology at the Boonshoft School of Medicine at Wright State University. Her research aims to improve student’s learning experience by helping them learn to study and interact with the material in meaningful ways and for faculty by helping guide them on implementing active learning in their classrooms. She is a co-principal investigator for an NSF grant related to this work (CAPER). She is also actively promoting diversity through her funded research projects centered around enhancing training for medical students related to the LGBTQ population. Kamie K. Stack is a PhD candidate in Curriculum and Instruction STEM education at the University of Minnesota - Twin Cities. She has a Master of Education in Curriculum and Teaching and a Master of Arts in Curriculum and Teaching: Secondary Mathematics from Columbia Teachers College. She is currently the graduate research assistant on the CAPER grant. Megan C. Deutschman has a Ph.D. in Organizational Leadership, Policy & Development from the University of Minnesota. She has a 15-year career in education, and her research focuses on race and identity in the classroom. Megan is currently working as a Senior Study Director at Westat. Megan Bernier is a third-year Chancellor’s Scholar studying neuroscience at Bishop’s University. She worked as an intern in The Fernandes Lab: Laboratory of Neural Plasticity and Repair, where she examined the effect of exercise on hippocampal neurogenesis in mice within the context of aging and degenerative diseases. Her research interests include applied psychological research, including art and nature therapy projects. Murray Jensen’s research focuses on implementing Process Oriented Guided Inquiry Learning (POGIL) within entry-level anatomy and physiology courses. Jensen also works on developing continuing education opportunities for educators who wish to promote inquiry and cooperative group learning within their classrooms. He is the principal investigator for the NSF-funded CAPER project.

Literature Cited


What makes Communities of Practice Persist? Lessons from Anatomy and Physiology Instructors Communities of Practice


Appendix 1: CIS Interview Questions

1. What degree and licensure do you hold?
2. How long have you been teaching?
3. How long have you been teaching in CIS?
4. How do you describe your role as a teacher?
5. How do your students learn science best?
6. How do you know when learning is occurring in your classroom?
7. What does a typical day in your classroom look like?
8. What do you feel is the most effective way to teach students a new concept?
9. Please describe your experience in CIS - what are some things you like and what could be improved?
10. What is the most valuable concept/idea that you've learned in CIS?
11. What is something you learned in CIS that didn't work for you?
Appendix 2: CAPER Interview Questions

Hello, thank you for taking the time to talk with me today. I’m going to ask you a few questions about your teaching practices, experiences, and beliefs. This interview should take no more than an hour of your time. We will be using a pseudonym when we write about you in articles. What would you like your pseudonym to be? You can always change it later.

Great! Do you have any questions before we begin?

1. How long have you been teaching?
2. In what teaching context have you been most satisfied?
3. Can you talk about some of your past A&P experiences?
4. What have been some of the most important influences to your teaching up to this point?
5. How do you describe your role as a teacher?
6. How do you maximize student learning in your classroom?
7. How do you recognize when something is effective in your classroom? What do you look for?
   a. What about when something is ineffective?
   b. How do you react to signals of effectiveness or ineffectiveness?
8. How do your students learn A&P topics best?
9. How do you decide what to teach and what not to teach in your A&P classes?
10. When do you decide to move on to a new topic in your A&P classes?
11. What are some of your personal goals for your teaching?
12. In what ways are your teaching goals beneficial to your current students?
13. Please describe any gaps between your teaching goals and what you are currently able to achieve in your classroom?
14. Describe any internal and external constraints that are preventing you from achieving your teaching goals.
15. Where do you turn to for new information or solutions to teaching situations that come up?
16. Are there any aspects of your teaching that you are not satisfied with at this time?
17. What professional communities do you most closely belong to? In what ways do they affect your teaching and/or research practice?
### Appendix 3: Codebook

<table>
<thead>
<tr>
<th>Theme</th>
<th>Explanation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation leading to the necessity of communities of practice</td>
<td>Participants discuss how they find support in communities of practice as a response to isolation in their own institutions.</td>
<td>“There are four people in my science department…but only one other person teaches life science. So I just don’t have a lot of other people as resources. College in the schools has given me a huge pool of like-minded educators in that way.” - Nina</td>
</tr>
<tr>
<td>Colleagiality within institutions as counter example</td>
<td>CAPER participants highlight how they approach their colleagues for support. Some of these participants also mention that they are not active members of any CoPs outside of their institutions.</td>
<td>“My colleagues. We do have amazing people in our department, and within our college and school, and I’ve been so lucky from day one that they just kind of took me under their wing. As an adjunct, it was very isolating. It was extremely isolating. I had no idea what I was doing…But my colleagues here have been beyond supportive…Just this stuff that takes so much time that you don’t even have time to prepare your course or think about pedagogy. These people have supported, allowed me to grow so much as an instructor. So that’s a huge resource. “Hey, I have this student that behaved this way.” Snap a picture of an email from a student, “Hey, what do I do here?” We have a group text message just for biology. We have a group text message with faculty from different departments. So much support from colleagues is a huge one.” - Yara</td>
</tr>
<tr>
<td>Professional development within communities of practice revitalizing teaching</td>
<td>Both CIS and CAPER instructors discussed the professional learning opportunities and knowledge sharing within their CoPs as giving them more ideas and revitalizing their teaching.</td>
<td>“With CIS… It revitalized my teaching. I’ve been teaching almost 20 years. And I needed a challenge. I needed something new and CIS did exactly that.” - Jason</td>
</tr>
<tr>
<td>Leadership in communities of practice</td>
<td>Participants in CIS often mentioned Murray Jensen, their leader, and the positive and negative aspects of his leadership.</td>
<td>“Well, I like I mean, Murray’s amazing since day one, once you’re in the program. He makes you work to get into the program, or at least he made me work to get into it. I feel like he loves being a teacher and teaching high school. You can tell he values high schoolers, which is kind of cool. So he values the education and has your back and he gives you all the support you need. And I love that he gives you the freedom to you go deep on certain subjects if you’re really into something, and as long as you’re doing the few things that he wants to make sure you have done, which I think align with what I talked about at the beginning with critical thinking study skills, Co-Ops, working in teams, as long as you’re hitting that stuff, preparing kids for the world, the actual content that you teach isn’t as huge, which I think is really refreshing. So I really like that aspect.” - Sandy</td>
</tr>
</tbody>
</table>
How Delivery Method Impacts Student Perceptions of Anxiety and Learning with Combined Muddiest Point and Peer Instruction Activities in Community College Anatomy & Physiology Classes: Lessons for Faculty, Higher Education Academic Leaders, and Educational Technology Leaders

Anthony C. Edwards, PhD¹, Suzanne Hood, PhD², Murray Jensen, PhD³, Ron Gerrits, PhD⁴, Melaney Farr, MS⁵, Chasity O’Malley, PhD⁶

¹Tarleton State University, Stephenville, TX, USA
²Bishop’s University, Sherbrooke, QC, Canada
³University of Minnesota, Minneapolis, MN, USA
⁴Milwaukee School of Engineering, Milwaukee, WI, USA
⁵Salt Lake Community College, Salt Lake City, UT, USA
⁶Wright State University, Dayton, OH, USA
Corresponding author: aedwards@tarleton.edu

Abstract
Muddiest point and peer instruction are evidence-based instructional practices that can be used to address student learning gaps. The purpose of this study was to determine the impact of modality (face to face or online) on student perceptions of the effectiveness of combined muddiest point and peer instruction activities in community college anatomy and physiology courses. Data was collected through end of course surveys and included quantitative and qualitative results. While there was no significant difference in student perception of anxiety or contribution to learning among face-to-face and online students, anxiety levels were low and contribution to learning was high for both groups. Both groups generally provided positive qualitative responses, but online students were more likely to provide positive feedback on muddiest point and peer instruction activities than face-to-face students. Negative responses tended to focus on wanting to work alone and dissatisfaction with classmates’ contributions. This study was supported as part of the Community College Anatomy and Physiology Education Research (CAPER) project (2111119). https://doi.org/10.21692/haps.2023.023

Key words: muddiest point, peer instruction, online learning, community college, evidence-based instructional practice

Introduction
Faculty use evidence-based instructional practices like muddiest point activities to better understand where students struggle in subjects like anatomy and physiology (Hyson et al, 2021). Mackos and Tornwall (2021) found that muddiest point activities helped faculty members identify topics needing clarification in large-enrollment graduate pathophysiology courses for nursing students. Students submitted topics they didn’t understand (muddiest points) and then instructors used these to provide instruction on the most difficult-to-understand topics. The muddiest points were examined by faculty inside the learning management system. Mackos and Tornwall (2021) found that examination scores where higher when the technique was used compared to scores in the year before the technique was implemented. Most students in that study indicated that identifying muddiest points and receiving targeted instruction increased their understanding of pathophysiology content.

Cooperative learning, also known as peer instruction, is another practice that has been associated with positive student achievement (Johnson & Johnson, 2009). In this technique, students learned from one another through interactive activities where one student provided information to help other students learn. Crouch and Mazur (2001) found that cooperative learning increased student learning in physics classes. While Premo and colleagues
(2018) found no correlation between collaborative learning and student achievement, they did notice an increase in student engagement, which can be an important factor in improving retention and academic performance (Preszler, 2017).

Engagement in classes can assist students with a sense of belonging, course retention, and persistence in their respective degree program regardless of course delivery method. In their synthesis of the literature, McCutcheon and colleagues (2015) found no difference in learning among nursing students whether the learning environment was face-to-face or online. England et al. (2019) found that students who perceived the course as difficult (an indicator of anxiety) tended to not perform as well as students who didn’t find the course as difficult. Sarkar et al. (2021) found that 83% of medical school students found online muddiest point activities effective. The goal of this project was to address a gap in the literature by determining if student perceptions of combined muddiest point and peer instruction activities in a community college-level anatomy and physiology course varied by delivery method and course length. This study aimed to address the following research questions:

1. Are students’ self-assessment of anxiety impacted differently when muddiest point and peer instruction activities are utilized in face-to-face vs. online anatomy and physiology courses?
2. Is student perception of the learning value of using both muddiest point and peer instruction impacted by delivery method (either face-to-face or online) in anatomy and physiology courses?

Methods

Student Population

The study group consisted of students taking anatomy and physiology at a rural community college in Texas during the fall 2022 semester. Courses were taught in either a face-to-face or an asynchronous online format. Each format was either offered in a 16-week or 8-week duration. This study (IRB #1899183-1) was granted exemption from full review by the Tarleton State University Institutional Review Board along with approval from Panola College to survey students, and informed consent was obtained from all participants.

Procedure

Each week, students were assigned a muddiest point activity that was completed in an online discussion post within the learning management system (including in the face-to-face courses) where students provided their own muddiest point. As part of the activity, students identified resources to help address their muddiest point, which were also shared with other students within the discussion board activity, thus providing a level of peer instruction. For the peer instruction/muddiest point activity, students completed online discussion posts where they provided the topic they understood least (muddiest point). Students also responded to at least two other students by providing resources that helped them better understand the concept that another student found difficult to understand.

Data Collection

Students were administered a survey at the beginning and at the end of the semester that included Likert scale questions related to perceived anxiety caused by the use of muddiest points and peer instruction activities as well as how helpful the combination of activities was to their learning. The full set of survey questions is available in the Appendix. Students were encouraged, but not required to complete the surveys. The survey also captured qualitative responses about topics including muddiest point and peer instruction activities.

Data Analysis:

Quantitative survey responses were analyzed through descriptive statistics and mixed-model analysis of variance (ANOVA). Free response questions were analyzed using content analysis (Cavanaugh, 1997). Qualitative analysis included identifying themes and coding the data by assigning responses to themes. The percentage of time that specific themes were mentioned was compared between face-to-face and online classes.

continued on next page
**Results**

A total of 134 (out of a possible 186) participants completed the full survey at the beginning of the courses. This included 72 students in traditional, in-person sections and 62 in online sections. There were only 34 participants who completed all aspects of the end-of-term survey. Student rating of anxiety caused by combined muddiest point and peer instruction activities did not differ between face-to-face vs online sections, and also didn’t change significantly over the course of the term.

Table 1 shows the mean anxiety ratings from students in response to the statement “How much anxiety do combined muddiest points and peer instruction cause you?” using a 5-point Likert-type scale (where 1 indicated no anxiety and 5 indicated extreme anxiety). Students in both the face-to-face and the online courses rated these combined activities as causing a low-to-moderate degree of anxiety. A mixed model ANOVA indicated that mean anxiety ratings did not differ significantly between course delivery conditions (face-to-face vs online), time of survey completion (start vs end of term), or an interaction of these variables.

Table 2 summarizes students’ mean ratings in response to the prompt: “How much did combined muddiest point and peer instruction activities contribute to your learning?”. Students responded to this question using a 5-point Likert-type scale on which 1 indicated very little and 5 indicated significantly. Overall, students rated these activities as contributing a moderate amount to their learning irrespective of course delivery mode or time of taking the survey. A mixed model ANOVA indicated no significant differences in mean ratings between course delivery conditions, time of survey completion, or an interaction of these variables.

<table>
<thead>
<tr>
<th></th>
<th>Start of Term</th>
<th>End of Term</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean Anxiety Rating</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Face-to-face</td>
<td>2.3 (± 1.1)</td>
<td>2.3 (± 1.4)</td>
</tr>
<tr>
<td>Online</td>
<td>2.7 (± 1.3)</td>
<td>2.3 (± 1.1)</td>
</tr>
</tbody>
</table>

*Table 1. Mean (+ standard deviation) ratings of anxiety caused by combined muddiest points and peer instruction.*

<table>
<thead>
<tr>
<th></th>
<th>Start of Term</th>
<th>End of Term</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean Learning Contribution Rating</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Face-to-face</td>
<td>3.1 (± 1.2)</td>
<td>2.7 (± 1.4)</td>
</tr>
<tr>
<td>Online</td>
<td>3.3 (± 1.2)</td>
<td>3.5 (± 1.3)</td>
</tr>
</tbody>
</table>

*Table 2. Mean (+ standard deviation) ratings of how much combined muddiest points and peer instruction contributed to students’ learning.*
Themes associated with “What do you like about muddiest point activities and working with peers?”

Forty-eight percent of online student comments (10/22) indicated that muddiest point activities helped them know that they weren’t alone compared to 20 percent of similar comments from face-to-face students (3/15). Thirty-three percent of online students indicated that muddiest point activities provided more understanding of course material compared to 10 percent of face-to-face students. Similar percentages of online students and face-to-face students indicated that muddiest point activities provided multiple perspectives and allowed them to learn from others. These results are provided in Table 3.

<table>
<thead>
<tr>
<th></th>
<th>Face-to-Face (n = 15)</th>
<th>Online (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowing I’m not alone</td>
<td>20%</td>
<td>48%</td>
</tr>
<tr>
<td>Fun</td>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>Multiple perspectives</td>
<td>30%</td>
<td>29%</td>
</tr>
<tr>
<td>More understanding</td>
<td>10%</td>
<td>33%</td>
</tr>
<tr>
<td>Help each other</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>Learn from others</td>
<td>40%</td>
<td>38%</td>
</tr>
<tr>
<td>Helpful</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>Not helpful</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>Don’t like group activities</td>
<td>0%</td>
<td>10%</td>
</tr>
<tr>
<td>Like to help others</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Table 3. What do you like about muddiest point activities and working with peers?*
Themes associated with “What do you not like about muddiest point activities and working with peers?”

Of comments made by face-to-face students addressing this question, twenty-two percent (3/14) indicated that muddiest point activities were not helpful compared to nine percent (1/13) of online student comments. Twenty-two percent of face-to-face students indicated that they didn’t like working with others on muddiest point activities compared to nine percent of online students. Eleven percent of face-to-face students did not like muddiest point activities because they learned differently than other students compared to zero percent of online students. Nine percent of online students indicated that classmates put little effort into muddiest point activities compared to zero percent of face-to-face students. These results are found in Table 4.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Face-to-Face (n = 14)</th>
<th>Online (n = 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other students learn differently from me</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Encourage one another</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Help one another</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Muddiest points not helpful</td>
<td>22%</td>
<td>9%</td>
</tr>
<tr>
<td>Nothing disliked about muddiest points and working with peers</td>
<td>33%</td>
<td>35%</td>
</tr>
<tr>
<td>Don’t like working with others</td>
<td>22%</td>
<td>9%</td>
</tr>
<tr>
<td>Didn’t know the information</td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td>Having to wait for the activity to be finished</td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td>Admitting weaknesses to others</td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td>Similarity in student responses</td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td>Nothing to improve upon</td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td>Requires too much study time</td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td>Little effort from classmates</td>
<td>0%</td>
<td>9%</td>
</tr>
<tr>
<td>Effort to find information</td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td>Activity caused overwhelm</td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td>Liked connecting with peers</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Provide individual comments</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 4. Themes associated with “What do you not like about muddiest point activities and working with peers?”.  

continued on next page
Themes associated with “How did your instructor help you to feel comfortable completing muddiest point activities and working with peers?”

Of face-to-face student comments made in response to this question, fifty-six percent of respondents (8/15) stated that reviews for understanding (based on trends from student muddiest points) by the instructor helped them feel more comfortable completing muddiest point assignments and working with peers compared to seventeen percent (2/14) of online respondents. Eleven percent of face-to-face students stated that instructor availability helped them feel more comfortable completing muddiest point assignments and working with peers compared to zero percent of online students. Eleven percent of face-to-face students stated that motivation from the instructor as well as reminders to complete assignments helped them feel more comfortable completing muddiest point assignments and working with peers compared to zero percent of online students. Eleven percent of online students stated that respectful and helpful feedback made them feel more comfortable completing muddiest point assignments and working with peers compared to zero percent of face-to-face students. These results can be found in Table 5.

<table>
<thead>
<tr>
<th></th>
<th>Face-to-Face (n = 15)</th>
<th>Online (n = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra credit</td>
<td>11%</td>
<td>6%</td>
</tr>
<tr>
<td>Availability</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Motivation</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Review for understanding</td>
<td>56%</td>
<td>17%</td>
</tr>
<tr>
<td>Not uncomfortable</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>Reminders to complete activity</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Covering most difficult concepts</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Opportunity to help other students helps you learn</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Not requiring participation made students more comfortable</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Great job</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>No one right answer</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Helpful and respectful feedback</td>
<td>0%</td>
<td>11%</td>
</tr>
<tr>
<td>More like a conversation than an assignment</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Didn’t make me feel comfortable</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Simple</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Professor asked students if they have questions</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Makes online students feel they are not alone</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Clear instructions</td>
<td>0%</td>
<td>6%</td>
</tr>
</tbody>
</table>

Table 5. Themes associated with “How did your instructor help you to feel comfortable completing muddiest point activities and working with peers?”. continued on next page
Discussion
This study has implications for institutions that offer face-to-face and online sections of anatomy and physiology and other STEM subjects. On average, students in both types of course delivery methods perceived combined muddiest point and peer instruction activities as inducing only a relatively low level of anxiety, and this perception did not differ as a function of course delivery method or time in the course. Similarly, students rated these activities as contributing in a moderate way to their learning, irrespective of course delivery method or time in the term. Student comments provided valuable insights into the features of these activities that they appreciated, as well as actionable factors that could be improved upon.

Many students provided positive feedback on the activities. Those with negative feedback often didn’t like working with peers or the quality of information provided by their peers. Online students tended to have more favorable opinions of online muddiest point and peer learning activities than face-to-face students. Online students don’t have the benefit of in-class activities to build community and gain feedback on misconceptions so they may find online muddiest point and peer learning activities more helpful than face-to-face students. Online students also tend to be more likely to indicate that these activities create a sense of belonging. These findings may be helpful for faculty who struggle to keep students engaged in online classes.

Given that many students struggle in online classes and that many students also struggle with anatomy and physiology, finding strategies that help students succeed in anatomy and physiology is critical to course completion and ultimately workforce development since many students take the course to become healthcare professionals. Higher education academic leaders and educational technology leaders may consider encouraging faculty to implement muddiest point and peer instruction activities, particularly for online classes.

About the Authors
Anthony Edwards serves as an assistant professor of Educational Leadership and Technology and Director of Tarleton Online at Tarleton State University. Suzanne Hood serves as an associate professor of Psychology at Bishop’s University. Murray Jensen is a professor of Biology Teaching and Learning at the University of Minnesota. Ron Gerrits is a Professor and Program Director at the Milwaukee School of Engineering. Melaney Farr serves as a professor of Biology at Salt Lake Community College. Chasity O’Malley is an associate professor at the Boonshoft School of Medicine at Wright State University.

Literature Cited


Appendix: Survey Questions

Q1. With which gender(s) do you identify?
   1. Male
   2. Female
   3. Trans male
   4. Trans female
   5. Genderqueer
   6. Non binary
   7. Other
   8. Prefer not to say

Q2. Please indicate your ethnicity (i.e. peoples’ ethnicity describes their feeling of belonging and attachment to a distinct group of a larger population that shares their ancestry, color, language or religion)
   1. White
   2. Black or African American
   3. American Indican or Alaska Native
   4. Asian
   5. Native Hawaiian or Pacific Islander
   6. Other: Prefer to self-describe
   7. Prefer not to say
   8. Arab
   9. South Asian

Q2a. If you answered ‘other: prefer to self-describe’ to the previous question, please enter your comments here.

Q2b. Are you of Hispanic, Latino/a/x, or of Spanish origin?
   1. No, not of Hispanic, Latino/a/x, or Spanish origin
   2. Yes, Mexican, Mexican American, Chicano/a/x
   3. Yes, Puerto Rican
   4. Yes, Cuban
   5. Yes, Another Hispanic, Latino/a/x, or Spanish origin
   6. Prefer not to say
   7. Other: prefer to self-describe
   8. Yes, Afro-Latino

Q2c. If you answered ‘other: prefer to self-describe’ to the previous question, please enter your comments here.

Q3. What grade (mark) do you expect to get in this class?

Q4. What is your estimated overall grade point average (GPA)?
Q5. What is your full name? (Please note that your name will be viewed by an independent third party, but not your instructor, and will be removed from all data prior to publication).

Q6. Are you a first-generation college student (i.e., neither your parents nor your grandparents attended college)?
   1. Yes
   2. No
   3. Unknown
   4. I prefer not to answer

Q7. Evaluate the following classroom activities based on how much anxiety they cause you to feel (no anxiety, some anxiety, extreme anxiety, I have never tried this activity before, prefer not to say).
   - Listening/watching the instructor deliver a PowerPoint lecture
   - Working alone to answer a question using an anonymous student response system (e.g., clicker) or an app (e.g., Tophat, Socrative)
   - Working with another student to answer a question using an anonymous student response system (e.g., clicker) or an app (e.g., Tophat, Socrative)
   - Volunteering to answer a question posed by the instructor
   - Being asked a question by the instructor without volunteering (cold calling)
   - Combined muddiest point and peer instruction activities

Q8. Evaluate the following classroom activities in terms of how much they contribute to your learning (very little, somewhat, significantly, I have never tried this activity, prefer not to say).
   - Listening/watching the instructor deliver a PowerPoint lecture
   - Working alone to answer a question using an anonymous student response system (e.g., clicker) or an app (e.g., Tophat, Socrative)
   - Working with another student to answer a question using an anonymous student response system (e.g., clicker) or an app (e.g., Tophat, Socrative)
   - Volunteering to answer a question posed by the instructor
   - Being asked a question by the instructor without volunteering (cold calling)
   - Combined muddiest point and peer instruction activities

Q9. For the activities that you found helpful, please explain why they were helpful. Did they help you develop more effective study strategies? If so, what were those strategies?

Q10. Please indicate how much the following problems have bothered you during the past week. Mark only one box for each problem and be sure to answer all items (not at all, a little bit, somewhat, very much, extremely, prefer not to say).
   - Fear of embarrassment causes me to avoid doing things or speaking to people.
   - I avoid activities in which I am the center of attention.
   - Being embarrassed or looking stupid are among my worst fears.
Q11. 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”. (Strongly disagree to Strongly agree)

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

The following three questions also appeared in the survey completed by students at the end of the term:

- What do you like about muddiest point activities and working with peers?
- What do you not like about muddiest point activities and working with peers?
- How did your instructor help you to feel comfortable completing muddiest point activities and working with peers?
Utilizing 3-D Digital Models in Synchronous Blended Anatomy & Physiology Courses During the COVID-19 Pandemic

Luis D. Rosado, PhD
Department of Biology, Worcester State University, Worcester, MA, USA
Corresponding Author: lrosado@worcester.edu

Abstract
The use of electronic media in the classroom was prevalent during the height of the COVID-19 global pandemic because it afforded the health and safety of students in blended course modalities. This project aimed to quantify the effectiveness of a three-dimensional computer-based human anatomical online platform in a blended synchronous course design. We asked our students to self-report the learning efficacy and overall student engagement of the online learning platform. We found that with intentional course design utilizing in-person anchored Zoom Buddy blended classes and a 3-D anatomy software, students reported high levels of learning efficacy and engagement in anatomy & physiology courses. The course design presented in this paper provides a viable option should we be faced with similar emergency learning situations or when course enrollments are high and class spaces are limited. https://doi.org/10.21692/haps.2023.019

Key words: course design, 3-D computer models, student-to-student interactions, anchor-student

Introduction
The COVID-19 pandemic and the resultant social distance precautions implemented in the classroom largely reduced important student-to-student interactions in higher education. Student-to-student interactions have been shown to positively enhance learning, a feeling of community, and student engagement within online classrooms (Bickle & Rucker, 2018; Majewska & Vereen, 2020). While strictly face-to-face courses typically provide the most ideal student-to-student interactions, the pandemic limited in-person interactions due to largely remote online and blended course modalities. Now more popular than ever, blended courses involve at least some portion of in-person instruction in combination with either asynchronous or synchronous online instruction. Learning about human anatomical structures can be particularly difficult under blended learning conditions and the constraints of the pandemic afforded us lessons on how to adapt the anatomy & physiology (A&P) learning environment for a blended course delivery.

Even under normal circumstances, learning human anatomy can be difficult for students because it requires good spatial awareness and three-dimensional (3-D) visualization of both surface level and deep body structures. Over the past two decades an increasing number of 3-D computer-based models of ever-improving quality have been incorporated into the human anatomy learning classroom to enhance student engagement with varying levels of success (Azer & Azer, 2016; Triepels et al., 2020). Others have shown the moderate effectiveness of earlier, more basic 3-D computer models for enhancing engagement and anatomical knowledge for students (Agbetoba et al., 2017; Hassinger et al., 2010). Yet student engagement and learning efficacy using highly sophisticated, modern, and web-based 3-D computer models of human anatomy remain largely unexplored.

While primarily positive student self-reporting of an online learning platform’s effectiveness can itself be representative of student engagement, directly determining engagement in an online learning modality is difficult to assess (Henrie et al., 2015; Sinatra et al., 2015). Even finding agreement in the literature regarding definitions of “engagement” can be challenging. Yet, anecdotally, the distinction between an “engaging” and “unengaging” class is clear to most students. When pressed, students find it difficult to say what makes an engaging class feel engaging or even how they would define engagement at all. However, they will definitively say that they know when they are engaged, and they distinctly know when they are not. Currently, the literature broadly defines student engagement as either behavioral (Boucheix et al., 2013; Thompson et al., 2012), cognitive (Bangert-Drowns & Pyke, 2002; Guertin et al., 2007; Zhu, 2006), or emotional (Kay 2011; Missett et al., 2010; Sun & Rueda, 2012).
Utilizing 3-D Digital Models in Synchronous Blended Anatomy & Physiology Courses During the COVID-19 Pandemic

For the purposes of this research project, student engagement should not be conflated with total usage of the technology. Students were required to take the course as designed due to the teaching constraints imposed by the COVID-19 pandemic and were not provided with an alternative resource to use. Consequently, this project did not measure the time students spent using the anatomy software. Therefore, for this project, student engagement in the course and with the online learning platform is defined primarily as behavioral and cognitive, but also to some extent as emotional. As such, behavioral engagement is classified as the level of student involvement with the software, while cognitive engagement is categorized as student perceived long-term value of the software and if students would recommend it to future students. Lastly, emotional engagement is categorized as the preference for the software used in this study over other available learning modalities and their intent to continue to use the software beyond the classroom.

The purpose of this project was to evaluate learning effectiveness and student engagement through enhanced student-to-student interactions in multiple synchronously blended lab sections utilizing an online human anatomy learning platform during the COVID-19 global health pandemic. Our working hypothesis was that a strong blended course design that enhanced student-to-student interactions and the high learning efficacy of the learning platform would link to correspondingly high levels of student engagement.

Methods

Course Design and the Visible Body® Learning Platform

Our blended course design included synchronous online lectures with 2.75-hour lab sections split into a weekly alternating in-person group (Group A) and a synchronous, remote, online group (Group B). The class utilized the video conferencing platform Zoom (Zoom Video Communications, Inc.) for all lab sections. One way in which the split-group was utilized in the lab was to generate breakout rooms that included a student from the in-person Group A with one or more students attending remotely from Group B in real-time. I categorized these blended breakout rooms as physically anchored Zoom Buddy groups.

An advantage of having these physically tethered groups was that social distance within the room was maintained while also fostering student-to-student connection with students attending remotely. Even though socially distanced, the in-person group established a sense of community for students physically present and those attending remotely. The largely positive response to the course design and the online software indicates that a greater sense of community was developed. While not directly measured in this project, the correlation between student-to-student interactions and increased sense of community has been shown using similar classroom technology in group-work-based course design (Bickle & Rucker, 2018). Additionally, the anchor-student from the physically present group linked real-time communication from the instructor to the tethered remote students in each collaborative Zoom Buddy group.

The Visible Body® learning platform (www.visiblebody.com) provides a suite of web-based and smart-device applications that include high definition 3-D graphical models of human anatomy and 3-D interactive learning modules (Figure 1). Along with in-class activities such as specimen dissections, Visible Body® was utilized by students within the Zoom Buddy breakout rooms to work on weekly collaborative lab assignments.

Figure 1. Visible Body® 3-D models of the skull (left), pelvis (middle), and shoulder joint (right). Images courtesy of Visible Body®.
Self-reported Learning Efficacy and Engagement Questionnaire

Most of the classes surveyed were the standard two semester sequence of A&P but combined single semester human biology courses were also surveyed. However, the survey did not collect information regarding which type of course was taken by each participant. It’s likely that responses came mostly from the A&P courses based on the number of students that typically take the two types of courses. When the courses were completed in the Spring of 2021, I surveyed all students with an anonymous online questionnaire (Appendix) utilizing primarily Likert scale responses from: strongly agree, agree, neutral, to disagree, and strongly disagree. The questionnaire explored course design and student self-reported learning efficacy of Visible Body® along two dimensions of inquiry: “Using Visible Body® during the COVID-19 global health pandemic” and “Overall information and learning effectiveness” respectively.

Student engagement was also measured in the first two dimensions of inquiry in addition to a third which was, “Visible Body® overall assessment”. The Institutional Review Board of Worcester State University approved this project as exempt, and informed consent was obtained from all participants.

Results

Of the approximately 90 students that utilized Visible Body® at our institution during the 2020-2021 academic year, 39 students (43%) responded to the online questionnaire. However, one participant submitted a blank questionnaire effectively reducing the response rate to 42%. No demographic or identifiable information was collected from our participants in order to keep their responses completely anonymous. The participant responses are categorized as overall agreement (agree and strongly agree responses), overall disagreement (disagree and strongly disagree responses), and neutral (neither agree nor disagree) with the survey questions. The survey did not address satisfaction or dissatisfaction with the course design, the online technology, or the participant’s motivation for filling out the survey. However, it is likely the participants who volunteered for this research project were sufficiently motivated by either their satisfaction or dissatisfaction with the overall course design to provide a response.

Student responses to course design questions in the “Using Visible Body® during the COVID-19 global health pandemic” dimension of inquiry were largely in overall agreement resulting in: 1. an 86.5% overall agreement with “The online functionality of Visible Body® was useful in a blended classroom modality”, 2. an 80.6% overall agreement with “The computer 3-D models were effective at group learning while maintaining safe social distancing”, and, 3. an 81.6% overall agreement with, “I preferred using the online 3-D models during the COVID-19 global health pandemic” (Figure 2). However, these values express overall agreement only and it is unclear if this represents the more moderate response of agree to a greater extent or if it trends more toward strongly agree.

Student responses to the learning effectiveness questions in the “Overall information and learning effectiveness” dimension of inquiry were also largely in overall agreement resulting in: 1. an 83.8% overall agreement with “The Visible Body® content was useful”, 2. an 89.2% overall agreement with “The Visible Body® content effectively supported my learning”, and, 3. an 82.0% overall agreement with “The Visible Body® content effectively supported my learning”.

<table>
<thead>
<tr>
<th>Dimension of Inquiry</th>
<th>Agree or Strongly Agree</th>
<th>Disagree or Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please rate how useful Visible Body has been during the COVID-19 global health pandemic.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The online functionality of Visible Body was useful in a blended classroom modality.</td>
<td>86.49%</td>
<td>6.25%</td>
</tr>
<tr>
<td>2. The computer 3-D models were effective at group learning while maintaining safe social distancing.</td>
<td>80.96%</td>
<td>6.90%</td>
</tr>
<tr>
<td>3. I preferred using the online 3-D models during the COVID-19 global health pandemic.</td>
<td>81.58%</td>
<td>16.13%</td>
</tr>
</tbody>
</table>

Figure 2. Response percentages for the three questions in the Course Design dimension of inquiry, “Using Visible Body® during the COVID-19 global health pandemic”. Overall agreement in blue, overall disagreement in purple, and neutral responses in orange.
studying of human anatomy”, and, 3. An 83.8% overall agreement with “The Visible Body® content improved my knowledge of human anatomy” (Figure 3). It is also important to note the small overall disagreement. It was decided that it would be less useful to further evaluate the overall disagreement responses since, in many cases, they were few in number and nearly equivalent to the neutral responses.

Student responses to the student engagement questions in the “Visible Body® overall assessment” dimension of inquiry were also largely in overall agreement resulting in: 1. an 89.2% overall agreement with “I would recommend this software as an educational tool to others.”, 2. an 89.2% overall agreement with “I primarily used this software instead of traditional physical anatomy models in this class.”, and, 3. a 73.0% overall agreement with “I plan to utilize this software in my future classes or clinical practice.” (Figure 4). Given that these values showed some decline in the overall agreement response category for the, “I plan to utilize this software in my future classes or clinical practice” question, it was decided to further explore the relationship between the strongly agree and agree responses with regard to all three study arms: course design, learning efficacy and student engagement. In other words, were the somewhat mediocre agree responses dominating the overall category and artificially inflating the overall agreement to appear as if there was an overall strong agreement?

<table>
<thead>
<tr>
<th>Dimension of Inquiry</th>
<th>Agree or Strongly Agree</th>
<th>Disagree or Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall information and learning effectiveness</td>
<td>Please rate the V.B. information content and learning effectiveness.</td>
<td></td>
</tr>
<tr>
<td>1. The Visible Body content was useful</td>
<td>83.78%</td>
<td>9.68%</td>
</tr>
<tr>
<td>2. The Visible Body content effectively supported my studying of human anatomy.</td>
<td>89.19%</td>
<td>6.06%</td>
</tr>
<tr>
<td>3. The Visible Body content improved my knowledge of human anatomy.</td>
<td>83.78%</td>
<td>9.68%</td>
</tr>
</tbody>
</table>

Figure 3. Response percentages for the three questions in the Learning Efficacy dimension of inquiry, “Overall information and learning effectiveness”. Overall agreement in blue, overall disagreement in purple, and neutral responses in orange.

<table>
<thead>
<tr>
<th>Dimension of Inquiry</th>
<th>Agree or Strongly Agree</th>
<th>Disagree or Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visible Body overall assessment.</td>
<td>Please provide your overall assessment of the Visible Body online platform.</td>
<td></td>
</tr>
<tr>
<td>1. I would recommend this software as an educational tool to others.</td>
<td>89.19%</td>
<td>9.09%</td>
</tr>
<tr>
<td>2. I primarily used this software instead of traditional physical anatomy models in this class.</td>
<td>89.19%</td>
<td>9.09%</td>
</tr>
<tr>
<td>3. I plan to utilize this software in my future classes or clinical practice.</td>
<td>72.97%</td>
<td>14.81%</td>
</tr>
</tbody>
</table>

Figure 4. Response percentages for the three questions in the Student Engagement dimension of inquiry, “Visible Body® overall assessment”. Overall agreement in blue, overall disagreement in purple, and neutral responses in orange.
To address our working hypothesis and to compare the strongly agree with the agree responses I scaled the three dimensions of inquiry to the 5-point Likert range for both of the overall agreement responses. To account for any missing responses to individual questions I corrected the scaled values to the total number of responses for each question of the survey. I then took an average of the three questions to express both strongly agree and agree as a single value under each dimension of inquiry making them comparable on a 5-point scale.

All mean comparisons between the three dimensions of inquiry for both the strongly agree and agree responses were not significantly different ($p > 0.05$). The means and standard deviations for strongly agree in the three dimensions of inquiry were $3.06 \pm 0.17$, $2.84 \pm 0.27$, and $2.97 \pm 0.49$ for course design, learning efficacy and student engagement, respectively. The corresponding results for agree in the three dimensions of inquiry were $1.08 \pm 0.11$, $1.44 \pm 0.41$, and $1.22 \pm 0.14$ (Figure 5). This shows that the trend towards strongly agree was almost double that of just agree on all three dimensions of inquiry. Indeed, these comparisons were all significantly greater in favor of strongly agree (course design, $p = 0.0002$, learning efficacy, $p = 0.03$, and, student engagement, $p = 0.01$).

**Discussion**

The COVID-19 global health pandemic constrained student-to-student interaction opportunities by largely isolating students within various virtual video telecommunication platforms. This project aimed to show that carefully planned blended course design and the learning efficacy of the Visible Body® online platform enhanced student engagement under these unusual constraints. The results show strong student agreement with the blended course design utilizing this platform, high self-reported learning efficacy of Visible Body®, and subsequent high levels of self-reported student engagement.

The largely positive self-reported response to this approach indicates the importance of student-to-student interactions even if only tethered through a Zoom breakout group. As such, these results indicate that anchoring-students with Visible Body® in Zoom breakout rooms may have enhanced a feeling of student-to-student interaction for our students. During the same period of the COVID-19 pandemic, the Visible Body® company surveyed over 800 students actively using their products and found the same largely positive response to their online learning platform (Visible Body®, 2021). Their results strengthen and help to corroborate the findings of this study. Since the positive impacts of collaborative learning such as social and psychological benefits are well known (Laal & Ghodsi, 2012), the take home message of this project is that using an online anatomy learning platform allowed for a collaborative, while remotely anchored, learning environment that engaged students who strongly agreed that it improved their learning of human anatomy and physiology.

While face-to-face courses will continue to provide the highest level of collaborative student-to-student interactions (Rokusek et al., 2022), utilizing anchor students for synchronous blended course modalities could be an effective strategy to increase these crucial interactions and positively influence student learning of human anatomy. However, there are technological limitations to this course design that if not addressed, could impact equitable and accessible learning for underserved students. The primary limitation is that all students are required to have a laptop computer that meets the technical specifications to run an online platform like Visible Body®. Worcester State University, like many institutions striving for equity and equal access, has a laptop purchasing program to ensure all students enrolled begin their education with the necessary technology for success. Therefore, the split-group and anchor-student course design utilizing an online learning platform does provide a viable option for any future emergency situations that might limit our student’s ability to be in a physical classroom or indeed when class enrollment sizes are too large for the available physical lab classrooms.

**Figure 5.** The three dimensions of inquiry on a 5-point scale comparing “Strongly Agree” (black bars) and “Agree” (light gray bars). Error whiskers represent standard deviation from the mean value listed above the bars. Refer to the text for all values.
Acknowledgments

I’d like to thank the Visible Body® integration team for their care and support of our students during the difficulties of the pandemic. I’d like to specifically thank Krystylynn Stiebritz and Emily Genaway of Visible Body® and I have no conflicts of interests to disclose regarding our collaboration. I’d also like to thank the supportive and dedicated A&P teaching team of instructors that handle the many sections of A&P each semester. Lastly, I thank our department staff for their support; especially our lab technician, Ashley Landry, M.S., for her tireless work providing technical support to the many lab sections at Worcester State University.

About the Author

Luis Rosado, Ph.D., is an Assistant Professor and the Anatomy & Physiology course coordinator in the Department of Biology at Worcester State University. He teaches human biology, A&P, basic kinesiology, endocrinology, and human movement & perception. His research goals aim to improve the integration of technology in all human A&P-related courses. His broader research interests include human visual perception from Gibson’s Ecological Approach. He is also very involved in the HAPS DEI committee and actively promotes diversity, equity, and access in the A&P two-course sequence at Worcester State University.

Literature Cited


---

**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 or at 1-800-448-4277. Follow this link to join and start benefiting from membership today!
Appendix: Visible Body® Research Questionnaire

**PROJECT TITLE:** How effective is the Visible Body® 3-Dimensional online platform for learning human anatomy?

**INVESTIGATOR:** Luis D. Rosado, PhD, Department of Biology, Worcester State University, Worcester, MA

**PURPOSE:** The purpose of this study is to determine the learning effectiveness of three-dimensional (3-D) computer based anatomical models in a blended classroom environment during the COVID-19 global health pandemic.

**PROCEDURES:** If you decide to participate in this study, you will complete an anonymous online survey about the effectiveness of the Visible Body® online learning software. The survey should take approximately 15 minutes.

**RISK/DISCOMFORT:** The risks or discomforts involved in the project are the same or less than what you would encounter sitting during your normal daily life. There may also be risks that are unknown at this time.

**BENEFITS:** While you will not experience any direct benefits as a result of your participation, the information that you provide will be adding to our understanding of how effective 3-D anatomical models are for learning human anatomy which could help future students of human anatomy.

**PAYMENT TO YOU:** There is no compensation for participating in this study aside from the knowledge that you could be helping future students of human anatomy.

**CONFIDENTIALITY:** Information produced by this study will be confidential and private. The survey is anonymous and no identifying information will be collected. All collected data would be reported numerically and as statistical results in research presentations or publications. However, confidentiality cannot be guaranteed; your personal information may be disclosed if subpoenaed or otherwise required by law.

To ensure that this research activity is being conducted properly, Worcester State University’s Human Subjects Review Board has the right to review your data but confidentiality will be maintained as allowed by law.

**COST TO YOU:** There is no personal cost involved in participating in this study.

**PARTICIPANT RIGHTS:** Your participation in this study is voluntary. You do not have to be in this study if you don’t want to be. You have the right to change your mind and leave the study at any time without giving any reason, and without penalty. Any new information that may make you change your mind about being in this study will be given to you. You will get a copy of this consent form to keep. You do not waive any of your legal rights by signing this consent form.

**QUESTIONS ABOUT THE STUDY OR YOUR RIGHTS AS A RESEARCH PARTICIPANT:** If you have any questions about the study, you may contact Luis Rosado at... If you have any questions about your rights as a research subject, you may contact Dr. Henry Theriault, Institutional officer at...
DO YOU CONSENT TO VOLUNTARILY PARTICIPATE IN THIS STUDY?  Mark only one oval.

☐ YES, I GIVE MY CONSENT TO PARTICIPATE IN THIS STUDY

☐ NO, I DO NOT GIVE MY CONSENT TO PARTICIPATE IN THIS STUDY

Overall information and learning effectiveness.  Mark only one choice per row.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Visible Body® content was useful.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Visible Body® content is easy to read and understand.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Visible Body® content is well formatted and well designed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Visible Body® content effectively supported my studying of human anatomy.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Visible Body® content improved my knowledge of human anatomy.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Visible Body® 3-D graphics and interphase.  Mark only one choice per row.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The interface for interacting with Visible Body® content is easily accessible.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The 3-D models were information rich (easy access to supplemental information).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The 3-D models were information starved (no access to supplemental information).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am satisfied with the 360° rotation of the 3-D computer models.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am satisfied with the selection menu of the 3-D models.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am satisfied with the hide function.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am satisfied with the fade function.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am satisfied with the zoom function.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Visible Body® 3-D models are of high quality.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Comparing 3-D computer models & traditional physical models. *Mark only one choice per row.*

<table>
<thead>
<tr>
<th></th>
<th>Computer models</th>
<th>Traditional physical models</th>
<th>No difference between the two learning modalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which learning modality helped most in improving your knowledge of the human skeletal system?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which learning modality helped most in improving your understanding of the human muscular system?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which learning modality helped most in improving your understanding of macroanatomy?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which learning modality helped most in improving your understanding of microanatomy?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which learning modality did you use the most?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Visible Body® overall assessment. *Mark only one choice per row.*

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would recommend this software as an educational tool to others.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The software was easy to understand and use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The software has accelerated my education and understanding of human anatomy.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I primarily used this software instead of traditional physical anatomy models in this class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I plan to utilize this software in my future classes or clinical practice.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Using Visible Body® during the COVID-19 global pandemic. *Mark only one choice per row.*

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The online functionality of Visible Body® was useful in a blended classroom modality.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The computer 3-D models were effective at group learning while maintaining safe social distancing.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The computer 3-D models were effective at group learning while wearing face masks.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I preferred using the online 3-D models during the COVID-19 global pandemic.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would have been OK using physical anatomical models during the COVID-19 global pandemic.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sally’s Phantom: A Case Study on Plasticity of Cortical Representation

Scott E. Dobrin, PhD
Eckerd College, Collegium of Natural Sciences, St. Petersburg, FL, USA
Corresponding Author: dobrins@eckerd.edu

Abstract
The brain organizes somatosensory experience based on the body location from which it originated and the pathway by which in arrived. Here, I present a classroom discussion-based activity centered around the concept of a phantom limb to allow students to explore how cortical representation of sensory experience can be altered. The goal of the activity is to allow students to explore concepts surrounding plasticity of cortical representation. The mouse barrel cortex, a common model system for studying these effects, will be presented to explore potential mechanisms of the change. Finally, the students will hypothesis how the mirror box therapy can be used to ameliorate phantom limb pain without the use of pharmacological treatment. The activity is designed for second- or third-year biology or physiology majors and can be conducted in a single class period. Students can work in small groups answering questions before discussing their answers as a class. There are many opportunities to expand the discussion described. https://doi.org/10.21692/haps.2023.022

Key words: phantom limb, plasticity, mirror box, sensory maps, barrel cortex, neuroscience

Introduction
A classic dogma in the field of neuroscience stated that the adult brain was static, meaning that new connections between neurons could not be formed. Studies in animal models as well as with human subjects have proven that this once central tenet of the field is inaccurate. It is now widely accepted that the brain changes itself based on experience. This is most evident in the sensory domain, but these concepts are broadly true of all synaptic connections. In almost every brain area explored, including motor, learning, and even language processing regions, neurons have been identified that reorganize based on activity, or lack of activity (reviewed in Fu & Zuo, 2011).

This new understanding, however, is rarely presented to introductory students, despite its value to a potential future career in healthcare and biomedical research. This article presents an activity to guide students through a classroom discussion of a case study exploring the concept of brain plasticity. Case studies are an effective approach to science education, in general, and specifically useful in engaging students in exploring physiological and medical concepts (Ghosh 2007; Herreid, 1994; Kay & Pasarica, 2019). Additionally, case studies encourage group work and can be effectively used in both large lecture style courses and online or hybrid courses (Herreid & Schiller, 2013; Kibble et al., 2016).

The case presented here allows students to discuss two examples of plasticity in the sensory domain and a behavioral intervention that is based on the brain’s capacity for change. Students will explicitly link changes in neuron structure with alterations in human perception. The questions in the activity allow the instructor to direct the conversation based on the interests of the class. The use of case studies to support learning of physiological topics is both perceived as helpful by students (Cliff, 2006; Nasr-Nasser et al., 2022) and has been shown to improve exam scores (Pekary et al., 2021).

Neurons of the anterior gyrus of the parietal lobe, the somatosensory cortex, process touch, pain, and temperature information from the skin. A so-called somatotopic map exists in which neurons are activated in response to stimuli from specific body parts. For example, one population of neurons in the anterior gyrus becomes active when touching the thumb. But the same perception of being touched on the thumb would occur by directly activating the same population of neurons (without touching the skin). The representation of neurons in the anterior gyrus is related to body anatomy: areas of the body close to each other are represented by populations of neurons near each other. Stimulation of a nearby population of neurons would lead to perception of touch on the index finger, and next to those the middle finger, etc. Interestingly, the size of this region (typically the number of neurons representing a body part or region of skin) relates not to the size of the body part but rather to the sensitivity of that region. For example, more neurons represent the tips of our fingers than the tips of
our toes. This is not fixed, however. The examples provided for class discussion provide evidence of changes in these representations.

In the 1970s H. Van der Loos and T. Woolsey described a region of the rodent somatosensory cortex specialized, both anatomically and functionally, for processing touch of the whiskers (Woolsey & Van der Loos, 1970; Van der Loos & Woolsey, 1973). They found that each whisker on the face corresponded to a specific area of the cortex. The region was named the ‘barrel cortex’ due to the representation of each whisker being a column that extends down into the brain, like a long, thin barrel. Van der Loos and Woolsey showed that during development the maps could be altered based on changes in sensory input from the whisker. Removing a whisker reduced the number of neurons that represented that whisker and caused the neighboring regions to enlarge and extend into that area of the cortex. It was later found that simultaneous stimulation of two neighboring whiskers causes fusion of their cortical representations (Welker et al., 1989).

Similar to what was observed in the rodent barrel cortex, changes in sensory inputs can lead to changes in cortical representation in the human somatosensory cortex (May, 2011). A dramatic example of this occurs with phantom limb. A phantom limb is the perceived sensation that an amputated limb remains present (Flor, 2002). Often, pain is perceived as coming from the phantom limb. A standard example of phantom limb pain is described as a missing hand that is clenched without any ability to relax the phantom fist. Phantom limbs may occur following surgical amputation or traumatic injury (Flor, 2002).

It was once thought that phantom limbs were purely psychological, but a neurological basis is now widely accepted. The leading hypothesis predicts that a phantom limb results from two interacting processes. First, the sensory neurons representing the now-missing limb reduce their activity due to decreased stimulation (since the limb is gone). This causes a coincident decrease in activity of cortical neurons which previously represented the limb. Then, through an unknown mechanism, nearby neurons representing intact body parts activate the cortical area which previously corresponded to the missing limb. In this way, phantom limbs are a disease of plasticity.

Phantom upper limb pain is often experienced as a clenched fist (Ramachandran & Rogers-Ramachandran, 1996). No specific tests exist to diagnosis phantom limb pain – determination is largely reliant on the exclusion of other disorders (Cleveland Clinic, 2021). Medications aimed at treating generic pain may be effective in some cases.

The classroom activity presented here culminates by discussing an effective drug-free treatment, the so-called mirror-box therapy. A visual-illusion is used to create the perception that the phantom limb returned and is under control of the subject. This is accomplished by placing both arms in a box with a vertical mirror dividing it. The subject experiences the sensation that their phantom fist is relaxing by viewing the reflection of their intact fist opening in the mirror. Despite the subject being aware that an illusion is occurring, an immediate relief of the phantom pain is experienced. With a single 15-minute session, the sensation may last a few minutes once the arms are outside the box. However, with prolonged training the patient may experience permanent pain relief (Ramachandran & Rogers-Ramachandran, 1996).

Here I present an activity designed to introduce concepts surrounding plasticity of cortical representation, including during development and in pathology, for students in an undergraduate anatomy and physiology course. Student learning objectives, classroom strategies, and opportunities to delve deeper into the topics will be described.

**Methods**

I have used this exercise in a 200-level anatomy and physiology course, a 300-level physiology course, and a 300-level neuroscience course. It is typically facilitated in the final class meeting of the unit on brain anatomy and function and serves as an opportunity to delve deeper into the concepts we have been discussing. I dedicate an entire 50-to-60-minute class period to this activity and do not require the students to read anything beyond the assigned textbook chapters for the class. The learning objectives associated with this activity are the following:

1. Define phantom limb.
2. Describe the relationship between the areas of the somatosensory cortex and body parts those areas are representing.
3. Predict how sensory changes may alter sensory maps.
4. Discuss one treatment of phantom limb pain.

Please refer to the Appendix to review the case. The class starts by reading the scenario together before breaking into groups of 2-4 to discuss the questions. The questions on the handout following the case are organized so that all sub-questions having the same number should be answered during a single breakout period. For example, students can work in a group for 5-7 min to answer questions 1a, 1b, and 1c. At this point, the instructor should encourage students to read and make an attempt to answer all of the questions before finishing the small group discussion. Students may ask questions of the instructor, but should work together to find answers. It is helpful to remind the students that each component will be discussed as a class and they should make a best effort before seeking assistance outside the group.

continued on next page
After students complete the discussion of the first batch of questions, they should return to their groups to discuss the next set of questions. For example, after finishing the class discussion of all of question 1, the students should discuss question 2 in small groups before examining it as an entire class. It is important for the instructor to remain active walking around the classroom to maintain engagement of the students.

Each set of questions is designed to move the students towards an understanding that the somatosensory system changes with experience. Question 1 focuses students on the concept of a somatotopic map – that body parts nearby on the body tend to be represented by neurons in proximity to each other. But also, that the amount of representation (number of neurons) representing a body part is related to the sensitivity of that body part, not its overall size.

Question 2 introduces the rodent barrel cortex. The instructor should emphasize that whisker sensory information is especially important to a rodent and that rodents over-represent this information in their brain. It should be explained that each whisker has a distinct group of neurons encoding it. Whiskers are named by the row and column it falls on the face of the animal; a matching column can be found in the barrel cortex. This exercise examines the whiskers in ‘row D’ and their associated neurons in the barrel cortex.

Question 3 asks students to describe how the barrel cortex changes when sensory input is altered. Students should notice that barrel D2 has disappeared. But rather than leaving a hole in the barrel cortex representing D2 (or those neurons ceasing their activity altogether), students should also see that the representation of whiskers D1 and D3 have enlarged to include the neurons which formerly represented whisker D2.

It is worth noting that the neurons in the barrel are changing function more than structure. While some synaptic growth and refinement is occurring, the changes seen are due to the neurons in the barrel cortex that once responded when D2 was stimulated are now responding to stimulation of whisker D1 (or D3), which they previously ignored. The instructor should point out that neurons want stimulation. When the barrel that represented whisker D2 stops receiving input (because whisker D2 is removed), the neurons in that barrel ‘seek out’ activation elsewhere. However, when whisker D2 and D3 are bound the barrels fuse because the inputs are synchronized. Experience, either stopping stimulation or synchronizing it, will alter the representation in the cortex.

Question 4 requires students to make deductions about the information they learned. First, they should put in their own words the concepts demonstrated by the fact that changing the whiskers changed their representation in the cortex. Then the students will take this knowledge of barrel cortex experience-dependent plasticity to hypothesize the mechanism of phantom limb pain that Sally, the protagonist of the case, is experiencing. Often, there is a spectrum of understanding at this point. Some students follow the logic and immediately can draw the appropriate conclusions while others need a little assistance. The instructor should gauge the comfort with the concepts for each group by walking around the room. This can allow the instructor to choose the groups best prepared to answer. Typically, a group can provide a reasonable answer that requires minimal supplement by the instructor or another student. After asking the class for additional input, the instructor should provide a more detailed explanation (possibly by reading from the answer key, please see Appendix). The second part of question 4 asks the students to link the data from the animal model to the clinical manifestation of phantom limb. The instructor should similarly prompt students to provide as much detail as possible before explaining (or reading from the answer key).

Question 5 – the final question in the activity – provides an opportunity for the students to think creatively in applying their knowledge of plasticity towards an explanation of a treatment for phantom limb pain. Students are introduced to a chemical-free, non-invasive, and highly effective procedure to reduce phantom limb pain. The mirror-box induces a visual illusion that the patient’s clenched phantom fist opens, which leads to the immediate sensation that the patient’s phantom fist has relaxed. The instructor should first directly address the question of developing a hypothesis to the potential mechanism. Students generally make the link that there is a latent signal from the missing limb miscommunicating to the brain that the patient’s fist is clenched. They recognize that the seeing the illusion of a fist in the mirror open as if it is the phantom fist must be sending a stronger visual signal that is overpowering the latent ‘clenching’ signal. It is not necessary for the instructor to describe how this occurs on a cellular or molecular level. However, the speed of the response does suggest that whatever neural circuitry is mediating this behavior is already present; new neural connections do not have time to grow and become functional in the time it takes for the mirror-box illusion to relieve the phantom pain.

The instructor can then lead the class down a variety of avenues depending on the interests of the class and comfort of the instructor. For example, a discussion of how phantom limbs are a disease of plasticity can occur. This is an example of plasticity gone awry. While plasticity is often, and rightfully so, thought of as a positive attribute, in this case it is the mechanism of a disorder. The mirror-box treatment fights plasticity with plasticity. The instructor can also emphasize that the mirror-box treatment is effective immediately, and with repetition can have long lasting effects. The class can discuss how this provides a biological mechanism of the idiom ‘Practice makes perfect’. Alternatively, students can reflect upon how the most effective treatment for debilitating chronic phantom pain does not involve surgery or drugs.
Discussion

The discussion of brain plasticity, phantom limbs, and the mirror-box treatment is engaging to students. While no assessment data were collected, the questions the students work through are designed to specifically discuss these points. Upon completion of the provided questions and engagement in the classroom discussion, students typically can provide a concept of phantom limb and can connect it with plasticity occurring in the brain. Moreover, generation of a hypothesis to describe the mechanism of the mirror box treatment allows students to develop their understanding of the relationship between sensory experience and representation in the brain.

In my experience, students who come with previous knowledge are excited to share and those learning for the first time become enthralled in the concept of a hallucination of body image. Through a classroom discussion of these topics one can explore brain plasticity and more generally experimental design, originality in science, or other tangential topics. By remaining flexible, instructors can allow their classes’ specific interests to inform the direction of conversation. You may wish to follow up with a discussion (or assignment) exploring a primary literature article on one of the topics. Below are ideas for further exploration and noteworthy papers that can be used to supplement a discussion in an area.

Sensory maps were most famously explored by the Nobel prize winning scientists Hubel and Wiesel. They showed that neurons in particular areas of the brain encode precise types of visual information and that visual experience during particular developmental times (so-called ‘critical periods’) affected visual processing as adults. The Journal of Neurophysiology has a wonderful essay on six of Hubel and Wiesel’s works exploring this topic (Constantine-Paton, 2008).

Many of these papers and concepts, however, can be overwhelming to undergraduate students. I prefer to explore sensory maps via a series of studies utilizing an interesting alternative model organism, the owl. Knudsen and Konishi (1978) recorded from individual neurons in auditory areas of the owl brain while playing sounds from a movable speaker at different locations in a room. They, like Hubel and Wiesel, found a map-like organization of neurons. Neurons responded to sounds relative to the location in the surrounding environment from which each sound emanated. Knudsen also wrote a very approachable essay in Scientific American (1981) in which he summarized his lab’s work describing how the relative volume of a sound in each ear and the timing disparity between the sound reaching the ears is used by the owl to determine the location from which the sound emanated. This article can be used to facilitate a discussion on how sensory stimuli are coded in the brain.

Woolsey and Van der Loos first described the one-to-one relationship between the mouse barrel cortex and whisker stimulation in 1970. However, the paper they published is 38 pages and not appropriate for use in-full for an undergraduate class. Consider choosing excerpts or focus on how the style of scientific writing has evolved. If students want to delve into the concepts explored by removing a whisker, the follow-up article (Van der Loos & Woolsey, 1973) is more approachable. Students can examine the photomicrographs of the barrels with and without whiskers to describe the changes. To achieve a broader discussion of the use of the barrel cortex in studying various topics in neuroscience, including topographic development and brain plasticity, consider a historical perspective published in the Journal of Neuroscience on the discoveries found in this model system (Erzurumlu & Gaspar, 2020).

Of the extensions offered here, I most enjoy discussing the original article describing the mirror-box treatment (Ramachandran & Rogers-Ramachandran, 1996). It is unique in so many ways. There are no statistics, no single variable, and no controls. Rather than a typical terse overview of the results of the study, the authors describe the personalized treatment and progress of each of the ten patients in an approachable tone. It is the first-time visual input was shown to overpower a phantom experience. The mirror-box is as simple and low-cost a treatment as can be imagined and, yet, is more effective than any developed and optimized chemical pain killer. Students should appreciate that advances in science do not always require cutting edge technology, but rather thinking about and understanding a problem to determine the most straight-forward solution.

An astute student might point out that the mirror-box treatment is not a panacea. There are very real limitations on the ability to generalize this treatment to other phantom body parts or other diseases of plasticity. The orientation of the eyes, the existing limb, and the mirror must precisely align with the location of the phantom. But other situations, such as double amputations or phantom pain that cannot be pinpointed to a body part, will be impossible to treat using a mirror-box approach. In these cases, the class can imagine how other treatments capitalizing on plasticity could be used to treat other forms of phantom limb pain.

A wonderful way to engage kinesthetic learners is for the instructor to ask the class to fully clench their fist for one minute. While the students do this, the instructor can explain the impact of chronic pain and the benefits of treatment without drugs or surgery. After the minute, the students can relax their fists while the instructor prompts them to imagine the relief the patients must experience as their phantom fist unclenches for the first time in, perhaps, years. This can be a very powerful moment.

In summary, the activity described here can be implemented in numerous ways depending on the instructor’s comfort level with the material and classroom practice. It can be adapted for students at different levels with varied expectations in terms of the depth and breadth of solutions in different classes. After all, everyone’s brain will be changed a little after participating in the class.

continued on next page
Acknowledgements
I would like to thank Alex Hernandez for assistance in drawing the rat head and brain used as part of Figure 2.

About the Author
Scott Dobrin is an Assistant Professor of Biology at Eckerd College, where he teaches cell biology, human physiology, neuroscience, and other courses in the discipline of biology. Dr. Dobrin's research focuses on experience-dependent plasticity using a honeybee model. Research in the lab links molecular and structural changes in the brain with changes in behavior. Using insect models that display complex social behaviors, the lab studies the impact of environmental stressors on learning and memory.

Literature Cited
continued on next page
Appendix 1: Case Study of Sally’s Phantom

(Answers indicated in italics and blue font.)

Learning Objectives

1. Define phantom limb.
2. Describe the relationship between the areas of the somatosensory cortex and body parts those areas are representing.
3. Predict how sensory changes may alter sensory maps.
4. Discuss one treatment of phantom limb pain.

Sally Moore was cutting down trees to chop for firewood on a breezy fall afternoon that would soon change the rest of her life. After topping a few trees, she dragged them across the field to the waiting woodchipper. Sally, noticing she was late for work, rushed to finish.

In Sally’s haste she forgot to check her gloves before operating the chipper. She turned it on and rushed to rapidly push the limbs into the woodchipper. On the final branch, her glove became entangled in the trimmings and Sally’s left arm was pulled into the blades of the chipper.

Sally was prepared enough to push the emergency stop on the woodchipper with her free hand. Unfortunately, her trapped hand and lower arm were completely eviscerated. She quickly wrapped her injury tightly and drove herself to the nearest hospital.

The surgeons stopped the bleeding, but unfortunately there was no way to restore Sally’s arm and hand. To make matters worse, 6 months following the injury Sally began complaining of excruciating pain coming from her missing limb. She told the doctor that it felt as if the missing hand was clenched in a tight fist and no matter what she did, she could not release that fist. Her doctor told Sally that this was known as a phantom limb (the sensation that an amputated or missing limb is still attached and perhaps even moving). What is going on with Sally?

1. The image (right) represents the somatosensory cortex of the parietal lobe of the human brain.
   a. What is the function of the somatosensory cortex?
      Detecting touch, pain, temperature, and sense of your body in space. It receives this sensory information from every part of your body.
   b. Various body parts are depicted above the brain. What does this represent?
      Each region of the somatosensory cortex represents sensory information from a distinct body part. The pictures represent which body part the nervous tissue beneath them is encoding.
   c. Describe the relationship between body parts close in proximity to each other and the brain areas which represent them.
      Body parts that are close to each other on the body are also represented by nearby parts of the brain. This is referred to as a somatotopic representation. Brain maps, or specific cortical tissue that only represent a subset of the full sensory information, are common to all sensory domains. Furthermore, these maps are not randomly oriented but tend to be established such that nearby brain areas represent similar sensory information. With touch for example, this means the hand and the arm are represented by distinct brain regions – but those areas in the brain are close to each other. For hearing, similar frequencies of sound are represented in neighboring brain tissue.

Figure 1. Somatosensory cortex of human brain. A map of the body is represented in the brain. Body parts which are anatomically close are also represented in nearby regions of the brain. The sensitivity of each body region is related to the size of the representation in the brain. From Wikimedia Commons, File:1421 Sensory Homunculus.jpg: OpenStax College derivative work: Popadius, CC BY 3.0 <https://creativecommons.org/licenses/by/3.0>.
2. In the 1970s, an area of the rodent brain was identified in which each individual whisker was represented by distinct brain areas (Woolsey and Van der Loos, 1970). This area, the so-called Barrel cortex, is depicted on the left side of Figure 2 above.

One row of whiskers has been labeled D1 through D6 on the right side of the image. What do you note about the relationship between the labeled whiskers and the area of the barrels represented by the labels on the left image?

There is a mapping of the whiskers such that each whisker is represented by a single neural region and nearby whiskers are represented by nearby regions of brain. This is similar conceptually to the body representation we saw in the somatosensory cortex. Humans do not have a barrel cortex. This is because, despite having hairs on our face, we do not rely on the sensory information from those hairs enough to dedicate the neural tissue to representing it so thoroughly. Rodents use their whiskers to identify the locations of objects near them while in the dark.

3. Figure 3 represents the barrel cortex of a mouse that had whisker D2 clipped shortly after birth.

a. Describe how the representation of the whiskers in the barrel cortex of this mouse is different from the “normal” mouse barrel cortex depicted in Figure 2.

The barrel representing whisker D2 has disappeared. The barrel representing whisker D1 has grown into the D2 space and the barrel representing whisker D3 has also enlarged into the D2 space. Thus, the area of the brain which formerly responded to touches of the D2 whisker would now respond to touches of D1 or D3 whiskers, not D2.

b. Why do you think these changes occurred?

While representation of whisker D2 has disappeared, the cells which composed the barrel are still alive and functional. The lack of input to those cells permits the inputs to regions representing whiskers D1 and D3 to ‘invade’ and input onto the cells which formerly represented whisker D2. This emphasizes the principle that neurons seek activation; when the normal input to an area is removed (during the appropriate developmental timepoints) that area is more likely to be taken over by neighboring regions with functioning inputs.
c. What changes in the barrel cortex would you predict if whiskers D2 and D3 were permanently bound together (using tape or glue) shortly after a mouse was born?

_D2 and D3 become represented by the same region; stimulation of either whisker activates the same area. If the whiskers are separated and touched individually, the mouse would not be able to differentiate which whisker was touched._

4. The changes described in the barrel cortex are an example of a brain altering its sensory mapping based on an animal’s sensory experience.

a. Support the statement above based on your answers to question 3.

_Cutting the whisker or taping two whiskers together alter how the world is experienced. When inputs to the brain change, the representation of the outside world by the brain will also change. Removing the input by cutting the whisker permitted regions still being used to invade the input-starved regions. Likewise, linking sensory experience by taping together 2 whiskers alters the mapping because the 2 whiskers are always in synchrony with each other. Donald Hebb famously wrote “Neurons that fire together, wire together” (1949), which succinctly emphasizes this idea._

b. Based on how the barrel cortex can change, make a hypothesis about what may be happening in Sally’s brain that is leading to the phantom limb pain she is experiencing.

_When Sally loses her arm, the area of the brain which previously represented that area no longer is receiving input. Nearby areas which are still being activated will invade the deprived area. This may cause a stimulus that is coming from another body part (say the face) lead to activation of the brain that formerly represented the arm. Touching that body part (i.e. the face) may lead to the false sensation that her arm is being touched._

5. Rather than drugs or surgery, it was discovered that pain experienced by patients’ phantom limbs could be alleviated using a simple mirror (Ramachandran and Rogers-Ramachandran, 1996). An open-topped box was constructed into which patients could insert their existing arm on one side of a mirrored divider and the stump of the missing arm on the other side of the divider. A patient complaining that their phantom hand was permanently clenched (an excruciatingly painful experience) would find the pain instantly relieved when they looked at the mirror image of their existing hand making and then unclenching a fist.

a. Make a hypothesis regarding the mechanism of this treatment. How might watching a hand (which appears to be the phantom hand) unclench lead to an alleviation of the pain?

b. What does this mean about the interaction between multiple sensory modalities (touch and vision, for example)

_The visual stimulus that the hand opening is sufficient input to convince the brain that the clenched fist it ‘thinks’ is occurring has been relaxed._

_This must mean that visual and somatosensory maps overlap and can influence each other. (Any reasonable answer is acceptable.)_
Teacher Empathy: A Personal View on Approaching Compassion Satisfaction, Avoiding Compassion Fatigue

Tracy L. Ediger, MD, PhD
Georgia State University, Atlanta, GA, USA
Corresponding Author: tediger@gsu.edu

Abstract
Teaching with empathy is an approach that values the emotional quality of both teacher and student experiences. To incorporate teacher empathy into our teaching practice, we must first recognize that distress is inevitable, and that building skills to deal with stressful situations is an important investment in our future mental health. Communication skills such as listening, validating, and reframing are useful in the midst of student interactions. Designing a personal strategy to handle email communications is also essential, as much of our student communication occurs via this route. Having a short list of phone numbers and email addresses for campus emergency contacts, such as the dean of students or campus counseling center, is another important step in preparedness. Creating appropriate boundaries, stepping back, and taking time for self-awareness all help to preserve teacher mental health. The overall goal is to position ourselves with the mental and emotional resources to interact with students in a manner that leads to successful student outcomes, and leaves us with a feeling of compassion satisfaction, rather than compassion fatigue. https://doi.org/10.21692/haps.2023.020

Key words: communication, boundaries, self-regulation, reflection, self-awareness, empathy

Introduction
Responding to students with empathy is helpful for both the student and the instructor. Subjectively, we might say that showing empathy is better than not showing it. As a social species, humans are drawn to help and support each other. It feels natural to care about one another and want to help. As professionals who have chosen to be educators, we have taken on a role where the primary objective is to increase student learning. Education occurs, however, within the context of individual student (and teacher) circumstances. Many of us routinely draw upon social and emotional skills as we interact with students in more of a helping professional role, whether it be coach, counselor, advisor, or social worker.

Sometimes students come to us for help with a course, and, in the process, we learn of traumatic and catastrophic events. As educators, we are not necessarily trained in how to respond effectively and with compassion, and we may need more skills in this area. Even if handling these deeply challenging situations feels natural to us, we still may struggle to practice boundaries and self-care. Speaking from personal experience, it is easy for the weight of the trauma, chaos, and sadness that walks through my office door to sap my energy and color my mood for days or weeks. This past semester, I embarked on a personal project to learn how to balance empathy with self-care. Here I aim to share some perspective, skills, and resources that I hope will enable you also to support students and yourself simultaneously.

Perspective
First of all, distress is inevitable. The statistics related to the prevalence of child abuse in our homes and sexual assault on our campuses are staggering. According to the Adverse Childhood Experiences survey conducted by the Centers for Disease Control and Prevention, 61% of adults report experiencing one adverse childhood event, and 1 in 6 adults reported 4 or more adverse events (Centers for Disease Control and Prevention, 2021). A 2019 survey by the American Association of Universities reported that 13% of students experienced nonconsensual sexual contact by physical force or the inability to consent; for undergraduate women, the number was 25.9% (Cantor et al., 2020). Reading the statistics can be overwhelming, but the key point is that child abuse and sexual assault are common, and it seems that, more likely than not, a student coming to office hours will have some history of trauma. Then we layer on the stresses of daily life. Many students are working to pay both rent and tuition bills. They may also be acting as caregivers for aging parents, sick family members, or small children. Now think about how many crises happen each semester. A parent has a heart attack; a partner is diagnosed with cancer; a house burns down. When we serve hundreds of students, the probability that some terrible event will happen becomes a certainty.

continued on next page
COVID-19 brought added stress and we, as a society, have not yet rebounded. Being in lockdown, isolated from social supports, while experiencing the uncertainty of living or dying from a novel coronavirus created a situation with increased stress and decreased emotional and mental resources to deal with the stress. We may have learned new strategies for coping with stress. Alternatively, we may see our students exiting lockdown with fewer emotional skills and resources for healthy engagement with normal everyday stresses. Anecdotally, it feels as though our student populations post-lockdown are more anxious and have less resilience.

Current stresses, recent catastrophic events, and a history of trauma can all influence student behavior. When we are interacting with students, we can’t possibly know all of the backstory for why a student is behaving in a certain way. Students who come to us with requests or questions (or even demands) may need attention to their inner emotional landscape before they are ready and able to dive into a more cognitive approach to problem-solving. This sequential process has been described as the need to first “regulate” agitation or difficult emotions, and then “relate” by creating a connection with the other person (Perry & Winfrey, 2021). Only after that can we use “reason” to work through the problem and come to a solution. This plays out in both big and small ways, depending on the situation.

When we interact with hurting people, we will also hurt. Witnessing trauma, in the moment or in the retelling, affects the observer. This is termed secondary trauma, which is a useful term because it clearly names the effect of the trauma on the witness (Figley 1995). Being around another person who is feeling a particular emotion will transfer the quality of that emotion to the observer. We can all feel happy for a friend who gets a promotion at work, and feel sad for a family member who experiences a loss. When students share the circumstances of their stress or trauma with us, it will affect our emotional state. This secondary trauma is not as intense or as personal as the primary trauma, but we will still experience shock, disbelief, horror, loss, sadness, or grief.

It is possible to respond in a manner that increases our personal sense of meaning.

Building skills to call upon in situations of student stress can allow us to experience compassion satisfaction. This occurs when we are able to connect, promote a feeling of understanding, and provide resources. Compassion satisfaction is the opposite of compassion fatigue, when the effect of dealing with stressful situations is to become overwhelmed, depressed, and burned out. By building empathy skills, and balancing them with self-care, we can shift towards experiencing compassion satisfaction rather than fatigue. The Professional Quality of Life (ProQOL) Measure, available free online, generates a quick snapshot of whether we are currently experiencing more compassion satisfaction, compassion fatigue, or burnout (Center for Victims of Torture, 2021). This website also has descriptions of the terms compassion satisfaction, compassion fatigue, and burnout.

Skills to Practice

There are many thoughtful and helpful resources as we consider what skills we need and how to practice them. What follows is a collection of skills that I came across in print (Meyers et al., 2019) or in podcasts (especially Vedantam, 2022) or discussed with friends, colleagues, and my therapist.

In the Moment, with a Student

Listening: We start with listening to the student. This sounds very simple, but it is the essential foundation for the interaction. We all know that sometimes we are distracted, thinking about other tasks or worries, while someone is talking to us. Listening requires an awareness of what the student is saying verbally and what they are telling us with body language. We also communicate that we are listening by having an open posture, facing the student, making some eye contact. It should go without saying that we cannot be looking at a phone or a computer while attentively listening. If possible, we can also be conscious of our facial expression; if we, ourselves, are worried about something else, this may be written on our face. Inviting the student in, with a smile, and communicating that we are glad to see them, can help to set the stage for good listening.

Validating: By communicating that we understand the situation, or that we have had similar thoughts or feelings or struggles ourselves, we can validate the student’s feelings about their situation. It can help to choose a specific sentence that almost becomes a reflex. Here are some suggestions for specific sentence templates:

- “I’m so sorry to hear that…”
- “I’m disappointed, too, that…”
- “Thank you for letting me know that…”
- “That sounds really… (tough, challenging, rough, difficult, etc.)”

What we are trying to communicate here is understanding, but not in a trite way. We can’t say that “we understand” if the reaction will be “You can’t possibly know how it feels to [insert situation] because you’ve never had to deal with [this particular situation].” We’re not trying to say that we have felt exactly the same way, and the goal here is not for us to share our experience. The goal is to allow for connection and for the student to feel that they have been heard and understood.
We don’t necessarily need to agree with the student. Often students come to my office with a complaint about another student, a teaching assistant, or another faculty member. In these moments, it would be inappropriate to side with the student against the other person. Validating simply acknowledges that this student, in my office, has had a particular experience.

There is also a fine line between communicating understanding, which is the goal, versus creating false hope by promising a particular response or action. I can agree, for example, that the course policy of requiring correct spelling can make some students anxious. However, I cannot promise to change the course policy in response. I can express my condolences over the loss of a family member, but I cannot promise to give the student a passing grade in response.

**Reframing:** When a student comes with a complaint, it can be helpful to follow validating with reframing. Reframing is a powerful tool that allows us to grant agency to the student. In reframing, we offer a different perspective, or suggest an appropriate action. If we offer another perspective on the situation, we can encourage flexibility in our thinking and we introduce the possibility that there is more than one way to interpret something. Sometimes this simple act is enough to get us moving again from a “stuck” mental position. If there is a tangible action that we can suggest, we encourage the student to see themselves as autonomous, responsible actors within the learning environment.

As an example of reframing, when a student comes to me complaining that they cannot understand their instructor, or they aren’t “getting anything” out of class, I encourage them to come to class prepared by reading before class, and to be sure to ask questions in class if they don’t understand. I try to encourage the student to realize that the instructor genuinely wants students to learn, so they want students to ask questions. And other students probably feel the same way, so, as long as they are polite, it’s a service to everyone.

**Referring:** It is helpful to have a list of the most useful phone numbers and email addresses within easy reach. This should include any on-campus resources, such as the Office of the Dean of Students, the Counseling Center, and the Title IX Coordinator. The latter handles complaints of sex-based discrimination, including sexual harassment and sexual violence, so this person is a resource in those types of situations. If you have received a list of on-campus resources, post it where it is easily accessible and update it as needed. If you didn’t, hopefully there is another seasoned faculty member who can provide you with the needed information. Once you find that person, you should ask them what to do if a student reveals that they are homeless, or suicidal, or being abused. There are also nationwide hotlines and resource centers. Michelle Obama’s recent book has a list of American resources in the back (Obama, 2022). As educators, we routinely see situations that require professional assistance beyond the scope of our training. We may feel inadequate in responding, or unsure of what to do. We must prepare ahead of time, so that we know where to point students and we can appropriately refer students for professional help.

**Saying “no” kindly:** We want to say “Yes!” to students who come to us asking for help. While it is completely possible that a student is coming to you with a question that would be answered “Yes” by reading the syllabus, I have found that this is the exception rather than the rule. Reframing, as described above, can help to reshape the question and provide alternate solutions. But often, the answer to the question has to be “Sorry, but no.” For me, these are the most important sentences to practice ahead of time, in order to be kind but firm. Speaking without thinking often leads me to feeling later that I mishandled the situation. So here are some suggestions for ways to say no kindly.

- “I see where you’re coming from. I understand your request. I just can’t do this.”
- “I really wish this were possible, I hear how important this is.”
- “Given the guidelines of the course, it’s not possible to …”
- “In order to be fair to all students, I would need to do this for all students, and this is not possible.”

It does help to have clearly-articulated course policies, designed with some flexibility built in.

**Communicating with Students via Email**

When student requests are handled via email, many of the same skills apply. It’s still important to practice validating, reframing, and saying no kindly.

**Leading with a positive opening statement:** This idea is a substitute for “listening” but has a similar role in email communication. Even a short statement such as “Thank you for your email” allows the recipient to relax for a moment and feel appreciated.

**Using standard templates:** Keeping a set of standard sentences or paragraphs that you use to respond to similar questions or complaints will allow you to feel confident in your communication without investing the same amount of time and emotional capacity each time.

**Encouraging in-person interactions:** For difficult conversations, it really is better to have a face-to-face (or even virtual) conversation rather than going back and forth with email. It is easy to misinterpret the tone of an email. Nonverbal cues are also very helpful in both interpreting a student’s meaning and in communicating empathy. In my experience, oftentimes students are grateful to be invited for an in-person conversation.
Limiting email availability: Bringing empathy to email communication requires emotional and mental reserves that must be cultivated by time away from email. Setting clear email boundaries and communicating them via your course policies allows for more space and potentially more positive email interactions.

Self-care

The idea of self-care comes up frequently in the popular press and even in casual conversation. At its most elemental level, self-care requires knowledge of how to care for oneself, and then making time and devoting precious personal resources to the implementation of self-care practices.

To me, we must start at the bottom of Maslow’s hierarchy (Maslow, 1943) by considering whether we are meeting our own basic needs. For me, this includes needs for food, sleep, and exercise, as all of these impact my energy levels and my mood. Whether I have had enough sleep is probably the biggest factor in whether I have a good mood and enough energy for the day. I have learned the hard way that I do not function at all when sleep-deprived, so getting enough sleep is not optional for me. The next question is: Am I eating enough calories and nutrients, with enough frequency, to sustain my energy level and provide some satisfaction? It’s not a choice whether to “eat to live” or “live to eat”; we do eat to live, and food can bring pleasure. I don’t generally enjoy exercise, but I do feel stronger and healthier when I walk, and stretch, and do some weight-bearing exercise. Every semester when I teach about the skeletal system in Anatomy & Physiology 1, I tell students about the beneficial effect of weight-bearing exercise on bone density, and that reminds of my own need to exercise.

Awareness of our Internal State

Next, we must cultivate an awareness of our ongoing mental and emotional state. Academic success comes along with many hours spent inputting knowledge into our brain’s circuitry database. As educators, we tend to be proficient at cognitive processes like analysis and synthesis. We spend a great deal of time in our heads, thinking. What I’m suggesting here is that we pay attention to how we feel, in our body, mind, and spirit. We need to pause routinely to register what is happening at each level. Pain is a mechanism to alert us that something needs attention, something needs to change. Anger is an emotion that indicates that something is wrong, or that a boundary has been crossed; I’m sensing a threat that necessitates some sort of action. Exhaustion tells us that we need rest and restoration. Awareness of these various states allows us to honor what is happening in the moment and to move back toward wholeness. Bessel van der Kolk (2014) described this eloquently when he wrote: “Neuroscience research shows that the only way we can change the way we feel is by becoming aware of our inner experience and learning to befriend what is going on inside ourselves.”. Awareness is the first step.

And sometimes, awareness is all that it takes to have an internal reset. A brief pause to check-in internally can lead to an acceptance that this particular email is causing me stress, followed by a deep breath before moving on to write a few sentences in response. Slowing down enough to acknowledge the feeling and keeping it in mind while writing helps me to feel satisfied that I have responded appropriately. When speaking to a student, awareness of my own emotional reaction can help me to connect with the student by sharing that I, too, feel the distress of their situation. Or that I, too, am disappointed with how the course went for them. If I’m feeling an angry reaction, and I am able to be aware of that while it is happening, I may be able to express that there is something wrong and I would like to work to fix it. These interactions must be followed by time for closure and for processing.

Closure and Processing

A closure routine or ritual is a personal choice to signal to my mind and body that I’m “closing” the door on a particular event. I may continue to feel the aftershocks of the encounter, I may carry sadness with me, but the initial threat to my sympathetic nervous system is over. A closure routine can be as simple as literally closing the office door and taking a few deep breaths. Or going to get some water, using the restroom, or walking outside for a few minutes. It’s a pause, a chance to offer myself the same empathy that I’m offering another and to hopefully reactivate the parasympathetic nervous system and allow for internal calming.

I often find it useful to process what happened by sharing with a close friend, someone who has similar experiences and a similar commitment to balancing empathy and self-care. The purpose is not just to vent and release pressure but to talk through my emotional reaction to a particular situation. Can I name and express my emotion out loud? It is powerful to verbally acknowledge my internal state and accept that the emotion is present. Another person can also perform the important work of validating and reframing for us as we reflect upon our role in an interaction. It is a gift to have another person at work who can do this for us. It could also be useful to have a group of likeminded, resourceful faculty who could meet together regularly to review difficult cases and build skills by sharing ideas for alternate ways to respond or resources to offer. Therapy also presents an opportunity to express my emotional ups and downs and to process. The benefits of a good therapeutic relationship are myriad. We should not be afraid or ashamed to seek professional help in dealing with the demands of student situations requiring the skills typically associated with the helping professions.
Boundaries

We create physical, mental, and emotional boundaries between ourselves and others. In this case, we are creating boundaries to protect ourselves from the ongoing emotional demands of our work. Boundaries are an important part of setting up a system of self-care that allows you to have time and space for private emotional work. Boundaries include being clear about when you are available to students, in class, on campus, in person, and over email. The ability to step away from your desk, your computer, and your email is essential in order to cultivate the mental and emotional space to come back to students with fresh eyes, ears, and open hearts. Mental boundaries allow us to come up with new solutions and new perspectives because we have allowed our subconscious time to work, unhindered by our anxiety and worry. We can create mental boundaries by taking time out to pursue other interests, by integrating mindfulness practices into daily life, or simply by listening to music while we attack our daily chores.

Emotional boundaries are the most challenging. Emotions come with us when we go to the gym or come home from school. Sometimes it works to visualize leaving the emotion behind: walking through the door and saying to oneself, “I’m home now.” Other times, I have learned that I can change my internal emotion simply by saying to myself, “I don’t want to feel this way anymore.” (It’s almost magical when that works, typically with small anger or irritation.) It’s very powerful when we can acknowledge and then change the emotion we are feeling. Another revelation to me was when I realized that I could simultaneously feel two differing emotions. This is also powerful because it releases me from being shackled to feeling one persistent emotion that I can’t shake. OK, this emotion is here, but I can also feel something else. If I really don’t like the emotion I am feeling and I just want it to be gone (but it won’t leave), then I try some mindfulness visualization practices. In one practice, I sit quietly, eyes closed, and imagine myself as a house, where I am inviting anger in to be a guest within my house. When anger is a guest, I am accepting that anger is present, but I also acknowledge that anger is not all that I am. Anger is simply visiting. I also like the practice where you sit quietly, again eyes closed, and picture the negative emotion inside you, and then picture a flow of black wind particles leaving with every exhalation. Breathe in light, breathe out anger.

In Summary: Lessons Learned

This past semester my balance between empathy and self-care has improved. I realized early on that I must be rested to able to be wholeheartedly present in my interactions with others. I prioritized going to bed at 10 PM so that I could get 8 hours sleep. I am a better human being if I get enough sleep. I also created a new closure ritual for myself. I keep a stack of origami paper in my office so that if I am feeling sad or upset about a student, I can take a few minutes to focus in on my feeling and my hopes for that student while folding an origami crane. I now have a short string of origami cranes stapled together, a visual reminder of my intention to be empathetic and also to have boundaries for myself. I have a colleague across the hall who is a partner in processing events and emotions. I can walk into her office and say, “I’m not OK,” and talk about it. That has been very helpful. And, I have met monthly with my therapist to communicate my thoughts, my feelings, and my concerns in this domain. Acknowledging that being around hurting people will hurt, I feel empowered to be intentional in planning my response. I believe in the process of committing internally to being open to the emotion, to allow it to flow through and release it, even as I know that I need help in the process. And I believe that my courses are better when I am rested, present, and aware. Brené Brown (2021) said that leadership requires genuine affection for the individuals you are leading. In the classroom, we are leading students in a learning experience. Genuine affection for students enables us to be better classroom leaders. Taking care of ourselves mentally, emotionally, and physically allows us as educators to come into the classroom bearing the gift of openheartedness. Having an empathetic approach to students allows us to view them with affection.

Resources

It’s important to have a list of the emergency phone numbers or email addresses for people on your campus who can help. This may include the Dean of Students office, the Counseling Center, or the Tutoring Center. You may have received a list of important phone numbers during campus orientation, or you may need to create your own short list that you keep on your desk. It’s helpful to know which types of situations each office can handle, and what resources are available. For example, your campus may have 24/7 suicide prevention or a mental health hotline, or you may need to have your own list of national resources (there is a helpful appendix in Obama 2022). Your Title IX Coordinator may also have resources to help in cases of domestic abuse or assault.

Likeminded colleagues are another important resource. We all need someone to help debrief and reframe the details of student interactions. This could be individual, informal, as-needed; or it could be a standing faculty group which meets routinely to support one another in practicing empathetic communication. Group members could bring challenging scenarios to the group to evaluate and discuss alternative communication strategies. If possible, a staff member from the counseling center could be present to facilitate the group sessions. Student counselors may also be available to lead educational groups on building empathetic communication skills.
Individual therapy sessions with a trusted, competent, and compassionate therapist can also help in processing difficult situations, finetuning communication skills and strategies, promoting self-awareness, and ensuring appropriate boundaries. In my experience, the therapy relationship is just like any other relationship which may require trial-and-error. If at first therapy is unsuccessful, it could be that a different therapist would be a better fit (see also: Lakshmin, 2023).

As I mentioned earlier, there are many written resources which may prove useful as we think about practicing teacher empathy. Recent writings that highlight the lifelong effects of trauma can be helpful in thinking about holding our students with an empathetic filter (Perry & Winfrey 2021; Van der Kolk 2014). For more thoughts on setting boundaries and treating yourself with compassion I recommend the recent book Real Self-Care (Lakshmin, 2023), which discusses strategies for elucidating our own values and living within our chosen purpose.

Final Thoughts

We want so much for our lives, our careers, our work, and our students. Taking a few moments to focus on self-awareness and how we feel in our bodies is essential in order to check in on how we really are. Knowing our boundaries allows us to feel our limits. In our teaching practice, we strive to create learning environments where students are supported, and student learning is maximized. Investing time in our practice of teacher empathy enables us to better care for both ourselves and our students.

About the Author

Tracy Ediger lives in Atlanta, Georgia, where she teaches Anatomy & Physiology to a diverse body of Georgia State students intent on pursuing health care professions. In her position, she is responsible for teaching 100-plus student lecture sections and supervising graduate teaching assistants who facilitate the labs. Tracy is interested in the science of how learning works and strives to incorporate teamwork activities and hands-on learning into the course framework of both lecture and lab.
From Cadaver Dissection to Digital Anatomy: Benefits of Multi-Dimensional Learning Modalities

Kathleen G. Tallman, PhD, Grace Matsuda, PT, DPT, Susan Shore, PT, DPT, PhD
Department of Physical Therapy, Azusa Pacific University, Azusa, CA, USA
Corresponding author: ktallman@apu.edu

Abstract
Digital anatomy programs such as the Primal Program™, BodyViz™, Complete Anatomy™, or Cengage™, provide rich learning opportunities with the ability to remove anatomical layers, highlight specific structures, and rotate images. However, supporting the diverse learning styles of today’s anatomy students requires more than access to digital learning tools. This article describes sequential changes made in an anatomy course for a doctor of physical therapy (DPT) program. The DPT program moved from cadaver dissection to digital anatomy in the years 2020 – 2023. The most significant change was moving from the cadaver table, where there was rich student engagement during dissection, to a robust digital program with less student interaction and more screen learning. Throughout this transition, additional learning modalities were added. Tutorial stations were the most effective learning modality developed. At each station, faculty taught a focused topic (e.g. rotator cuff muscles), using multiple modalities such as a mounted skeleton, digital program, and Therabands™ to simulate muscles. Students learned how to integrate modalities and benefited from active engagement as faculty asked questions. These tutorial stations reinstated the learning environment of the cadaver tables and were optimal when students were allowed as much time as needed to gain confidence at each station. A post-survey sent to all enrolled students in the course each year identified the tutorial stations as the most preferred learning modality in 2023. To summarize, moving to a digital learning paradigm benefits from creative problem solving and persistent effort to support diverse student learning styles and student engagement. https://doi.org/10.21692/haps.2023.024

Key words: anatomy education, cadaver dissection, digital anatomy, multimodal learning styles, VARK

Introduction
This paper is about the simultaneous implementation of a digital anatomy platform with a change from cadaver dissection to observation of prosected material, from the perspective of an anatomical educator with decades of experience in cadaver dissection and demonstration. Successful implementation of this movement from the cadaver table to a digital anatomy platform required careful reflection on the elements of the cadaver experience most beneficial to teaching and learning as well as creative brainstorming on modalities that would provide similar pedagogical benefits outside of the cadaver lab. The hope is that sharing this experience provides insight to other educators in the midst, or considering, a similar pedagogical movement.

The Heart of Anatomical Education
Like many students struggling with their first dissection course, I (KT) found the experience confusing, frustrating, and bewildering as I tried to find and identify all of the small nerves, blood vessels, and muscles in a region of the body. When dissecting cadavers for the first time in graduate school, those of us assigned to each table learned to pool our resources and our wits, to tenaciously support each other by holding an atlas, reading the dissector, or taking a turn to dissect. This was especially important during times when we had to wait for a faculty member to assist us. The team assigned to each cadaver table were more than classmates; it was our hub as students. We supported and encouraged each other along the way.

As a young faculty member and throughout my career, the team concept at each cadaver table has been the pulse of the anatomy lab. As I supported student dissections on the assignment for that day, I was able to dialogue with students about the material, what they were looking for, the landmarks they thought would help them identify the structure(s) for dissection that day. Through these interactions, it was clear who was keeping up on the material and who was falling behind, who was struggling and who was appropriately confident. As an instructor, I knew the temperament or personality of each cadaver team. Knowing some cadavers provided greater dissection challenge than others, I knew which teams might have a greater need for more guidance and support.
The cadaver experience itself conveyed an educational experience that is almost indescribable. While intimidating to some at first due to the smell, the sights, and the texture of human tissue, over time students became drawn into the amazing structures that compose the human body. The ability to feel the difference between an artery and a vein, to palpate the attachments of a muscle and understand its action based on those attachments, and to understand the impact of disease and pathology on anatomical structures, all leave an indelible mark. Cadavers represent the tremendous variability in human bodies; in a cadaver lab of one or two cadavers, there will be several “normal” variations (Erolin, 2019). Specific examples of diseases become engraved in memory because of the cadavers encountered at the dissection table. For many students, the cadaver experience is the first time they have been around a deceased person. When given some time to reflect, students find this part of the experience extremely valuable (Erolin, 2019).

Anatomical education has long been about much more than anatomical structures. These non-traditional, discipline-independent skills (NTDIS) include team learning, peer interaction, professionalism, and empathy (Lachman & Pawlina, 2022). Dissection skills, themselves, are taught by mentoring and close collaborations between faculty and students. In dissection-based anatomy, students have to learn to search for specific structures or relationships using relevant clues and landmarks along the way.

Anatomical education has a long history of innovation and adaptability (Hildebrandt, 2010; Trelease, 2016). There are many reasons for pedagogical movement away from the “gold standard” of cadaver dissection (Green & Whitburn, 2016; Green et al., 2018; Hisley et al., 2008). Anatomy without cadavers, or with less use of cadavers, is becoming a reality in both undergraduate and graduate teaching, as shown in a recent study that examined world-wide trends in anatomical instruction (Salinas-Alvarez et al., 2021). According to their research, a little more than half of graduate level anatomy courses taught in the United States practice cadaver dissection. This means that almost half use digital anatomy or other pedagogical techniques. In other countries such as New Zealand and Australia, the trend toward digital anatomy is amplified, and most students in graduate anatomy program do not dissect cadavers.

The anatomy course in the doctoral of physical therapy (DPT) program embarked on a similar pedagogical journey from cadaver dissection to a digital anatomy program. The following sections discuss the work by faculty in the DPT program to identify the critical components of the anatomy course and to replicate them with new modalities. Every anatomy course is unique in the resources that are available, and because the skills and talents of the teaching staff differ, the process and outcome of a pedagogical transition will be different. One goal for this paper is to encourage others engaged in a similar transition to think reflectively and plan creatively in this process.

Digital Anatomy

The first goal of the transition in DPT anatomy was to incorporate a digital anatomy platform. This is appropriate since anatomy, and the health science careers it supports, are becoming more and more digital. In some places even now, digital imaging is available at the hospital bedside and health care providers need an understanding of anatomy through the lens of digital technology (Erolin, 2019; Wickramasinghe et al., 2022). The development of robust digital programs for learning anatomy has steadily increased over the past decades and there are many options to consider. For example, there are digital anatomy tables such as Anatomage™ which provide a digital means to dissect body structures as well as study pathology and normal human variation. This is an engaging way for students to dissect without the cost and exposure to toxic chemicals such as formaldehyde.

There are many web-based digital anatomy programs that students can access outside of class or lab times. Selecting the one that delivers high quality anatomical engagement and meets program or course objectives can be challenging. Several studies have reviewed these programs and made suggestions (Hisley et al., 2008; Sugand et al., 2010; Temkin et al., 2006). In summary, programs that allow three-dimensional rotation and removal of layers offer significant learning benefit for students. The ability to customize tools and the ease of navigation are also important elements to consider (Havens et al., 2020).

The Primal Program™ (Anatomy.TV™) was selected for the DPT program and has met the needs of the students well. It offers a variety of systems and regionally based anatomy apps. The 3DRealTime app, a part of the Primal Program™, has been the cornerstone of the anatomy course because it allows rotation, layering, or isolation of structures. Structures can be easily added, deleted, or labeled. Images from the program have been easy to integrate within teaching materials, quizzes, or exams on our learning management system, Canvas.
Ironically, the first semester that the Primal Program™ was adopted was the spring of 2020, when the Covid pandemic began. The cadaver lab was inaccessible and the digital program became the primary learning modality. This facilitated overcoming the learning curve with the Primal Program™ because of the amount of time we spent using and teaching with the program. It was clear that there is a significant learning curve to using any digital anatomy program. This shouldn’t be surprising since cadaver dissection also has a learning curve in which students gain skills through dissection. To facilitate the digital learning curve, an extensive two-week training was developed with step-by-step instructions on how to use the apps and tools in the program. This replaced the part of the lab schedule where cadaver dissection was previously introduced. Thus, a digital anatomy tool may include as much of a learning curve as cadaver dissection.

To guide students during each lab, a lab handout was created using images from the Primal Program™ and instructions to digitally dissect. Each handout was loaded on Canvas at the beginning of the term. Images from the handout were also incorporated into a weekly practice quiz that modeled the types of questions and responses students would be expected to answer on a lab practical exam.

Despite these efforts to anticipate student needs and provide quality guidance, student and faculty engagement was not as robust as it had been in the cadaver lab. The ambience of the course was quite different. When some students struggled academically, faculty were not well enough experienced in using the new pedagogy to support them. One of the common challenges faced by DPT students in the first semester was managing the volume and pace of the material. Additionally, some students had not been in an academic environment for several years and they found it difficult to recall basic science information. Students often relied on passive learning by watching video files or reading power point slides. Some students were successful with this strategy; others struggled considerably.

Once there were low quiz or exam scores indicating that a student’s academic performance was below minimum standards, faculty in the DPT anatomy courses met with that student, asking very open-ended questions about their study strategies. This provided an opportunity to point out additional modalities that promoted active learning. The VARK™ survey became a roadmap to assess the learning styles and pedagogical modalities needed to meet student learning needs. Literature supports that physical therapy students learn best when engaged in kinesthetic, hands-on activities (Good et al., 2013; Stander et al., 2019). Good et al. (2013) found a significant negative correlation between a kinesthetic learning style and academic success in anatomy. Thus, a digital anatomy program, by itself, may not engage all learners in deep learning. Understanding the learning styles of students in the DPT cohorts was essential to assessing the effectiveness of the modalities implemented.

Each anatomy class was invited to take the VARK™ survey. These data were de-identified and expressed as the percentage of the cohort for each trait (data not shown). The data indicated that 71% of DPT students at this institution were multimodal learners with 98% of all physical therapy students having a kinesthetic component to their learning styles. This may explain why some students specifically struggle with screen learning, stating that they spend much time studying, but “nothing sticks”. Faculty realized that additional modalities that promoted active learning were needed.

Several iterations of active learning were used before identifying the best approach for this DPT program. Early on, students worked in lab groups of six students per group. Each lab group was assigned three topics and they were tasked with creating digital images with a question and answer for each topic using the digital anatomy program. The goal was to have students work in a small group to digitally dissect and engage with material by developing questions and images. This experience was beneficial in developing peer support, peer learning, and engagement with material. However, it was still screen learning.
Clay modeling was added for one year (2021). This was very helpful for some students; however other students found it frustrating and unhelpful. The clay didn’t always stick to the mounted skeleton, or the non-drying clay was stiff and sometimes difficult to mold to the correct shape or structure. When the students used clay, there was greater focus on using the clay than on learning what it represented. Clay modeling is still used for specific ligaments (e.g. medial collateral ligament or lateral collateral ligaments of the ankle joint) or small muscles (e.g. rotator cuff muscles). Demonstrations are usually set up by faculty within the lab and used on lab practical exams.

Over time, the image of a successful student in the context of the new pedagogy began to emerge. Successful students integrated bones, mounted skeletons, and models with the digital anatomy program. They had multiple modalities at the lab table and made integrative notes to study from. Struggling students had separate files for lecture notes, lab images, and muscle attachments and innervation. The DPT anatomy course has always asked integrative questions on exams. For example, marking the median nerve and asking, “Identify one muscle innervated by this nerve.” This is an example of higher reasoning skills necessary for use in the clinic. For example, when a patient has atrophy of specific muscles or weakness in specific movements, a clinician identifies the affected muscle(s), the nerve that innervates these muscles, and potential sites of entrapment or injury. Faculty routinely asked questions similar to this in their discussions with students at the cadaver table. In the move to digital anatomy, when students focused on their computer screens, the ability to model integrative learning through discussion was more challenging.

As each term progressed, faculty developed and led tutorial stations where this integration was modeled by faculty using multiple modalities to explain a specific topic and engage in discussion with students. For example, one faculty member might hold a tutorial station focused on the rotator cuff muscles. They might have a scapula, humerus, and clavicle at their station, a mounted skeleton, and the digital anatomy program. Strips of Theraband™ could be used on the mounted skeleton to simulate the muscles. By placing one end of the Theraband™ on the origin and the other end on the insertion, students could simulate muscle attachments and movements. This could be compared with images from the digital anatomy program. Students could then work with the individual bones (e.g. humerus) and integrate the information. A successful student should eventually be able to look at an individual structure (e.g. lesser tubercle of the humerus) and visualize the span of the entire muscle attached to that tubercle, its action(s) and its innervation.

Eventually, these tutorial stations become the most effective teaching modality as perceived by students. These tutorial stations have filled the gap for instructor engagement with students, asking questions, assessing knowledge, and encouraging students to think more deeply about the material. They have been extremely successful when offered during open labs, when students can select the topics they need help with the most and can stay at the tutorial station for as long as they want. The groups at each tutorial station are also smaller during open labs, facilitating discussion.

Evaluating the success of tutorial stations using grades or performance scores is difficult. In a DPT course, the goal is for all students to have sufficient resources to pass and continue in the program. Student motivation is high to do well and grades tend to be strong. Attendance is also required at all labs and lectures. Open labs and cadaver observation are optional to attend, but may be required if students participate in academic tutoring. Often in a graduate anatomy course, the challenge is not to improve the grades of the entire cohort, but to focus on the struggling students, one at a time if necessary. If a student struggles throughout the anatomy course, but in the process gains new strategies for learning that will help them finish the program successfully, this is a success.

Peer Learning and Peer Support

Peer learning support was also important to student success. Lab groups are now organized around the bone boxes instead of the cadaver table. These lab groups meet during regular lab sessions and for a review each Friday. During the Friday review, stations with two mock practical questions are set up. Lab groups have five minutes to answer the question. Answer keys are provided to guide students on what constitutes a complete answer on the lab practical exams. Overall, these lab groups have provided an avenue for students to support each other and learn collaboratively.

Survey to Evaluate Pedagogical Effectiveness

A survey (Table 1) was developed to assess student perceived effectiveness of each learning modality. IRB was consulted before the data were collected. The survey was classified by IRB as action research which does not fall under the oversight of IRB at this institution. Each semester, the survey was sent to students after final grades were posted. Data were collected using a 5-point Likert scale (1 = was confusing or made learning more difficult, 2 = not very helpful, 3 = did not help or hurt, 4 = somewhat helpful, 5 = extremely helpful) and are expressed as the average (Table 2). In 2021, COVID-induced restrictions on lab access and face-to-face learning significantly impacted the anatomy course. This made comparison of any data from 2021 to other semesters extremely difficult. For this reason, data from 2021 is not included.
Data (Table 2) demonstrated that student perceptions continued to shift positively towards use of the Primal Program™, with the average increasing from 4.41 to 4.51. The addition of the tutorial stations was also seen as very positive. The addition of the open lab time with the stations increased the average from 4.18 in 2022 to 4.56 in 2023. The anatomy course continues to use cadavers, but as an optional learning experience. The cadaver lab is available for the DPT course early in the morning, before lecture and lab; student comments indicated that the early time was a deterrent for some. Cadavers are not used in testing, which may decrease student motivation to spend time in the cadaver lab. Student comments indicated that the cadaver lab is a valuable experience, but is not as great a focus for their time or energy. These factors are demonstrated as a declining helpfulness of the cadaver experience from 4.68 in 2020 to 3.49 in 2023.

Table 1. Survey Questions (2023)

<table>
<thead>
<tr>
<th>Question</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>In previous anatomy courses, which learning modality did you use?</td>
<td>Multiple choice (check all that apply)</td>
</tr>
<tr>
<td>In a previous anatomy course, if you used a digital anatomy program, how helpful was it?</td>
<td>5-point Likert scale</td>
</tr>
<tr>
<td>In a previous course, how helpful was learning from a cadaver (whether observation or dissection)?</td>
<td>5-point Likert scale</td>
</tr>
<tr>
<td>This semester, how did the Primal program™ impact your ability to learn anatomy?</td>
<td>5-point Likert scale</td>
</tr>
<tr>
<td>This semester, how did cadaver observation impact your ability to learn human anatomy?</td>
<td>5-point Likert scale</td>
</tr>
<tr>
<td>This semester, how did the “stations” or “tutorials” during the open lab time (3-5pm) impact your ability to learn anatomy?</td>
<td>5-point Likert scale</td>
</tr>
<tr>
<td>What is your most preferred (#1) learning modality?</td>
<td>Multiple choice (2023 only)</td>
</tr>
<tr>
<td>What is your second most helpful modality in learning anatomy?</td>
<td>Multiple choice (2023 only)</td>
</tr>
<tr>
<td>Please select all modalities that you feel are beneficial and should be used in a future semester (select all that you feel we should keep in the course).</td>
<td>Multiple choice (check all that apply; 2023 only)</td>
</tr>
</tbody>
</table>

Table 2. Impact of learning modalities in the DPT anatomy course. For those questions using a 5-point Likert scale, 1 = was confusing or made learning more difficult, 2 = not very helpful, 3 = didn’t help or hurt, 4 = somewhat helpful, 5 = extremely helpful. As a note, in 2022 and 2023, cadaver observation was optional only; therefore, not all students were exposed to cadaver anatomy, and this may have affected their response.

<table>
<thead>
<tr>
<th>Statement</th>
<th>2020* (n = 46)</th>
<th>2022* (n = 43)</th>
<th>2023* (n = 39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This semester, how did the Primal program™ impact your ability to learn anatomy?</td>
<td>4.41 ± 0.92</td>
<td>4.36 ± 0.65</td>
<td>4.51 ± 0.64</td>
</tr>
<tr>
<td>This semester, how did cadaver dissection (observation) impact your ability to learn human anatomy?</td>
<td>4.68 ± 0.68</td>
<td>4.21 ± 0.84</td>
<td>3.49 ± 0.84</td>
</tr>
<tr>
<td>This semester, how did the “stations” impact your ability to learn anatomy?</td>
<td>4.18 ± 0.83</td>
<td>4.56 ± 0.71</td>
<td></td>
</tr>
</tbody>
</table>

*values are mean ± SD
In 2023, students were asked to rank the learning modalities in order of helpfulness (Table 3). The tutorial stations received the highest ranking of 33.3%. The second choice of learning modalities was a tie between the Primal Program™ (18.0%), and the stations, lecture notes, and the daily lab manual (15.4% each). Student responses indicate that the bone boxes were not often used to study; however, the tutorial stations included the use of bone boxes and mounted skeletons, so students used bones for study, but possibly not from the assigned bone boxes. Student responses indicate that all learning modalities were beneficial and should be retained. These data support the benefit of multiple learning modalities to support student success in a graduate anatomy course (Rizzolo et al., 2010).

**Conclusion**

Cadaver dissection or observation of prosected material has historically provided a deep and rich learning environment for anatomy students, with modalities for all learning styles (Green et al., 2018; Green & Whitburn, 2016; Hisley et al., 2008). A pedagogical shift to a digital anatomy program should be carefully evaluated and implemented to ensure that multi-modal learning experiences are provided and that student learning styles and learning needs are met. There is not a “one size fits all” approach to anatomy (Good et al., 2013; Stander et al., 2019).

Literature in anatomical pedagogy has demonstrated the benefits of multimodal learning opportunities for students (Rizzolo et al., 2010). Kinesthetic learners, especially, may struggle with anatomical terminology and concepts (Good et al., 2013). This study supports the use of multimodal learning modalities in a doctoral program of physical therapy. In 2023, of a list of nine learning modalities and study aides, all were selected as worth keeping. The development of multimodal modalities began after the movement from cadaver dissection to a digital anatomy program and took several years to complete. Additional modalities such as silicone SynDaver™ upper limb and lower limb models continue to be added. Thus, it takes time to develop a multimodal approach.

For anatomy in a professional program such as DPT, transitioning curriculum from cadaver dissection to digital anatomy requires careful consideration of multiple modalities. Given that students are continuing to catch up on study skills and learning techniques lost during COVID-induced distance learning, a careful approach to multimodal learning and hands-on, kinesthetic experiences will benefit student learning and preparation for later clinical experiences.

For some students, a one-on-one approach is most beneficial and may be necessary. This may especially be the case for students who are primarily kinesthetic learners. These kinesthetic learners may not know how to implement

### Table 3. Most preferred (#1) and second preferred (#2) learning modality in(2023 (n = 39 respondents).

<table>
<thead>
<tr>
<th>Learning Modality</th>
<th>Most preferred*</th>
<th>Second preferred*</th>
<th>Retain for next year, choose all that apply*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadaver</td>
<td>0</td>
<td>5.13</td>
<td>7.58</td>
</tr>
<tr>
<td>Primal program</td>
<td>20.5</td>
<td>18.0</td>
<td>12.6</td>
</tr>
<tr>
<td>“Stations” or “tutorials” during open lab (3-5pm)</td>
<td>33.3</td>
<td>15.4</td>
<td>11.6</td>
</tr>
<tr>
<td>Lecture notes</td>
<td>12.8</td>
<td>15.4</td>
<td>11.6</td>
</tr>
<tr>
<td>Lab PDF files or checklists</td>
<td>10.3</td>
<td>15.4</td>
<td>11.6</td>
</tr>
<tr>
<td>Weekly practice practical exams on Canvas</td>
<td>2.56</td>
<td>10.3</td>
<td>13.4</td>
</tr>
<tr>
<td>Friday review</td>
<td>12.8</td>
<td>12.8</td>
<td>10.1</td>
</tr>
<tr>
<td>MP4 files</td>
<td>7.69</td>
<td>7.69</td>
<td>9.39</td>
</tr>
<tr>
<td>Bone boxes</td>
<td>0</td>
<td>0</td>
<td>11.2</td>
</tr>
</tbody>
</table>

*values are % of responses
kinesthetic study strategies and may benefit from one-on-one tutoring as they develop these skills. The tutorial stations during lab and in the open labs provided a faculty hub for engagement with students, mirroring the experience around the cadaver tables during dissection. By continuing these tutorial stations during open lab, students who grasped material quickly or felt confident in their learning left the tutorial sessions, providing students who wanted more support in a smaller group setting with better access to faculty.

A transition from cadaver dissection to other modalities can be successful but may require several years to fully implement. Requesting and responding to student feedback may be a helpful component of this process.

About the Authors
Kathleen Tallman is a Professor of Physical Therapy at Azusa Pacific University. She teaches graduate and undergraduate courses in anatomy, physiology, and neuroscience. Grace Matsuda is an Assistant Professor in Physical Therapy at Azusa Pacific University. She has taught human anatomy and assists in the lab. She worked as a physical therapist in acute rehabilitation and home health care. Susan Shore serves as Professor and Chair of the Physical Therapy Department at Azusa Pacific University. The focus of her 20 years of teaching is cardiopulmonary patient management.

Literature Cited


Standing Committees:

**2024 ANNUAL HOST COMMITTEE**  
*Cinnamon VanPutte*  
This committee is in charge of coordinating the 2024 Annual Conference to take place in Pittsburgh, Pennsylvania

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

**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**  
*Juanita Jellyman*  

**FUNDRAISING**  
*Stacey Dunham*  

**MEMBERSHIP**  
*Jacqueline Van Hoomissen*  

**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.

**Special Committees and Programs:**

**HAPS EDUCATOR**  
*Jackie Carnegie, Editor-in-Chief*  
*Brenda del Moral, Managing Editor*  
This committee is responsible for publishing a quarterly edition of the HAPS Educator, the journal of the Human Anatomy and Physiology Society. The committee works closely with the Steering Committee and the President of HAPS.

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

**FINANCES**  
*Ron Gerrits*  

**NOMINATING**  
*Melissa Quinn*  
This committee recruits nominees for HAPS elected offices.

**PRESIDENTS EMERITI ADVISORY COMMITTEE**  
*Kyla Ross*  
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