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Cognitive Processes in Undergraduate Anatomy and Physiology Courses

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Abstract

Multiple problems facing society in the 21st century, including climate change and global concern over pandemics, require a greater number of STEM graduates with content knowledge and critical thinking skills. This has led to additional funding and research in teaching and learning, but much of the published literature in the context of biology education has investigated the impact of specific instructional practices across a spectrum of classrooms (undergraduate and professional) or the learning strategies specifically of medical students.

As the science of learning has developed, it has become clear that the process of learning is context-dependent. Despite continued attention to the improvement of undergraduate biology education, we still understand little about the context-dependent cognitive processes and pathways students use while learning the life sciences. This research seeks to fill this gap by collecting and analyzing data on the cognitive processes and pathways that undergraduate students use while undertaking the task of learning anatomy and physiology. This work addresses the specific research question: What are the differences and similarities in cognitive processes and pathways for undergraduate students enrolled in anatomy and physiology courses?

Students enrolled in two different anatomy and physiology course sequences at a highest research university in the southeastern United States completed a 20-question survey to identify those planning to take both courses in each two-semester

sequence and to categorize them as either surface or deep learners. From those, I recruited 11 students to participate in qualitative data collection as part of a comparative case study. These participants were interviewed three times and provided written feedback to weekly reflection prompts for 24 weeks across the two semesters. Participants also completed two quantitative survey instruments: the revised Student Process Questionnaire (R-SPQ-2F) and the homeostasis concept inventory (HCI) at various times during the academic year. Prior to analysis, interview and weekly diary data were block coded for themes present in two previous studies conducted with medical students. Analysis proceeded with two cycles of coding with multiple passes in each cycle. First cycle coding involved open coding of the previous block-coded passages, using the constant comparative method. At the conclusion of first cycle coding, a code map was generated. Second cycle coding involved elaborative codes, which is the process of analyzing textual data to develop theory further. The themes that emerged were synthesized as individual case descriptions to compare differences in curriculum. I then compared cases to identify similarities and differences between the cases.

Two additional analyses were conducted. First, participant definitions of the common terms "learning," "memorizing," "studying," and "understanding" were analyzed. Code categories were developed and definitions were grouped after discussion with research team members of any coding differences. Multiple definition groups emerged for each term. Learning, memorizing, and studying had definition groups which highlighted processes, outcomes, or a combination of both a process and outcome. Understanding definition groups focused solely on an outcome. These findings highlight the need for communication between students and instructors in regard to the use of these terms. Second, initial review of interview transcripts raised concerns about the validity of the R-SPQ-2F instrument for the current population. Find-

ings suggest that the R-SPQ-2F was not able to group students by deep or surface approach in the context of an undergraduate anatomy and physiology course and requires additional refinement and testing to be a valid instrument for this population. Further, six interviews demonstrated a new theme of "Surface Leading to Deep" with participants indicating that memorization was necessary for the purpose of gaining a full understanding of the course material. This finding has significant implications for instruction, as memorizing and other surface strategies are often minimized and discouraged, yet they are an important step in student learning.

Findings from the comparative case study indicate few differences in the cognitive processes and pathways used by undergraduate anatomy and physiology students in different curricular structures that either separated or integrated the study of anatomy and physiology. Eight main categories emerged for learning activities undertaken by participants. However, participants enrolled in the separated curricular structure displayed greater negative affect related to the outcome of *completing assessments* when compared to those in the integrated course structure. This may be due to students not taking advantage of formative assessment opportunities in the course. Additional study is needed to fully understand this phenomenon.

Dedication

To my grandmothers - Dorothy Hodges Galyon and Billie Joyce Neas. One always emphasized the importance of education and the other still provides my model for how I want to interact with others.

To Eric, Tinley, Troy, and Trent. None of this would have been possible without you.

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No only really tells you what you are getting yourself into when you start work on a PhD. And this seems especially true when you are not a "traditional" student. The journey to this PhD could be considered 20 years in the making. I completed an MS in Animal Physiology in August 1999 and immediately started a PhD in that program. However, I learned I was expecting a baby as school began and never could find the motivation to continue after maternity leave. Returning when my three children needed me less - aka when they were teenagers - seemed like a great time. Despite the fact that I knew this journey would be supported and enabled by a lot of different people in my life, I did not fully appreciate the degree to which so many people would sacrifice on my behalf. While a mention in this acknowledgment section can signify my notice of your contribution, it is in no way a sufficient "thank you".

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Rocky Nation was my colleague but remains my friend. As much as I hated his departure from SWU, chairing the search committee for his replacement introduced me to the ESED department at Clemson. Who knew that Googling "STEM Education PhD" would help me find such a great program.

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Southern Wesleyan University has been my academic home since fall 2005. Administrative changes in recent years created a climate that pushed me to search for a doctoral program relevant to my faculty appointment in biology and to officially enroll in Spring 2017. Many colleagues from other departments have provided encouragement, prayers, and positive thoughts throughout this three year journey. I am forever thankful for your partnership and understanding during this time.

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To my heavenly Father - I am thankful for His provision of all I have mentioned above and all those that have played some role in this degree. I pray that the gifts and abilities He has provided to me will not be squandered, but will be used daily for His glory.

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Chapter 1

INTRODUCTION

Multiple problems facing society in the 21st century, including climate change, emerging medical technologies and more, require a greater number of STEM graduates with content knowledge and critical thinking skills [PCAST, 2012, Shelton and Rawlings, 2015]. The demand for STEM graduates in the United States continues to grow at a faster pace than employment in other fields [Wackler and Kontos, 2018]. In addition, individuals with a STEM degree earn more money than those with a non-STEM degree, even when working outside of a STEM field [Wackler and Kontos, 2018]. The Association of American Universities states, "Effective STEM teaching is crucial to developing a science-literate population that can address the complex and interdisciplinary health, energy, security and environmental challenges of our time" [Bradforth and Miller, 2015].

In addition to a shortage of STEM graduates in the United States, the Association of American Medical Colleges (AAMC) estimates a significant physician shortage within the next 12 years and recommends new approaches to educating future physicians [Dall et al., 2018]. Physician demand is growing faster than supply. Recent projections indicate a shortfall between 42,600 and 121,300 physicians by

2030, with shortfalls expected in primary care and most specialties [Dall et al., 2018]. Society's ability to tackle these challenges requires both skilled STEM and medical professionals and an informed and educated citizenry.

1.1 Context and Significance

In response, the past decade has seen significant attention turned to the improvement of undergraduate STEM education. In the life sciences, a series of conferences culminated in the Vision and Change Final Report [Brewer and Smith, 2010], which provides recommendations for implementing change in undergraduate curricula. These recommendations fall into two categories: 1) **WHAT** to teach, including core concepts and competencies and 2) **HOW** to teach in the classroom context. Following the release of the Vision and Change Final Report [Brewer and Smith, 2010], *The Core Concepts of Physiology* was published by physiology education researchers, defining core concepts and providing a possible direction for educational research and pedagogical improvement in the sub-discipline of physiology [Michael et al., 2017]. Within both of these publications is a call to develop and use evidence-based teaching practices.

However, the development of evidence-based teaching practices is not a simple process and many gaps exist in this body of literature in the life sciences. Recent literature on student learning has been built on findings from the 1970s and 1980s related to student approaches to learning (SAL) and whether these approaches are unchanging (*fixed-*) or *context-dependent* [Beattie et al., 1997]. As the science of learning continued to develop, it became clear that the process of learning is context-dependent [Marton and Ramsden, 1988]. Highlighting the importance of research

about learning, Roth and Anderson [1988] noted in *Improving Learning: New Perspectives*:

> Many teachers think about science as consisting of two distinct components - as a body of knowledge and as a set of processes used to investigate phenomena. In translating this two-pronged view of science into thinking about teaching and learning, teachers often overemphasize one or the other, fostering either as "science is acquiring facts" view or a "science is messing about" view. Teachers should also understand student learning in a particular way. They must understand this is a difficult and complex process of conceptual change, rather than as a process of acquiring and memorizing facts. Instead, of blaming learning failures on students' lack of effort, *teachers need to explore and understand the difficulties students have in changing their ideas.* (emphasis added) [Roth and Anderson, 1988, pg. 139]

Roth's quote highlights an important idea about how STEM instructors should approach their teaching. In light of this, it is important to develop evidence-based instructional practices which are built on current understanding of student learning and conceptual change in the context of specific STEM disciplines. However, the process of developing evidence-based instructional practices from learning theory in discipline-based education research (DBER) is not consistently implemented as a linear process. Over the past 50 years, researchers have identified and addressed instructional issues or other gaps in our understanding of teaching and learning in specific disciplinary contexts, such as biology. One example is the evidence-based teaching guide that was recently published as open access tool for life science education [Gui]. This guide provide summaries of and links to recent literature in the areas

of group work, inclusive teaching, and peer instruction. Additional literature about student learning in biology courses has focused on various pedagogical approaches or tools [Franklin et al., 2015, Philip and Taber, 2016, Eagleton, 2015]. Few studies have attempted to develop context-specific, biological science learning models.

Rebello et al. [2004] describes how the process of building evidence-based practice from discipline-specific theory may occur. While Rebello conducts his work in the context of physics education, the process and categories he outlines may be applied in other disciplines, including life sciences or anatomy and physiology education. The process begins with the development of discipline-specific learning theory indicated by Clinical Research (stage 1 in Figure 1.1). One example of work with undergraduates in life science comes from Southard et al. [2016]. This study was completed to characterize knowledge integration in undergraduate molecular and cell biology (MCB) as a student moves through various levels of courses in their degree program. The authors used the Theory of Knowledge Integration (TKI) [Clark and Linn, 2013] to understand how students sort, connect, and integrate ideas, as well as the nature of the connections in MCB. Key components of TKI include sorting through ideas to construct cohesive views, creating connections between ideas, and integrating ideas to build complex knowledge structures. The research utilized a single Think-Aloud Interview with each participant (n=8) in which students completed test-

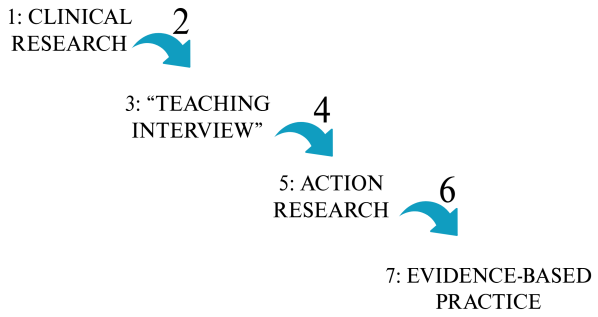

Figure 1.1: Process of Developing Evidence-Based Instructional Practice from Learning Theory [Rebello et al., 2004]

like tasks that allowed for assessment of concept understanding. The paper presents a model of how students understand the concepts of transcription, translation, and DNA replication (Vision and Change, core concept 3 [Brewer and Smith, 2010]), but the research questions and analysis focused specifically on MCB topics rather than cognitive processes or pathways of the context-dependent learning.

Examples of Clinical Research in anatomy and physiology (A&P) education include work by Wilhelmsson et al. [2010, 2011] and Fyrenius, Wirell, and Silén [2007]. Wilhelmsson, Dahlgren, Hult, Scheja, Lonka, and Josephson [2010] interviewed 13 second year medical students in a phenomenography to understand the various ways students learn anatomy. The participating students were enrolled in anatomy (learning of the parts of the body) and would undertake physiology (learning the functions of the body) as separate courses taken in sequence. Each informant in this study participated in a single semi-structured interview in which they were asked to describe their study process and "the most important things to keep in mind when studying anatomy." The authors reported that students approached the task of learning anatomy in one of three ways: memorizing, contextualizing (grasping whole site, connecting with surrounding structures, and linking to functional aspects), or experiencing (which included visualizing or experiencing, perhaps through dissections). They discuss the "dual nature of anatomy," which actually describes how the understanding of anatomy informs physiology and vice versa. Also of note, they state, "It is suggested here that the two approaches are linked in the sense that a majority of students recognize the importance of mastering both of them [anatomy and physiology] to develop understanding, but also that the extent to which each student moves between perspectives can be seen as an indicator of depth" [Wilhelmsson et al., 2010, pg. 162]. These findings indicate that a majority of students in their study moved beyond simple memorization and attempted conceptual understanding of "form fol-

lows function" despite the fact that they were only responsible for learning "form" in the anatomy course.

Wilhelmsson, Dahlgren, Hult, and Josephson [2011] also published a phenomenography of eight medical students nearing graduation. The expressed focus of the article was on the *nature* of learning anatomy, rather than a process. The authors note "memorization acts may well be part of an intention towards understanding, and understanding in turn needs to be committed to memory" [Wilhelmsson et al., 2011, pg. 154]. These findings indicate some type of spiral pathway to describe the *process* of understanding. The reported results grouped the "ways of understanding anatomy" into four categories: contexualization (the need to connect the topics to other subjects), visualization, selection (development of knowledge over time), and anatomical language. In addition, the informants were described as having developed two qualitatively different forms of understanding: perceptual (static understanding of parts) and conceptual (theoretical). The paper gave additional information to define important terms. Consider the following quote:

> When students discussed their understanding, it was necessary for them to define an opposite of understanding, which they termed "rote learning" or "memorization"... Deep and surface approaches to learning denote the intention students have in going about the learning task, while memorization and understanding describe what actually takes place when they do this [Wilhelmsson et al., 2011, pg. 161].

Fyrenius and colleagues attempted to elucidate the approaches taken by students to achieve understanding about physiology in another Clinical Research work [Fyrenius et al., 2007]. This phenomenographic study involved single interviews with 16 medical students. The medical program these informants were attending was

taught using problem-based learning. The results outlined two groups of findings 1) the approaches to achieving understanding and 2) relationships of detailed knowledge to understanding of wholes. The authors described approaches to understanding as "Sifting," "Building," "Holding," and "Moving," but group "Holding" and "Moving" as subgroups of "Building." They also present the spread of informants across these categories. Only one informant stayed within the "Sifting" category throughout the interview, but five other informants stayed in either "Holding" or "Moving." For the relationships of detailed knowledge to understanding of wholes, three categories were identified. A linear conception was evidenced by an "unproblematic" relation between parts and wholes. In contrast, a competing view conceived that details could be studied at the expense of understanding the whole. The collaborating conception was evidenced when details and wholes were studied together and the understanding of whole evolved simultaneously. All participants stated that understanding details in physiology could be achieved at different levels (for example: cellular vs. organ level), but the process was experienced in these different ways. The authors discuss the connection of these findings to those of previous SAL literature, specifically aligning the categories of approach to understanding to surface and deep approaches to learning.

When researchers build on findings from discipline-specific learning theory, "Teaching Interview" research is conducted (stage 3 in Figure 1.1). This could involve creation of new research questions based on findings from Clinical Research, as indicated by arrow 2 in Figure 1.1. Examples of "Teaching Interview" research include a large body of work within science education seeking to understand processes and strategies used by students to solve problems, as well as research to find information about student misconceptions as discipline-specific, foundational knowledge. "Teaching Interview" research is distinguished from Action Research by the research

design, specifically by being experimental or quasi-experimental in most cases. Several studies have sought to elucidate cognitive processes while students undertake specific academic tasks. For example, Prevost and Lemons [2016] sought to understand problem-solving procedures used by students when answering multiple-choice questions about biological concepts. Their findings indicate the importance of modeling domain-specific problem-solving for students, moving them from simple recognition of content when studying to greater depth of understanding of the concept. While this study possesses several features of Clinical Research, the authors also present several applications to teaching practice which falls more closely in line with other "teaching interview" publications.

Within anatomy and physiology education, Cliff [2009] used a conceptual diagnostic test of two questions, as well as written explanations for their answers, to assess student understanding of concepts related to calcium and phosphate homeostasis. The majority of student explanations demonstrated misconceptions about the application of chemical principles to physiological mechanisms. The author describes pedagogical interventions and changes to correct this issue in future classes. Lira and Gardner [2017] conducted interviews with 10 undergraduate students enrolled in a physiology course to understand how mechanisms and functions were characterized. The findings from their qualitative analysis revealed a "struggle to coordinate and distinguish mechanisms from function due to cognitive processes germane to learning." These authors then provided instructional suggestions to incorporate their findings into the classroom.

Pandey and Zimitat [2007] explored the relationships between perceptions of and approaches to learning anatomy utilizing both quantitative and qualitative data in a study that would also be considered "Teaching Interview" Research. Ninety-seven medical students self-reported their study approaches through the Study Process

Questionnaire (R-SPQ-2F) [Biggs et al., 2001] and also responded to three open-ended survey questions presented on a website. From the qualitative data collected from the three survey questions, student approaches fell into multiple categories, but three were highlighted: memorizing, understanding, and visualizing, along with a combination of these approaches. For students that mentioned more than one approach, there was variation of sequence of events and emphasis. However, 47 participants did not identify any of these categories. Data from the Revised Study Process Questionnaire (R-SPQ-2F) showed how students approach a subject, and gave information about both motivation and strategy [Pandey and Zimitat, 2007]. These are categorized as surface approaches (SA) or deep approaches (DA) to learning. For 63% of the students in this study, their DA score was higher than their SA score. Of note, memorization strategies were reported in the survey questions by 44% of students with high SA scores, compared to 33% of students with high DA scores. Overall, the authors note that students showed reliance on both surface and deep learning approaches when learning anatomy. They also conclude that there is a positive relationship between a student's approach to learning and the quality of learning demonstrated on the final examination questions. Pandey and Zimitat note that students frequently focus on memorization when learning anatomy, pointing to the importance of further attempting to understanding the process of learning students use. Like Fyrenius et al. [2007], these findings provide a possible framework for future work about student learning in A&P courses.

Following recommendations from "Teaching Interview" research, Action Research sometimes follows (stage 5 in Figure 1.1). Action Research seeks to apply findings and recommendations in a broader context and is usually observational and descriptive, as opposed to experimental or quasi-experimental as seen in previous steps. Examples of Action Research are prevalent in the literature for both biology

and anatomy/ physiology education. The most commonly published work in this area investigates the effect of an instructional technique or practice on student performance [Entezari and Javdan, 2016, Franklin et al., 2015, Lin et al., 2012, Lombardi et al., 2014, Momsen et al., 2013, Montayre and Sparks, 2017, Saltarelli et al., 2014, Vanags et al., 2013]. For example, Momsen, Offerdahl, Kryjevskaia, Montplaisir, Anderson, and Grosz [2013] compared the cognitive skills assessed in introductory biology exams and found an overwhelming majority of questions written to assess knowledge (54%) or comprehension (39%).

A number of studies over the past 20 years have sought to clarify some aspect of a student's approach or intention for learning in the context of physiology or anatomy courses. Other work has attempted to assess teaching practices without a connection to the impact on students or their performance. These studies would be examples of Action Research. As an example, Roth and Anderson [1988] discussed how textbooks could assist in confronting student misconceptions of course content. Franklin et al. [2015] sought to understand how specific pedagogical practices impacted learning of undergraduate students. Students were divided into three instructional groups, which were taught using a different instructional strategy. Other research in this area may include description of existing programs, like that described by Hughes [2011], or understanding student perceptions of anatomy or physiology courses, similar to the work by Andrew John Notebaert [2009]

It is important to re-emphasize that the above examples did not clearly follow from research in the preceding step in Figure 1.1. However, they are examples of particular "steps" for the development of evidence-based instructional practice. The research in most DBER fields has proceeded in a more haphazard fashion, with many projects being undertaken with little connection to previously established theory or practices. In addition, the pathway indicated on Figure 1.1 intentionally does not con-

tain bi-directional arrows. While some relevant information may flow "backwards," findings downstream do not allow for direct building of the previous informational piece. As an example, findings from "Teaching Interview" research do not provide a full picture to allow learning theory development in the absence of Clinical Research. Additionally, the lack of any orderly progression may account for the lack of generalizability or transferability of research findings at the "Teaching Interview" and Action Research steps to Evidence-Based Practice with biology education, specifically. Additional shortcomings in the DBER literature have been noted by Talanquer [2014], such as the need for additional conceptual integration and translation into practice. We can only begin to address these shortcomings by addressing the gaps that exist in the Clinical Research literature in each area of DBER, including anatomy and physiology education research with undergraduate students.

1.2 Purpose of This Study

The above examples seem highlight the need for additional Clinical Research and "Teaching Interview" work within anatomy and physiology education research. Baxter-Magolda [2009] and others have noted the differences in learning due to student maturity and age. All of the previously reported studies in A&P education have been conducted in the context of medical education and with medical students. Undergraduate students have different experiences, motivations, and ultimately, processes of learning [Felder and Brent, 2004, Baxter-Magolda, 2009]. Ultimately, few studies have been conducted to understand the cognitive processes that are used or important for learning in the context of A&P education of *undergraduate students*. Therefore, I undertook this research as an item of Clinical Research to understand the cognitive processes that are used by undergraduate students learning the related

subdisciplines of anatomy and physiology. This information is imperative to allow for the design and implementation of evidence-based instructional strategies in anatomy and physiology, as well as other areas of life science education.

1.3 Terms

Learning To build a context-dependent Learning Theory, a clear definition of "Learning" is essential. However, this is a difficult task, since many definitions are used in the literature and are not always in agreement. In fact, many studies provide no specific definition of the term "learning" despite utilizing the term frequently. In this study, I draw from several works, which are outlined below. In the final chapter of the book *Improving Learning: New Perspectives*, Marton and Ramsden state:

> Learning should be seen as a qualitative change in a person's way of seeing, experiencing, understanding, conceptualizing something in the real world - rather than as a quantitative change in the amount of knowledge someone possesses. It is logically impossible for learning defined in this way to be content- and context-free. Learning techniques and instructional strategies are inextricably linked to subject matter and the students' perceptions [Marton and Ramsden, 1988, pg. 271].

Roth and Anderson [1988, pg. 139] use a similar definition, saying that learning is a "difficult and complex process of conceptual change, not a process of acquiring and memorizing facts." These definitions are in agreement that learning is a process that changes the learner and is not a process of acquiring facts or information. More recent work in biology education research has adopted a definition of learning to include both acquisition of facts and conceptual change. Southard, Wince, Meddleton, and Bolger

[2016] have defined learning as "a dynamic process involving the acquisition of new ideas, the development of connections between ideas, and the reorganization of prior knowledge" (pg. 2). Wilhelmsson et al. [2010] define learning as "the ability to identify structures with their internal relationship and the talent to compile details into a three-dimensional whole" (pg. 154). All of these studies and others [Bailin, 2002] are in agreement that learning is context-dependent and may take many forms, but they disagree about the inclusion of quantitative changes or knowledge acquisition. In this study, I define "learning" as both the act and process of *developing knowledge objects*. A "knowledge object" is defined as a tightly integrated body of knowledge [Entwistle and Entwistle, 2003]. I believe my definition captures the essence outlined by Southard et al. [2016] and is consistent with more recent scholarship on "learning" described above.

Understanding "Understanding" has been defined in multiple ways in the literature, as well. Kember [1996] defined understanding as "the intention of seeking inherent meaning." Fyrenius et al. [2007] defined the term to mean "capability in action." Wilhelmsson et al. [2011] provide a more detailed definition, stating that understanding is "the mental act of connecting parts into a coherent system, as well as decomposing larger objects into sub-parts." Interestingly, the Wilhelmsson et al. [2011] definition is incongruous with that provided by Kember [1996]. In addition to a lack of agreement on the definition of "understanding," there is also a lack of consensus on the appropriate method to measure this state. Despite the lack of consensus regarding the definition of "understanding," or standards for measuring it, previous studies consistently indicate that instructors believe that understanding is the desired end-point or "destination" of student learning, while also noting that memorization is frequently employed by students as a course strategy [Entwistle and Entwistle, 1991,

Kember, 1996, Michael, 2007, Pandey and Zimitat, 2007, Wilhelmsson et al., 2010, Slominski et al., 2019]. In this study I define "understanding" as *possessing a relevant knowledge object that can be applied to a problem.*

Cognitive Processes Previous work by Roelle, Nowitzki, and Berthold [2015] connects "cognitive processes" to the development of understanding. "Cognitive processes" may be defined as "the internal and external actions by which learners construct knowledge." This may include "identifying or structuring main learning content" or "generat[ing] examples that link new content to prior knowledge" [Roelle et al., 2015]. Gaining information about the cognitive processes of students is imperative to allow for the design and implementation of evidence-based instructional strategies and/or learning tools for undergraduate students. Because learning and understanding are context-dependent, it is important to examine the strategies, intentions, and processes by which students develop knowledge objects (i.e. learn) for each core life science concept. In this study, I asked participants to focus on their learning of the concept of "homeostasis," which is considered by Michael et al. [2017] to be the most important concept in the A&P curriculum, as these mechanisms affect the function of all the body's organ systems.

Student Approach to Learning Present research on student learning has been built on findings from the 1970s and 1980s related to student learning approaches and whether these approaches are *fixed-* or *context-dependent* [Beattie et al., 1997]. This body of literature is often referred to as Student Approach to Learning (SAL) and its progression can be traced through four main research groups.

The Lancaster group led by Entwistle mainly used quantitative methods of study and delineated specific types of learners accounting for a student's personality,

motivation, and study methods. Originally, this group held that a student's approach to learning was a fixed characteristic, but later amended that view in light of findings from the other three SAL research groups. The Swedish group led by Marton mainly used the qualitative approach of phenomenography in describing deep and surface learning. The main contribution from this group was that a student's intention when learning was critical, and SAL was flexible and context-dependent [Marton and Saljo, 1976]. The Richmond group led by Pask also adopted a qualitative approach to studying SAL and reported two main approaches, which they termed as serialistic (mastery of procedural skills) or holistic (construction of knowledge, development of comprehension). These terms were described in conjunction with deep or surface learning approaches, but were used less frequently in the broader literature.

The Australia group was led by John Biggs and mainly utilized quantitative methods to understand student approaches to learning. Biggs developed various iterations of a learning model which recognized the impact of student characteristics, teaching context, learning processes, and learning outcomes. He also developed the Study Process Questionnaire (SPQ) to distinguish between deep and surface learning approaches of students. This instrument categorizes students based on their motive for learning and strategies used. In addition, Biggs developed the Congruence Hypothesis which outlines how effective learning requires *congruence* between surface or deep approaches to both the motive and strategy in learning. Biggs also held that learning and its approach were context dependent and flexible [Beattie et al., 1997]. The work of Biggs is used in this project and additional discussion will be provided in a future section.

Beattie, Collins, and McInnes [1997] summarize the findings from this period of work in this manner:

> Thus this literature, viewed as a whole, demonstrates that a student's approach to learning is only partly a function of his or her general characteristics, since it can be modified by specific learning situations. Such situational influences include the students' perception of the relevance of the learning task, the attitudes and enthusiasm of the lecturer and the expected forms of assessment. The extent to which a student's predilection for a particular approach can be modified is determined by their meta-learning capability [Beattie et al., 1997, pg. 10].

Looking at the connection of this line of research to understanding and learning, the specific *ways* of understanding are closely aligned with SAL. SAL can be viewed as a bottom-up process which combines both affective traits of the student and the specific learning context. This interaction leads to a specific cognitive response to the task. Overall, the idea of deep and surface learning was widely adopted in the study of learning in higher education and beyond. As research programs moved forward, they began to focus on how to promote deep learning, as well as how to assess deep learning in students [Beattie et al., 1997].

Surface and Deep Approaches to Learning The terms of deep approach and surface approach to learning are widely used in education research over the past 40 years. Table 1.1 presents specific details of how these terms are defined. A deep approach to learning has been previously defined as "an approach that connects new information to previous relevant knowledge" [Beattie et al., 1997] and is clearly aligned with a focus to gain understanding of meaning and an intention to comprehend [Marton and Saljo, 1976]. Biggs also connected this approach to the process of "internalizing" which is an interest in personal growth and an intrinsic motivation to learn. When viewing the full body of SAL literature, deep learning is

Deep Approach	· Is interested in the academic task and derives enjoyment from carrying it out. · Searches for the meaning inherent in the task. · Personalizes the task, making it meaningful to own experience and to the real world. · Integrates aspects or parts of task into a while, see relationships between this whole and previous knowledge. · Tries to theorize about the task, forms hypotheses.
Surface Approach	· Sees the task as a demand to be met, a necessary imposition if some other goal is to be reached. · Sees the aspects or parts of the task as discrete and unrelated either to each other or to other tasks. · Is worried about the time the task is taking. · Avoids personal and other meanings the task may have. · Relies on memorization, attempting to reproduce the surface aspects of the task.

Table 1.1: Description of deep and surface learning approaches [Kember, 1996]

nearly synonymous with Pask's definition of a holistic approach to learning. A surface approach to learning has been previously defined as "an approach that focuses on bare essentials and reproduces through rote learning or memorization." [Beattie et al., 1997]. Other characteristics may also include memorization to succeed on a test, retention of literal aspects with no critical analysis or personal contribution, or simply storage of information [Marton and Saljo, 1976]. Biggs also connected this approach to the process of "utilizing" which is viewing study as a task to accomplish and overcome to pursue a career. When viewing the SAL literature, surface learning is nearly synonymous with Pask's definition of a serial approach to learning.

Multiple quantitative measures have been developed which use the terminology of surface and deep approach to learning. Of note are the Approaches to Studying Inventory (ASI) [Entwistle and Entwistle, 2003], Student Cognitions about Learning (SCALI) [Ferla, 2008], and the Inventory of Learning Styles (ILS) [Vermunt, 1994]. As previously mentioned, the Australian group developed a 43-question quantitative

instrument, the SPQ, to categorize students as surface or deep learners. This instrument was later revised and shortened to a 20-question instrument, termed the Revised Study Process Questionnaire (R-SPQ-2F). This instrument had the same intention as the original SPQ, but also categorized students on the two factors of motive and strategy. A summary of these categorizations can be found in Figure 1.2.

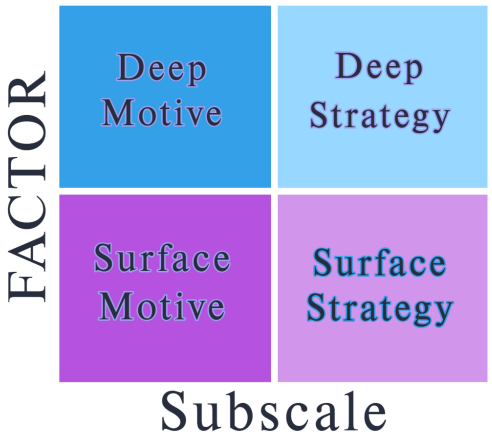

Figure 1.2: A graphical representation of the factors and subscales measured by the R-SPQ-2F [Biggs et al., 2001]

As deep and surface learning approaches were studied in additional cultures and contexts, new questions arose. The simple categorization of deep or surface approach and the associated motives and strategies failed to capture the approaches taken by all students. A "new" approach of learning that combined understanding and memorization was described and coined as an "achieving" learning approach by Kember [1996]. In addition, this work focused on how a student's preferred learning approach interacted with the teaching environment to produce learning activities. Ultimately, Biggs' work has a specific focus on trying to influence pedagogy and has been broadly applied in many context-specific areas of higher education. Given the desire for this research to develop a context-specific learning theory to inform evidence-based practices, use of Biggs' models and ideas seems most appropriate.

As previously mentioned, I define *learning* as developing a knowledge object/ tightly integrated body of knowledge. However, learning may take the different forms of surface or deep learning. I define *surface learning* as focusing on bare essentials and reproduction through memorization, while *deep learning* is defined as connecting new

Knowledge Object:	a tightly integrated body of knowledge
Learning:	developing knowledge objects
Understanding:	possessing a relevant knowledge object that can be applied to a problem
Surface Learning:	approach that focuses on bare essentials and reproduces through rote learning or memorization [Beattie et al., 1997]
Deep Learning:	approach that connects new information to previous relevant knowledge [Beattie et al., 1997]
Cognitive Processes:	the internal and external actions by which learners construct knowledge [Roelle et al., 2015]

Table 1.2: Working definition of relevant terms.

information to previous relevant knowledge. Understanding is defined in this study as the possession of a relevant knowledge object that can be applied to a problem. Both learning and understanding can be the result of *cognitive processes* which are defined as the internal and external actions by which individuals construct knowledge. A summary of the working definitions used in this study is available in Table 1.2.

Curriculum Differences in Anatomy and Physiology The life science subdisciplines of Anatomy and Physiology are often linked since they both describe the human or animal body. Anatomy is the study of the names or parts of the body, while Physiology is the study of the functions and interactions within the body. In medical education, the topics are separated with Anatomy being taught first and Physiology following in later terms. In undergraduate education, these areas of study may be taught separately or together. For curriculum that separates these subdisciplines,

Anatomy is completed in one semester with Physiology completed in another. The order in which the courses may be taken could be mandated is sometimes mandated by the institution. Other curriculum teaches these topics in an integrated manner. This most commonly results in a two-semester sequence of Anatomy & Physiology, often referred to as A&P I and A&P II.

Within medical education, Wilhelmsson et al. [2010] noted that medical students enrolled in an Anatomy course often sought to contextualize the content of the course, most commonly by connecting the content to Physiology, a course they would enroll in during a later semester. In a later publication, they note:

> Anatomical knowledge does not seem to be self-sufficient in terms of understanding, and [neighboring] disciplines are, therefore, needed to arrive at understanding ([Wilhelmsson et al., 2011, pg. 158]).

1.4 Research Questions

Despite continued attention to the improvement of undergraduate biology and A&P education, we still understand little about the context-dependent cognitive processes and pathways students use while learning the life sciences. Such information could begin to form context-specific learning theory for the life sciences and its subdisciplines. This research seeks to fill this gap by *describing the cognitive processes and pathways used by undergraduate students while undertaking the task of learning A&P.* To do so, I have undertaken multiple stages of comparative case analysis to address the following specific questions.

What are the differences and similarities in cognitive processes and pathways for:

RQ1: Students enrolled in a course sequence of Human Anatomy → Human Physiology (A→P) vs. Anatomy & Physiology I → Anatomy & Physiology II (A&P1→2)?

RQ2: Students with surface learning approaches vs. deep learning approaches?

Chapter 2

BACKGROUND

2.1 Presage-Process-Product (3P) Model

As noted in Chapter 1, there is no consensus on the definitions of key terms such as "learning" or "understanding," and no context-dependent learning theory has been published to focus or guide additional educational research within biology or the associated sub-discipline of anatomy & physiology. However, previous work from SAL has produced learning theories that have been applied within specific contexts.

The Australian Group, led by John Biggs, utilized quantitative methods to categorize student learning approaches as *surface* or *deep*. This led to the development of the Presage-Process-Product (3P) Model [Biggs et al., 2001] (see Figure 2.1) in which students' approaches to learning are situated within a larger educational system that includes dynamic interactions between student factors, teaching context, on-task approaches to learning, and learning outcomes. The Presage factors (termed "predictive" factors in some literature) include Teaching Context and Student Factors. Teaching context, as defined by Biggs includes the overall learning environment, course and exam design, teaching and assessment methods, and the instructor's be-

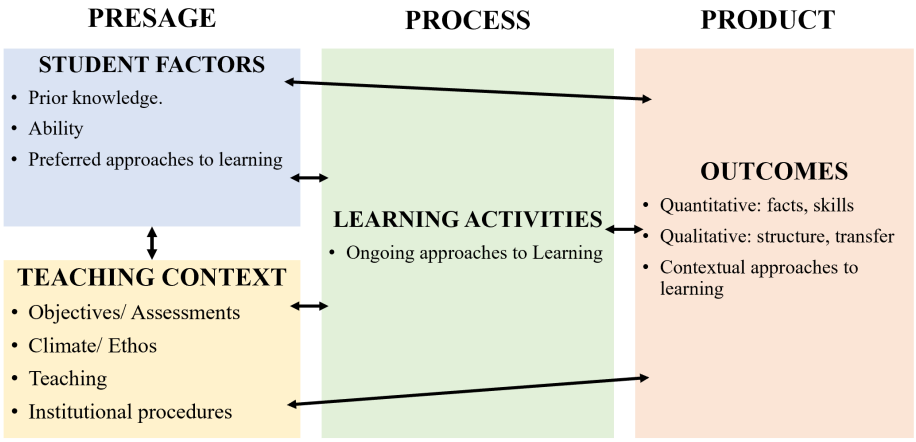

Figure 2.1: The 3P (Presage-Process-Product) Model for student approaches to learning [Biggs et al., 2001].

liefs. Student factors were defined by Biggs to include information processing skills, personality, age, prior knowledge, motivation, and preferred approaches to learning. The Process factor includes the single area of Learning Activities, defined as "how students approach a task." This included actual approaches to learning within the context, which encompasses motivation and study strategies. The Product factor includes the single area of Learning Outcomes, which included quantitative, qualitative and affective results.

In his review of the contributions of Biggs, Barattuci [2017] describes the 3P Model in this way:

> With regard to predictive variables, we can see that the student's individual characteristics include information processing skills, personality, age, prior knowledge in similar or preparatory subjects, prediction of success, motivation. The characteristics of the educational context include environmental variables such as course and exam design, teaching and assessment methods, type of exams, teachers' beliefs about teaching and students. Compared to the previous [versions of] models, the division into

> groups of variables involved in the learning process, is neither strict nor unidirectional. In fact, not only changes in predictive variables can determine changes in approach to study and, as a results, in outcomes, but outcomes, in turn, can affect the subsequent learning experiences and can act backwards by influencing process and predictive variables. ([Barattuci, 2017, pg. 82-83])

Therefore, the 3P Model serves as a fruitful starting point or framework from which to better understand these processes in specific contexts.

Previous research has been conducted using the 3P Model [Biggs et al., 2001] as a theoretical framework. Clinton [2014] sought to examine the impact of a student's preferred approach to learning on the Process stage of the model. In her work, she asked 67 participants to read and comment, using a think-aloud protocol, on expository texts about different scientific concepts. Participants also completed the revised Study Process Questionnaire (R-SPQ-2F), an instrument developed by Biggs et al. [2001] and described in Chapter 1, and pre- and post-testing using open-ended questions to assess information recall and deeper understanding. While the data analysis showed some positive correlations of accurate answers on comprehension questions and students scoring with a high deep approach to learning, I have concerns about the design of this study. First, the task set before the students was "artificial," meaning the tasks were not a part of a specific context. While this is similar to the work of Marton and Saljo [1976], more recent scholarship has highlighted the importance of this aspect of SAL. In addition, Clinton notes that student approach to learning is not a fixed characteristic, but then administers the R-SPQ-2F after the reading, think aloud, and post-term processes, activities which Biggs acknowledges to alter student approach [Clinton, 2014, Biggs et al., 2001]. Because of these issues,

it is difficult to use Clinton's findings about learning process. In a separate study, Ganotice and Chan [2019] utilized the 3P Model to better understand the roles of specific presage, process, and product traits in the context of computer-supported interprofessional team-based learning. However, the model they produced limited the characteristics measured in each area of the model and was conceptualized as a linear process.

Others studies have sought to confirm the relationships and interactions in the 3P Model utilizing structural equation modeling. Fryer and Ginns [2017] conducted a longitudinal study to quantify the relationships theorized in the 3P Model. Their findings support the reciprocal relationships represented in the model, but note that these may not easily predict student achievement. Lee and Chan [2018] also conducted a longitudinal study to quantify relationships between Presage, Process, and Product areas of the model. However, they measured a single variable, student epistemic beliefs, for the Presage area. It is notable that this student characteristic has not been associated with Student Characteristics of the 3P Model in previous work. Additionally, there was movement for some variables in the 3P Model factors demonstrated in this study. For example, student perception of the learning environment was considered a Process variable, rather than a Presage variable.

Despite the remaining questions about the 3P Model as a predictive tool, there is little question that the noted areas in the model are important factors to consider concerning student learning and that there are interactions between the groups. As noted by Barattuci [2017]:

> The strength of the construct approach to study lies in the fact that it is focused on a set of factors influencing the quality of learning, such as

learning and teaching environment, types of teaching and assessment, and the related students' perceptions.

Therefore, use of the 3P Model to guide data collection in a qualitative study would be valuable. However, the Process factor of the model, also described as Learning Activities, is not fully defined or described by Biggs et al. [2001]. Given the aim of this study is to better understand these processes, previous research in A&P education provides additional structure and detail for this area of the 3P Model.

2.2 Learning Activities in Anatomy & Physiology Education

As noted in Chapter 1, examples of Clinical Research in A&P education include work by Wilhelmsson, Dahlgren, Hult, Scheja, Lonka, and Josephson [2010], Wilhelmsson, Dahlgren, Hult, and Josephson [2011], and Fyrenius, Wirell, and Silén [2007]. The work led by Wilhelmsson et al. [2010, 2011] identified approaches to learning and ways of understanding. However, Fyrenius et al. [2007] categorized approaches to learning with additional categories and details. In addition, the work of Pandey and Zimitat [2007] described learning activities are used in A&P courses.

Fyrenius, Wirell, and Silén [2007] described four approaches to learning as "Sifting," "Building," "Holding," and "Moving," but grouped "Holding" and "Moving" as subgroups of "Building." Sifting is defined as "receiving or condensing information from books and teachers," while Building is defined as "actively relating new information to previous knowledge." Within Building, Holding is defined as "structuring and reorganizing information in a way that may be threatened by new input or information." Moving is defined as "continuously striving for change in perspec-

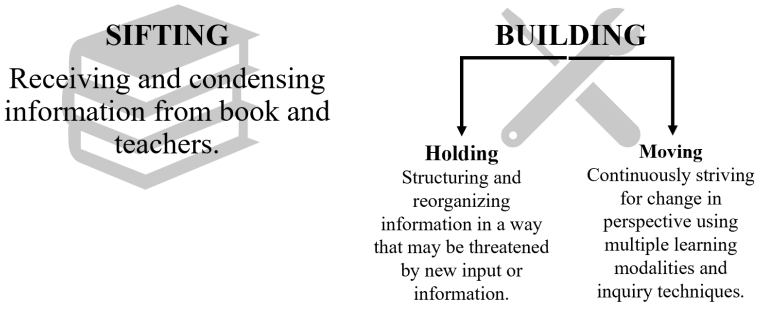

Figure 2.2: A graphical representation on approaches to learning from Fyrenius et al. [2007] with their definitions.

tive using multiple modalities and inquiry techniques." A visual representation with category definitions is provided in Figure 2.2.

Pandey and Zimitat [2007] collected both quantitative and qualitative data to understand the relationship between perceptions and approaches to learning anatomy. Students (n=99) were asked to complete a series of three open-ended questions asking about their perceptions of successful approaches to learning anatomy in their current course. The questions were:

1. What is the best approach to learning anatomy?

2. How did you go about learning anatomy?

3. Elaborate on resources used to study anatomy this semester.

The resulting qualitative data was read by the research team to identify the general themes. These were presented in a tabular format with number of students who mentioned each particular group/ idea. These results were grouped into three areas - Internal approaches, External approaches, and Motivation. Internal approaches were memorizing, understanding, and visualizing. External approaches were attending class, discussing, drawing or note-taking, revising constantly, taking time on task, and using specimens. Motivation approaches identified were finding the material interesting and working hard. (See Table 2.1.)

Themes identified by Pandey and Zimitat [2007]	Themes identified by Fyrenius et al. [2007]
EXTERNAL	**INTENTION**
Attending class	Sifting
Discussing	Building
Note-taking/ Drawing	Holding
Revising constantly	Moving
Taking time on task	
Using specimens	**CONCEPTION**
INTERNAL	Linear
Memorizing	Competing
Understanding	Collaboration
Visualizing	
MOTIVATION	
Finding interesting	
Working hard	

Table 2.1: Themes identified by Pandey and Zimitat [2007] and Fyrenius et al. [2007] in previous work.

2.3 Pilot Study

No published work has been conducted to understand the processes of learning in undergraduate A&P courses. Therefore, it was important to conduct a pilot study to both determine which of these existing frameworks would be useful in the full study and to see what type of information would come from prompts used in previous SAL studies with undergraduate A&P student populations. Given my desire to understand the cognitive processes and pathways of learning in physiology over the course of an academic year, weekly diary entries were determined to be the most practical approach to gather this information.

Methods Two female students at a small, private liberal arts university volunteered to respond to two weekly prompts over the duration of two courses: Anatomy & Physiology I and II. I created a shared GoogleDoc for each student and this was updated weekly with two new questions. Seven pairs of prompts (one prompt for *learning process* and one for *learning product*) and one inclusive prompt were tested

over the course of 10 weeks in fall 2017 and spring 2018 semesters. The previous week's responses were cut from the GoogleDoc and pasted into an unshared document. At the conclusion of the spring semester, I unitized and masked all responses to hide prompt number, week, and participant identifiers. I coded the unitized data [Campbell et al., 2013] using simultaneous coding of process codes and provisional codes [Saldaña, 2016]. For both categories, *a priori* codes were used. Process codes describe actions in the data [Saldaña, 2016] and were taken from Pandey and Zimitat [2007]. The Pandey and Zimitat [2007] framework used 12 codes, as two groups from the original publication were split to better fit the pilot study data (indicated with "a" in Table 2.1) Provisional codes provide anticipated categories based on previous qualitative work [Saldaña, 2016], in this case from Fyrenius et al. [2007]. The use of these *a priori* codes provided an opportunity for communicative validity, by ensuring that the prompts elicited information from participants that aligned with the theoretical frameworks under consideration [Walther et al., 2013]. I bracketed throughout the process about my thoughts and observations. These reflections included discussion of the length and depth of response at each data collection and the emerging ideas during coding and analysis. .

I revised these codes as gerunds to be used as process codes [Saldaña, 2016] without changing their meaning. The Fyrenius framework used seven codes (see Table 2.2). I developed a complete code book to define each code as applied to the data. Of the 92 units of data, only 10 of these units did not code into either framework. As an example:

> The information this week was pretty self explanatory talking about senses I do not have any questions regarding the lectures. (Participant 1, sample uncoded quote)

Codes from Pandey and Zimitat [2007]	Codes from Fyrenius et al. [2007]
EXTERNAL	**INTENTION**
Attending class	Sifting
Discussing	Building
Drawing[a]	Holding
Note-taking[a]	Moving
Revising constantly	
Taking time on task	
Using specimens	**CONCEPTION**
INTERNAL	Linear
Memorizing	Competing
Understanding	Collaboration
Visualizing	
MOTIVATION	
Finding interesting	
Working hard	

Table 2.2: *A priori* codes from Pandey and Zimitat [2007] and Fyrenius et al. [2007] Used in Pilot Study

However, all prompts produced at least one coded unit between the two participants. In general, *learning product* prompts produced shorter answers with less detail than the *learning process* prompts. The information suggests that communicative and pragmatic validity are present for the weekly diary prompts used in this pilot study.

I mapped the first cycle codes from Pandey and Zimitat [2007] and Fyrenius et al. [2007] for both of the participants over the time of the pilot study (see Figure 2.3). It is unknown how the student's preferred approach to learning or course performance could have impacted their pathways to learning, as this data was not collected during the pilot study. However, the selected prompts were sufficient to provide information from students about their learning processes, as defined by both Pandey and Zimitat [2007] and Fyrenius et al. [2007].

To determine which framework was most appropriate to answer my research question, I entered the assigned codes for both frameworks into an Excel spreadsheet, and counted each match between the codes. This process provided information about the relationship of the frameworks to each other. The matched codes with example

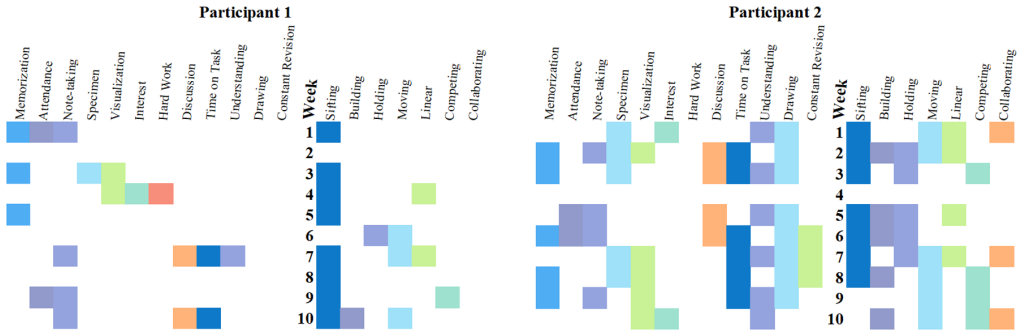

Figure 2.3: Map of Pandey and Zimitat [2007] and Fyrenius et al. [2007] codes throughout the pilot study. Different colors were used to make columns easier to distinguish and are not intended to convey qualitative differences among the categories.

quotes are provided in Appendix A. I also created a Sankey diagram to show the alignment between the frameworks. Eleven units coded in only one framework, with six units coding only in the Pandey and Zimitat [2007] framework and five units coding only in the Fyrenius et al. [2007] framework. There was no exact alignment for codes in the two frameworks. I then created focused codes [Saldaña, 2016] from the *a priori* codes (see "bold" terms in Figure 2.2) for each framework to see if alignment were present at a higher level. The Pandey codes were grouped into Internal (memorizing, visualizing, understanding), External (attending class, note-taking, revising constantly, using specimens, taking time on task, discussing, drawing), and Motivation (working hard, finding interesting) [Pandey and Zimitat, 2007]. The Fyrenius et al. [2007] codes were grouped into two groups, as presented in their paper - **Intention** (sifting, building, holding, moving) and **Conception** (linear, competing, collaborating). Figure 2.4 shows the alignment of the focused code groups between the frameworks.

In both rounds of coding, unexpected results are present. For example, "Memorizing" is often maligned in the literature as an something students should move

beyond [Pandey and Zimitat, 2007, Wilhelmsson et al., 2010]. However, some cases are showing "memorizing" to align with the deep learning strategy of "moving."

> After a lot of repetition and drawing and writing out on a whiteboard many different times in different colors, I feel more confident in these areas and am not confusing them as easily." (Participant 2, sample quote demonstrating alignment of "memorizing" with "moving.")

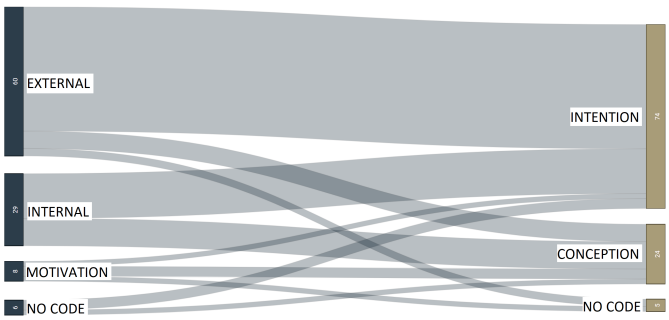

Figure 2.4: Sankey diagram representing alignment between focused codes of Pandey and Zimitat [2007] and Fyrenius et al. [2007].

The pilot study data provided two main findings that informed the full study. First, the prompts selected from previous literature did elicit information from students about their approaches to learning in A&P courses [Pandey and Zimitat, 2007, Roelle et al., 2015, Tanner, 2012, Metzger et al., 2018]. Second, these data indicate that the frameworks from both Pandey and Zimitat [2007] and Fyrenius et al. [2007] are important to understanding the cognitive processes and pathways used by undergraduate students when learning physiology. These codes [Pandey and Zimitat, 2007, Fyrenius et al., 2007] can be embedded within the *Learning Activities* of the 3P+ Model to yield the theoretical framework informing my study and shown in Figure 2.5.

Quality Concerns The Q3 Quality in Qualitative Research framework provides language, rigor, and typology for making and handling data in a qualitative study

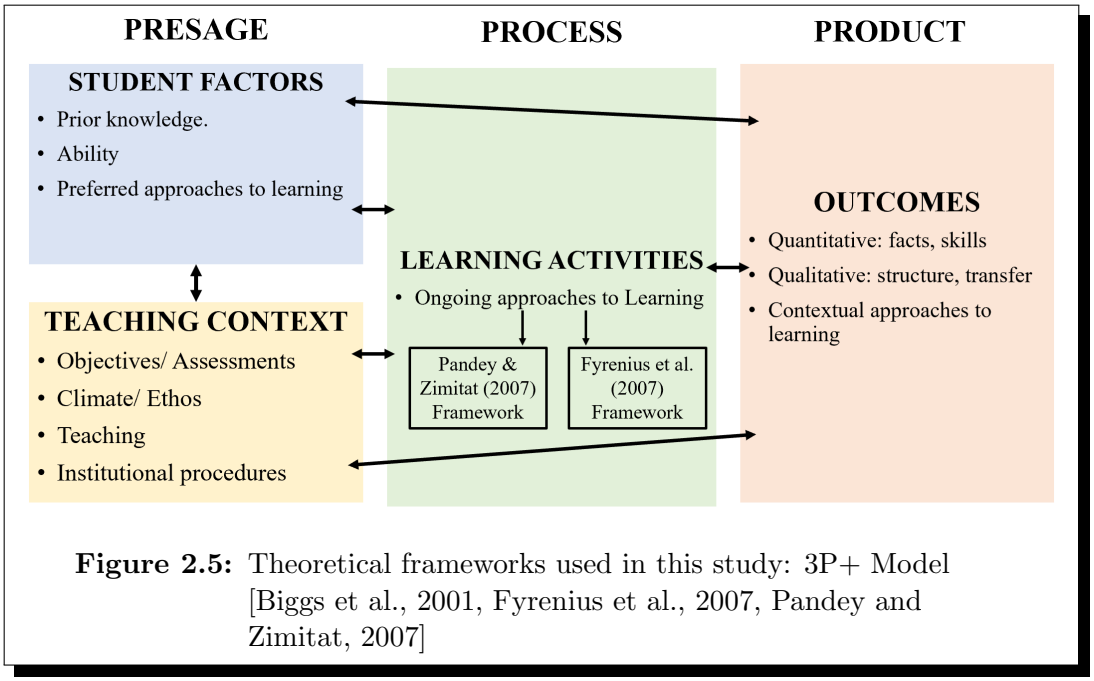

Figure 2.5: Theoretical frameworks used in this study: 3P+ Model [Biggs et al., 2001, Fyrenius et al., 2007, Pandey and Zimitat, 2007]

[Walther et al., 2013]. Conducting this pilot study provided opportunities for procedural, pragmatic, and communicative validation in this work. Procedural validation suggests that features should be introduced into the research design to improve the fit between theory and the phenomenon under investigation [Walther et al., 2013]. Pragmatic validation concerns the extent to which theories are compatible with empirical reality [Walther et al., 2013]. Opportunities for procedural and pragmatic validation were present through the use of existing frameworks while remaining open to the story told by the participants. Communicative validation allows for co-construction of knowledge in the research context and the research community [Walther et al., 2013]. Opportunities for communicative validation were present through the use of writing prompts. This allowed for an accurate capture of participant thoughts for analysis. While the use of previously published frameworks can help provide structure and direction for my analysis, they may not be in line with the processes and pathways demonstrated within these cases. Therefore, it was important to remain

open to the story told by the data, from the pilot study stage to the conclusion of the study and its dissemination.

Limitations This pilot study was conducted with the intent of beginning to establish procedural, communicative, and pragmatic validation. The collected data cannot be generalized to a broader context. Only two participants were included with only nine weeks of data collected for each. Additional data about the participants preferred approach to learning, ability, or course performance was not collected. However, this data sets the stage to move forward with additional data collection in the form of weekly diary entries and interviews.

Chapter 3

METHODS

3.1 Methodology

I locate my work within an interpretivist or social constructivist theoretical perspective [Mack, 2010]. This perspective approaches a research question from the position that research can attain interpretations of the socially constructed world but these cannot be objectively observed from the outside [Mack, 2010]. Since my research questions are focused on student perspectives and experiences, this theoretical perspective aligns with my expected research findings. This theoretical perspective is based in the epistemology of constructivism and ontology of relativism, which form the basis of my assumptions about my data and eventual findings. As described in Chapter 2, the 3P+ Model [Biggs et al., 2001, Pandey and Zimitat, 2007, Fyrenius et al., 2007] is the theoretical framework for this work. I describe my choice of methodology in the next section. Table 3.1 summarizes the guiding elements of this work.

	Definition	**Selected for This Study**	**Description**
Epistemology	Theory of knowledge	Constructivism	Knowledge is socially constructed by interactions, Researcher and participant cannot be separated
Ontology	The nature of existence and empirical reality	Relativism	Social reality is seen by multiple people who interpret events differently which provides multiple perspectives [Mack, 2010].
Theoretical Perspective	"A loose collection of logically related assumptions, concepts, propositions that orient thinking and research" [Mack, 2010].	Interpretivist (Social Constructivism)	A process of understanding and explaining social reality through the eyes of different participants, recognizing that reality cannot be objectively observed from the outside [Mack, 2010]
Theoretical Framework	Addresses why or how we expect certain relationships to exist	3P+ Model [Biggs et al., 2001, Fyrenius et al., 2007, Pandey and Zimitat, 2007]	Previously used frameworks that outline the various factors and actions that impact student learning
Methodology	Philosophical justification for research design	Comparative Case Study	Analysis of similarities, differences, and pattern across two or more cases, bounded in advance with intent of generalizing about causal effect

Table 3.1: Summary of selected theoretical elements for this research study

Description of Case Study Methodology To study the cognitive processes and pathways of undergraduate students while learning the concept of homeostasis in A&P, I have employed comparative case study methodology. Case study research is intended to provide an intensive, holistic description and analysis of a single entity, instance, phenomenon, or social unit [Baxter and Jack, 2008]. It provides an account of new insights into the processes in question based on observations of the case in question. As noted by Gay et al. [2015], case study research is appropriate when the researcher wishes to focus on a *process*. Generally, the purpose of undertaking a case study methodology is to develop a comprehensive understanding of the phenomenon in question that uncovers relationships applicable to similar situations. In addition, comparative case studies provide an analysis of similarities, differences, and patterns across two or more cases. The outcome of a comparative case study is a thorough description and analysis of a phenomenon of interest that shows similarities and differences between individual cases and allows for replication of findings across cases [Baxter and Jack, 2008].

Other Methodologies Considered The decision to undertake a comparative case study was made after considering several qualitative methodologies. Grounded theory is often utilized when there are no previous theories or those developed are found to be inadequate [Gay et al., 2015]. However, as I have already described in Chapter 2, I plan to use conceptual frameworks previously developed by Biggs et al. [2001], Pandey and Zimitat [2007], Fyrenius et al. [2007]. Therefore, grounded theory methodology was eliminated from consideration. Ethnography may study cultural patterns or participant perspectives in a natural setting [Gay et al., 2015]. However, fully understanding the *processes* that students undertake in their A&P courses goes beyond

an understanding of course culture or participant perspective, and this fact caused ethnography to be elimiated from future consideration.

Phenomenology is focused on understanding the *essence of experience* of a particular group of individuals [Starks and Trinidad, 2007]. The focus of data collection about the student experience would not lead to a complete description of the *processes and pathways* used by students while learning in their A&P courses. Therefore, the focus of understanding the essence of this experience would not allow me to answer the specific research questions I have identified.

Ference Marton, described previously for his contributions to SAL theory, is credited with development of phenomenography, which looks for differences or variations of experience in a phenomenon and has been used in previous studies in A&P education. Marton [1986] describes phenomenography to be "more interested in the *content* of thinking" than the process itself. Since the stated research question for this project desires to focus on *processes used by students*, the use of phenomenography would have prevented me from addressing this aspect. In addition, use of phenomenography would have limited the type of data collected and would have focused only on categories of variation in the participants.

Overall, case study methodology aligns best with my research questions and possesses several strengths. Case study data collection allows for the use of multiple data sources and quantitative data can be integrated with the qualitative data [Baxter and Jack, 2008]. Observational data may be collected over a long period of time, and there is less dependence on structured questions. The varied data collection also strengthens the study, since these various data points provide opportunity for triangulation in the data. In addition, a comparative case study allows for data collection and analysis to understand differences between two or more well defined groups. For this study, the use of comparative case study methodology allows description

and analysis of distinct groups outlined in previous literature and of interest to me. In addition, collecting and analyzing data from multiple sources throughout a two-semester sequence provided me the opportunity to observe and capture the *process* of context-specific knowledge transformation by undergraduate students. Overall, use of case study methodology allowed me to answer the research questions I have posed.

Potential Challenges Given the strengths presented above, case study methodology may suffer from the collection of an overwhelming amount of data [Baxter and Jack, 2008], and this study was no different. Several steps were implemented to overcome this issue, based on recommendations in the literature. First, the data collected was carefully selected to ensure it provided information to help answer the research question. Interview and weekly diary data formed the basis of data collection, with course document collection allowing for triangulation when needed. In addition, computerization of data in a data management and analysis software helped with organizing and viewing of the documents and associated codes. I chose to use NVivo 12 for this purpose [NVi, 2018]. While it is also true that case studies are inherently subjective and care must be taken to ensure reliability and validity throughout data collection and analysis, I chose to apply the accepted quality frameworks of Q3 Framework [Walther et al., 2013] and Legitimation Framework [Onwuegbuzie et al., 2011] to help address these concerns. Specific opportunities and threats to reliability and validity are outlined for each step of the study and are summarized in Chapter 4 in Table 4.9.

3.2 Institutional Review Board Approval Information

An Institutional Review Board (IRB) application was submitted and approved (2018-310) by the Clemson University IRB as an exempt protocol under category B1 [CFR, 2018]. I have maintained human subjects certification and conducted all aspects of this research in accordance with ethical guidelines for human subjects research.

3.3 Case Study Design

3.3.1 Bounding the Cases

In a comparative case study, it is essential to establish the bounds of the cases. This allows for finite data collection and a focus on characteristics of particular concern. The selected bounds were based on findings and limitations noted in the literature [Entwistle and Entwistle, 1991, Pandey and Zimitat, 2007, Wilhelmsson et al., 2010, 2011].

Case 1a/1b As noted previously in Chapter 1, Wilhelmsson et al. [2010] noted that medical students enrolled in an Anatomy course sought to contextualize the content of the course by connecting the content to Physiology. However, undergraduate courses are also offered in an integrated format which combines anatomy and physiology into a two-course sequence of A&P I and A&P II. Because of this finding, I wished to compare students enrolled in a sequence of courses teaching Anatomy separately from Physiology to those enrolled in an Anatomy & Physiology sequence, where the content is presented in context for the students.

Case 2a/2b Entwistle and Entwistle [1991] found that a qualitative analysis of student interviews and written responses paralleled a *surface* and *deep* approach to learning. Pandey and Zimitat [2007] also categorized students on the basis of *surface* and *deep* approach. Their study sought to better understand medical student perceptions of learning anatomy and how that correlated to the quality of learning and course grades. Student approach to learning was quantified by the R-SPQ-2F [Biggs et al., 2001]). Mean scores on the R-SPQ-2F found balanced scores for surface ($\bar{x} = 30 \pm 3.4$) and deep ($\bar{x} = 31 \pm 4.2$) approaches to learning. They noted a significant negative correlation between surface approach scores and final grades (r = -0.30, P<0.01). Successful learning was described by the students as involving hard work, and a combination of memorization, understanding, and visualization [Pandey and Zimitat, 2007]. Wilhelmsson et al. [2010, 2011] also noted connections between learning and understanding with student approaches to learning, similar to Pandey and Zimitat [2007]. Because of these findings, I wished to compare students who adopt a surface approach to learning with those who adopt a deep approach to learning.

In addition to the impact of course structure and student approach to learning, I wished to understand how *undergraduate* students learn in their anatomy and physiology classes. In summary, I defined boundaries for cases associated with each research question as shown in Table 3.2.

3.3.2 Planned Data Collection

In keeping with case study methodology, I collected data from multiple sources and integrated the data to yield a single case description. Each type of data collected

What are the differences and similarities in cognitive processes and pathways when learning about homeostasis for:

RQ1: Students enrolled in a course sequence of Human Anatomy → Human Physiology (A→P) vs. Anatomy & Physiology I → Anatomy & Physiology II (A&P1→2)?

Case 1a	**Case 1b**
Students enrolled in a two-course sequence of Human Anatomy → Human Physiology at University X in AY 2018-19	Students enrolled in a two-course sequence of Anatomy & Physiology I → Anatomy & Physiology II at University X in AY 2018-19

RQ2: Students with surface learning approaches vs. deep learning approaches?

Case 2a	**Case 2b**
Students enrolled in a two-course A&P sequence in AY 2018-19, who initially demonstrate a *surface* learning approach	Students enrolled in a two-course A&P sequence in AY 2018-19, who initially demonstrate a *deep* learning approach

Table 3.2: Bounding the cases.

was intended to provide insight into one or more aspects of the theoretical framework, as shown in Figure 3.1.

R-SPQ-2F The revised Study Process Questionnaire (R-SPQ-2F) as it is noted in the literature [Biggs et al., 2001], is designed to provide information about the learning approaches of students. The R-SPQ-2F consists of 20 items that fall on two approach scales: *surface* and *deep*. The full survey and scoring instructions are available in Appendix C. I administered this instrument three times during the study - at the beginning of the study and at the conclusion of both the fall and spring semester. The first administration was intended to provide information about the Presage factor of *preferred approach to learning*. The second and third administration were intended to provide information about the Process factor of *ongoing approaches to learning* at

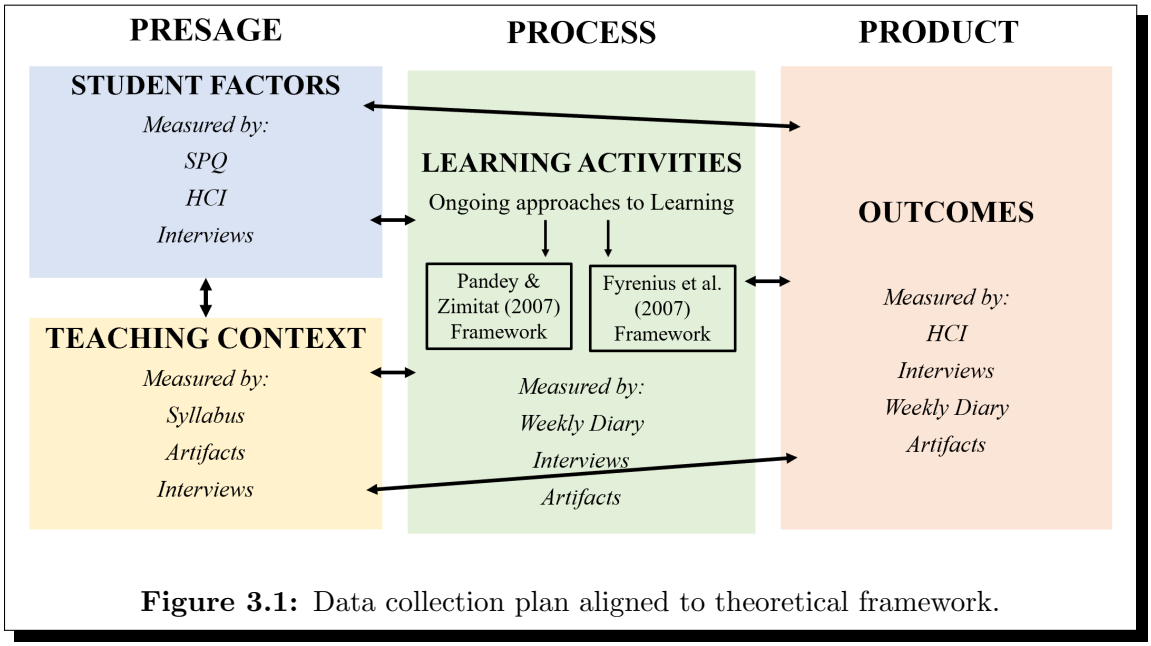

Figure 3.1: Data collection plan aligned to theoretical framework.

the conclusion of each semester. The R-SPQ-2F was selected for this study due to the shorter length, its open availability, and published data with previous undergraduate populations indicating valid separation of students into the categories of *surface* or *deep* learners. The R-SPQ-2F instrument was originally published in 2001 as a revised instrument of only 20 items with no cost for use and measuring surface and deep learning approaches. Previous psychometric analysis has found the instrument to have acceptable scale reliability (Cronbach's α of 0.73 for *deep* approach and 0.64 for *surface* approach) and a good fit to the 2-factor structure. Justicia et al. [2009] conducted exploratory and confirmatory factor analyses of the R-SPQ-2F with Spanish undergraduates. Findings from these analyses describe the underlying structure of the R-SPQ-2F to be the two-factor model of *surface* and *deep* learning approaches measured by the associated items from the original publication [Biggs et al., 2001]. However, no published data is available that provides psychometric properties of this instrument used as an online instrument or in the context of an American university. To address this concern, I tested the face validity of the R-SPQ-2F in an online sur-

vey platform with the study population. Seven undergraduate students (6 female, 1 male) enrolled in A&P2 in summer 2018 reviewed the R-SPQ-2F, providing feedback on the perceived meaning of each statement and their feelings about clarity and word choice. One participant indicated two statements (Q9 and Q16) contained "weird wording" but no other issues were noted by any other participant.

Homeostasis Concept Inventory (HCI) The Homeostasis Concept Inventory (HCI) [McFarland et al., 2017] provides information about a student's knowledge and understanding of the physiology core concept of homeostasis at the time of inventory completion. For the purposes of this study, I defined *homeostasis* in a manner consistent with the field of anatomy and physiology as "the maintenance of a relatively stable internal environment by an animal in the face of a changing external environment and varying internal activity" [McFarland et al., 2016]. Previous publications have indicated that many physiologists and educators consider homeostasis the central core concept of this sub-discipline [Michael et al., 2017]. Discussion of "homeostasis" runs throughout the teaching and discussion of all body systems. Because of this broad application, I believed it to be an appropriate concept to monitor in terms of student knowledge throughout the project. The HCI consists of 20 multiple choice items, and strong evidence of reliability and validity has been presented [McFarland et al., 2017]. Six tests for validity, three tests for reliability, and six tests at an item-level analysis were completed by the research team. Overall, the developers found the HCI to discriminate based on knowledge of the concept of homeostasis, but found no evidence of cultural or gender bias to impact student performance on the instrument. The full survey is available in Appendix D. The HCI was administered at three time points: prior to Interview 1 to provide information about *Student Factors: Prior knowledge*, at the conclusion of the fall semester (November 2018), and again

at the conclusion of the study (April 2019) to provide information about the Product factor of *Outcomes: Quantitative and Qualitative*.

Instructor Interviews Instructor interviews were conducted to probe for information about all areas of the Presage factor of *Teaching Context* and to gain more information about the intended outcomes of each course. Instructors of two course sequences of anatomy and physiology were interviewed in early September 2018, prior to participant recruitment. The interview protocol consisted of open-ended questions in a semi-structured protocol to allow participants the freedom to expand or elaborate on their responses. The interview protocol included prompts to probe for specific areas of the theoretical framework (see Figure 3.1) and important interactions between these areas. The full protocol is available in Appendix E.

Student Interviews I conducted three interviews with each student. The interview protocols consisted of open-ended questions in a semi-structured protocol to allow participants the freedom to expand or elaborate on their responses. Each interview protocol included prompts to probe for specific areas of the theoretical framework (see Figure 3.1) and important interactions between these areas. The full interview protocols are available in Appendix F.

Based on previous literature [Ritchhart et al., 2009, Sellmann et al., 2015, Golightly and Noras, 2016], I used a protocol that guided each participant through construction of a concept map in Interview 2 and 3 to observe both the Product factor of *learning product* and cognitive processes and pathways present in the Process factor of *learning process* through the construction and description of thinking. I guided students verbally through this process of creating a concept map about "homeostasis" through a modified think-aloud protocol writing with a Livescribe® pen, asking them

to explain the choices and connections they were making [Hickman, 2013]. These data have not yet been analyzed but will be included in future work that extends from this dissertation.

Weekly Diary To capture the context-dependent processes that participants used over time, I constructed ten (10) pairs of diary prompts. These prompts probed for information about several Process factors and the Product factor of *Outcomes: Quantitative and Qualitative*. All prompts are presented in Appendix G.

Course Artifacts Course syllabi, assignments, and grading rubrics were requested from the instructors to provide information about *Teaching Context* (objectives, assessment, climate/ethos, and institutional procedures) and intended learning outcomes. However, I only received course syllabi and example exam questions. I also requested graded assignments, course notes, or any other study documents from participants to provide information into teaching context (climate/ethos, teaching, approaches to learning, assessment, and outcomes), and received a variety of these documents from most of the participants of the study.

3.4 Participant Recruitment and Selection

The study was conducted at a University X, large, public, highest research (R1) university [Indiana University Center for Postsecondary Research, 2015] in the Southeast. This institution offers both a Human Anatomy → Human Physiology sequence (A→P) and an Anatomy & Physiology I → Anatomy & Physiology II sequence (A&P1→2) for undergraduate students. Both sequences are housed in the same department and college. Instructor 1 teaches the only section of the A→P courses, while Instructor 2 teaches all sections of A&P1→2 courses each year. The

large class size of all sections provided an adequate number of students to recruit for this project, therefore no additional research sites were considered for this study. To minimize the impact of random influence and to ensure retention of an adequate number of participants for the duration of the study, I sought to recruit four participants in each "block" for each case. This process of oversampling was intended to ensure retention of an appropriate number of participants throughout the study while minimizing random influences. This provided an opportunity to maintain process reliability in the research [Walther et al., 2013]. In addition to the 20 items that form the R-SPQ-2F, I wished to ask respondents for their intent to enroll in the subsequent course in the next semester and their major. Although the majority of students who enroll in the first course do indeed enroll in the second course in the subsequent semester, some have already received transfer credit for the second course, some plan to change majors, some plan to use a course substitution for the second course, and some are not required to take the second course. I planned to exclude those in any of those categories from the study as another step to ensure minimal attrition in each case. In addition, some students enrolled in the courses were non-STEM/ non-health science majors. These classifications were based on the Classification of Instructional Programs (CIP) Code assigned to each major [Paige et al., 2000].

After meeting with both instructors of A→P and A&P1→2 in summer 2018, they agreed to administer the initial survey, which included the R-SPQ-2F, to their classes as a required assignment in August. This was intended to provide the greatest number of students for participant selection.

During Fall 2018, two sections of A&P1 were offered with 311 students enrolled in section 1 and 215 students enrolled in section 2 (526 students total). Enrollment in the lone section of Anatomy was 298 students. This provided a total of 824 students from which to recruit the participants for this study. While both instructors

had agreed to cooperate in this study, they altered the level of participation in the week prior to survey administration. First, they agreed to send an email and class announcement to their students inviting them to complete the initial "Anatomy and Physiology Questions" recruiting survey. However, they declined to make completion of this survey a required course assignment, as had been discussed in previous conversations. This change resulted in a one week delay in survey distribution.

During the second week of classes, I emailed text for a class announcement and a separate email to course instructors 1 and 2. The instructors agreed to share the email invitation and link to the "Anatomy and Physiology Questions" Survey, which included the R-SPQ-2F instrument and additional qualification questions with their students. This was completed on August 30, 2018. The full text of the "Anatomy and Physiology Questions" survey is provided in Appendix C.

Students completed the R-SPQ-2F on a voluntary basis after receiving the invitation from their course instructor. Overall, two hundred thirty (230) students completed the survey (230 out of 824 total students, 27.9% response rate). For A&P1, 154 of 526 students (29.3%) responded. For Anatomy, 76 out of 298 (25.5%) responded. Potential participants were identified from those who provided informed consent, planned to take the second course of sequence in spring 2019 (A&P2 or Physiology), and were in a STEM or health science major. Given the wide variety of majors possible, I utilized CIP codes to identify my participant pool. Respondents with a major classified as *Engineering* (code 14), *Engineering Technologies and Engineering Related Fields* (code 15), *Biological/ Biomedical Sciences* (code 26), *Physical Sciences* (code 40), or *Health Professionals and Related Professions* (code 51) were considered for the full study [Paige et al., 2000].

The R-SPQ-2F may yield a surface or deep approach score between 10 and 50. Since it is possible to have a high score for both surface and deep learning approaches

on the R-SPQ-2F, I calculated the difference in *deep* and *surface* learning scores, and selectively recruited students with extreme differential scores for Case 2a and 2b. For A&P1, deep approach scores ranged from 11 to 49 and surface approach scores ranged from 13 to 48. The differential of deep and surface scores ranged from -33 to 26. For Anatomy, deep approach scores ranged from 19 to 48 and surface approach scores ranged from 13 to 39. The differential of deep and surface scores ranged from -17 to 29. Based on the results of the R-SPQ-2F, I selectively recruited four students from each course who indicated a high *surface* learning approach differential (Case 2a) and four who indicated a high *deep* learning approach differential (Case 2b). I selectively recruited eight students from Anatomy to provide data for Case 1a, and eight students from A&P1 to provide data for Case 1b. Invitation emails were sent to students on Monday and Thursday of each week from September 6 through September 25. Some students responded with an intent to accept or decline the invitation, but most did not respond to the initial invitation or a reminder email 2 days later. Information about attempted recruitment and those who accepted is available in Appendix H.

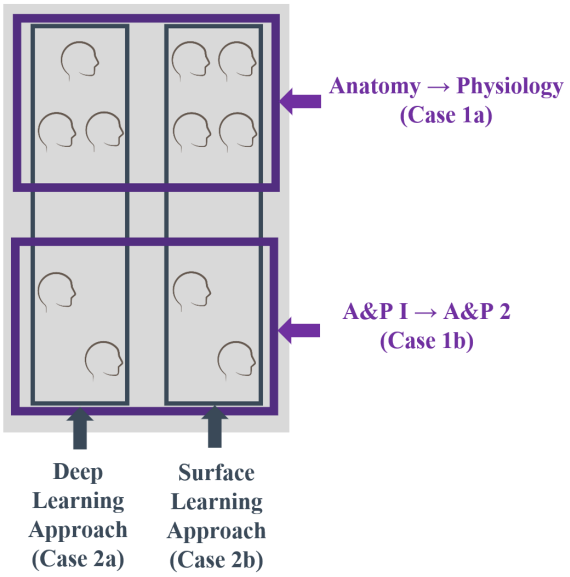

Figure 3.2: Actual participants recruited for all cases. Each head represents a single participant.

Information about distribution of differential scores and recruitment of individual participants is provided in Figures 3.3 and 3.4. Tables in Appendix H present the full ranking and invitation order for each of the four recruitment groupings. Recruit-

ment concluded with 11 participants in early October 2018 to allow for completion of all first interviews with participants to occur within the same unit of study for the anatomy and physiology course. Data collection began with a total of 11 participants: three students from Anatomy with a deep approach (Case 1a/2a), four students from Anatomy with a surface approach (Case 1a/2b), two students from A&P1 with a deep approach (Case 1b/2a), and two students from A&P1 with a surface approach (1b/2b) (See Figure 3.2).

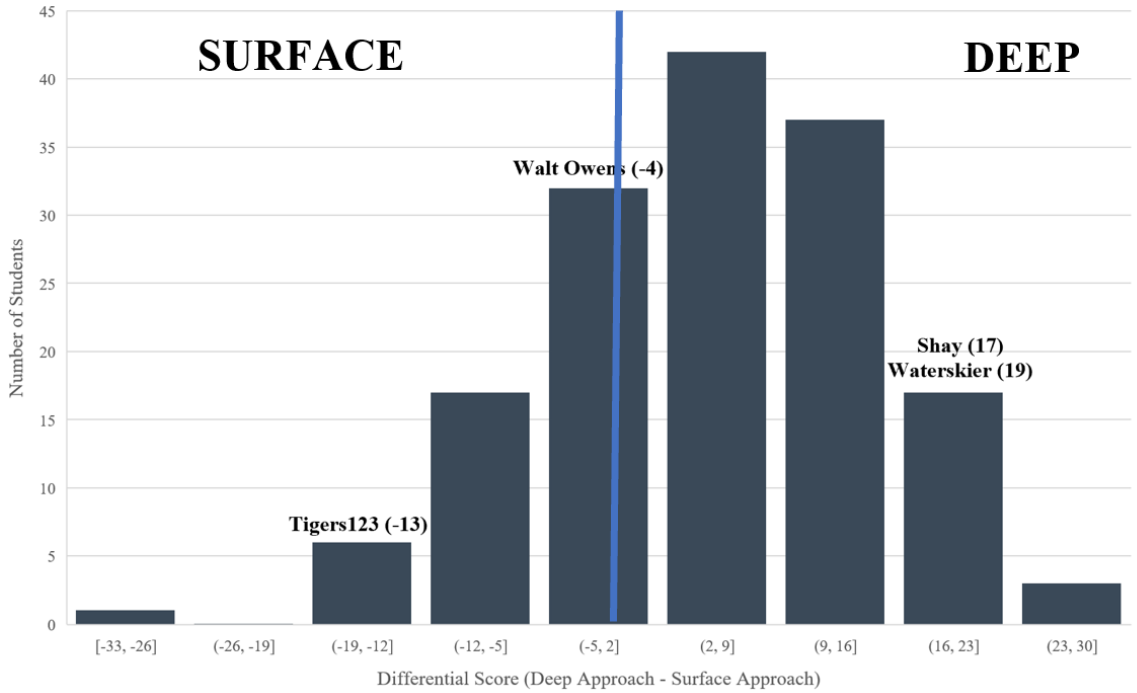

Figure 3.3: Distribution of student differential scores (Deep Approach - Surface Approach) from R-SPQ-2F in Course 2. One hundred fifty four (154) of 526 enrolled students responded and are represented in this graph. The blue line represents a differential score of 0.

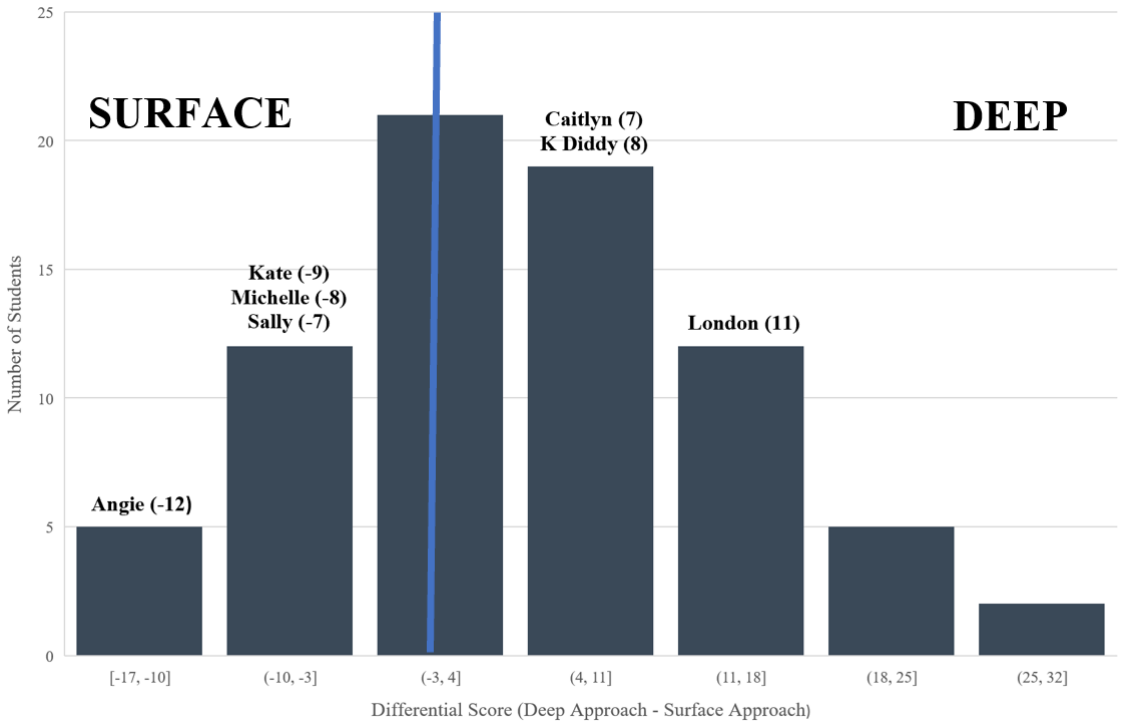

Figure 3.4: Distribution of student differential scores (Deep Approach - Surface Approach) from R-SPQ-2F in Course 1. Seventy six (76) of 298 enrolled students responded and are represented in this graph. The blue line represents a differential score of 0.

3.5 Data Collection

Data collection for this project occurred from September 2018 to May 2019. A detailed outline of the timing of each type of data collection is presented in Figure 3.5. I designed this study to collect multiple data types, which allowed for triangulation during analysis. This provided an opportunity for procedural validation by adding this feature to improve the fit between reality under investigation and existing theory [Walther et al., 2013]. Throughout the study, I maintained a log trail of my thoughts, written memos about personal feelings and thoughts following each interview, and bracketing responses to specific prompts to strengthen evaluative validity [Thomson,

	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19
Instructor Interview									
R-SPQ-2F									
HCI									
Student Interview									
Weekly Diaries									
Course Artifacts									

Figure 3.5: Data collected with associated dates for the project.

2011]. The specific steps and outcomes of each data collection are described in the following sections.

R-SPQ-2F and HCI The R-SPQ-2F instrument was administered at three times during the study using Qualtrics [Qua, 2005]. Use of this previously validated instrument provided an opportunity for process reliability [Walther et al., 2013] since responses to items would be expected to vary based on student approach to learning rather than due to random influences. However, using such an instrument can present both an opportunity and threat to theoretical validity [Walther et al., 2013]. While the instrument should capture previously identified factors, additional important factors related to approach to learning would be missed in this format. Survey completion rates for the first administration are provided in *Participant Recruitment and Selection* section.

The HCI instrument was also administered at three times during the study. For each administration the instrument was administered using Qualtrics [Qua, 2005]. Use of this validated instrument provided an opportunity and threat to theoretical validity [Walther et al., 2013]. While successful performance with these questions should correspond to content knowledge, it is possible that participants may have a mastery of the overall concept of homeostasis without system details contained on the

instrument. In addition, while the use of Qualtrics to collect participant responses provided an opportunity for process reliability [Walther et al., 2013], completion of the concept inventory in one's own time allowed for participants to use other resources besides their own knowledge to answer the questions. Participants were reminded that this was a no-stakes quiz to provide their current knowledge level, it is not possible to know if they used outside resources to complete the HCI questions or not. All participants completed the concept inventory at the first administration in September/ October (11 of 11, 100% completion rate). A final question was added to this survey asking participants to select a pseudonym for researcher use throughout the remainder of the study. For the second administration of the R-SPQ-2F and HCI in November/ December, eight participants completed the surveys (8 of 9 current participants, 89% completion rate). For the third administration in April 2019, six participants (6 of 8, 75% completion rate) completed the surveys.

Instructor Interviews Both instructors consented to be interviewed up to three times. Each interview was expected to last approximately 60 minutes. The first interview was conducted in early September and was held in the instructor's office. Holding the interview in this location allowed for comfort of the instructor and a quiet space for quality recording which provided opportunities for procedural validation, communicative validation, and process reliability [Walther et al., 2013]. This setting provided the best opportunity for honest responses from instructors and accurate capture of their responses with the recording device. The length of the interviews with Instructor 1 and 2 were 57 minutes and 51 minutes, respectively. The full interview protocol is available in Appendix E. Prior to the start of the second semester, an email was sent to each instructor to ask for a copy of the spring syllabus for both lecture and lab course sections, including important dates. They were also asked

about differences of their goals or approach to the second semester course. Both instructors indicated no differences between their approach or goals, and no interview was conducted between fall and spring semesters or at the conclusion of Spring 2019 semester. Since the instructor interview at the beginning of the fall semester and ongoing participant information about teaching context were in alignment, there is no evidence to suggest that this decision impacted the quality of results for this study.

Student Interviews Student interviews were conducted at three times during the study. The interview prompts were designed to expose the reality of the unique cognitive pathways taken by members within each bounded case, thereby providing an opportunity for theoretical validation [Walther et al., 2013]. Protocols used the same core prompts across participants but were also tailored to each participant based on weekly diary or previous interview responses. This approach was intended to minimize random influences on the research process, while also ensuring that the words of the participants were accurately captured and interpreted, providing opportunities for process reliability and communicative validity [Walther et al., 2013].

Sample interview prompts are presented in Table 3.3 and the full protocols are available in Appendix F. Prompts for interview 1 were designed to understand multiple areas of Student Context, including preferred approaches to learning, as well as their current perceptions of the Teaching Context. Prompts for interviews 2 and 3 were specifically designed to expand or clarify information given in a previous interview or diary prompt for each participant while also probing for information about specific learning processes used in their anatomy and physiology course. Designing the prompts in this manner provided additional opportunities for validity and legitimation. For example, opportunities for theoretical and communicative validation were strengthened by designing prompts to gain specific information about areas of the the-

oretical framework while also following up with participants to ensure their thoughts and ideas were being accurately captured and understood [Walther et al., 2013]. The opportunity for weakness minimization, which is concerned with the weakness of one approach being compensated by the strength of another, was present by collecting quantitative surveys and following with qualitative data collection [Onwuegbuzie et al., 2011]. The semi-structured nature of each interview allowed for clarification of student use of words such as *memorization*, *understanding*, and *learning*. Each interview was expected to last approximately 60-90 minutes. Interviews were conducted in person, in a neutral location to allow for privacy and quality recording, which provided opportunity for process reliability and communicative validity [Walther et al., 2013] as these steps allowed for accurate capture of participant words. Interviews were recorded with a digital recorder and transcribed verbatim for analysis, providing additional opportunity for communicative validation [Walther et al., 2013] and inside-outside legitimation [Onwuegbuzie et al., 2011] by again insuring the accurate capture and reporting of participant words.

Eleven interviews were conducted between September 18, 2018 and October 3, 2018. Interviews ranged in length from 22 minutes to 33 minutes, with a mean time of 27 minutes. Ten interviews were conducted between November 7, 2018 and November 14, 2018 for interview 2. This included nine current participants and one student who had left the study. Interviews ranged in length from 41.5 minutes to 83.5 minutes with a mean time of 52.2 minutes. One interview was conducted via Zoom due to participant illness and quarantine. Interview three was conducted between April 1, 2019 and April 16, 2019 with the eight remaining participants. Interviews ranged in length from 42 minutes to 94 minutes, with a mean time of 68 minutes. The full interview protocols for each participant are available in Appendix F.

Int-1 Sept.	1. Describe your A&P class? What do you think about the assignments? Grading procedure? Teaching style? 2. How is this different from your previous biology physiology courses? 3. How do you define "learning?" "memorizing?" "studying?" "understanding?" 4. How would you rank these (cards labeled "learning," "studying," "memorizing," "understanding") in terms of your personal preference? For this A&P course? 5. What do you think is the best approach to learning in this A&P class? (Variable based on response to Q4. Use terms 1 and 2.) 6. What do you hope to gain from this course? 7. (Provide copy of course learning objectives.) How do you think these learning objectives will help you meet your personal goals?
Int-2 Nov.	1. In your diaries, I've noticed that you use (use example) during your study time. Why do you choose that approach? (Probe for other approaches.) Can you describe a time this has worked well this semester? 2. (Example of 'win' and 'loss' from diary OR ask for example) Can you tell me more about this? What was different in this case than other times? (Probe to understand similarities and differences between examples.) 3. I've written down (on cards) the activities that you have participated in as a part of your A&P class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected these? 4. How has your approach to this course changed over the semester? 5. During our first interview, you tole me you hoped (answer from Interview 1, Q6) in this course. Can you tell me about how this has gone this semester? 6. Create concept map of homeostasis 7. Overall, how do you think this A&P course is going?
Int-3 April	1. Repeat Interview 1, Q3 and Q4 2. Repeat Interview 2, Q1, Q5, Q6. 3. Here is the concept map that you created at our last interview. I see some differences - can you talk me through how your thoughts have changes? (Guide student through map differences, asking for clarification and depth.)

Table 3.3: Outline of student interview protocols. The specific interview prompts for each participants and how those aligned to the theoretical framework are presented in Appendix F.

As previously mentioned, several steps have been taken to ensure reliability and validity. All prompts were developed with the purpose to provide information about some aspect of the theoretical framework, and *learning processes* were observable through responses to interview and prompts. Each round of interviews was conducted in a short time frame so variations between participants was not due to differences in course content or calendar. This provided an opportunity for process reliability [Walther et al., 2013] by minimizing random influences in the research process. Additionally, all prompts were similar to questions used in previously published studies of learning in the life sciences [Pandey and Zimitat, 2007], providing another opportunity for procedural validation and process reliability [Walther et al., 2013] by seeking to understand the fit between current theories and the social reality under investigation. For each interview, I sought to build rapport with the participants by not wearing professional or formal attire, providing another opportunity for communicative validation [Walther et al., 2013]. However, it should be noted that the age discrepancy between myself and the participants produced a mild threat to communicative validation [Walther et al., 2013].

Weekly Diaries Weekly diary responses were collected from each participant during the study. These multiple data collections were intended to provide an opportunity for procedural validation, communicative validation, and process reliability [Walther et al., 2013] by collecting data in a convenient manner for participants and by using the same prompts for all participants during a given week. As in the pilot study, I created a shared GoogleDoc for each participant which provided an opportunity for procedural validation, communicative validation, ethical validation, and process reliability [Walther et al., 2013] by providing a convenient way for participants to share their ongoing thoughts and answers, while also accurately capturing their own words.

This also provided an opportunity for triangulation by collecting additional data for each participant. I uploaded prompts to the document on each Monday morning and students were asked to complete their answer by the following Sunday evening. Some of these prompts were previously tested during the pilot study [Pandey and Zimitat, 2007, Roelle et al., 2015, Tanner, 2012, Metzger et al., 2018], providing an opportunity for procedural validation, pragmatic validation, and process reliability [Walther et al., 2013] since evidence had been provided that these prompts provided information about ongoing approaches to learning of students in an A&P course. Other prompts were constructed in response to information gained during a previous interview or diary response. All prompts were designed with course timeline, content coverage, and emerging themes in the data in mind. Some prompts were repeated during the course of data collection. This allowed me to see differences due to the teaching context of the course or student approaches or pathways to learning as the course progressed which provided an additional opportunity for theoretical validity [Walther et al., 2013]. All participants were asked the same diary prompts in a given week providing an additional opportunity for communicative validity [Walther et al., 2013] since variations should be due to participant differences rather than other factors. The full set of prompts, their connection to the theoretical framework, and the timeline they were asked is present in Appendix G.

Diary responses were collected from the shared GoogleDoc weekly. Response rates to the prompts varied across the two semester data collection period, as presented in Figure 3.6. Responses varied from 43% to 100%, with a mean rate of 83%, and included each student until either the conclusion of the study or until formal notice of the participant's desire to leave the study.

The word count for each prompt was obtained each week to monitor participant engagement across the data collection period, to assess the usefulness of diary

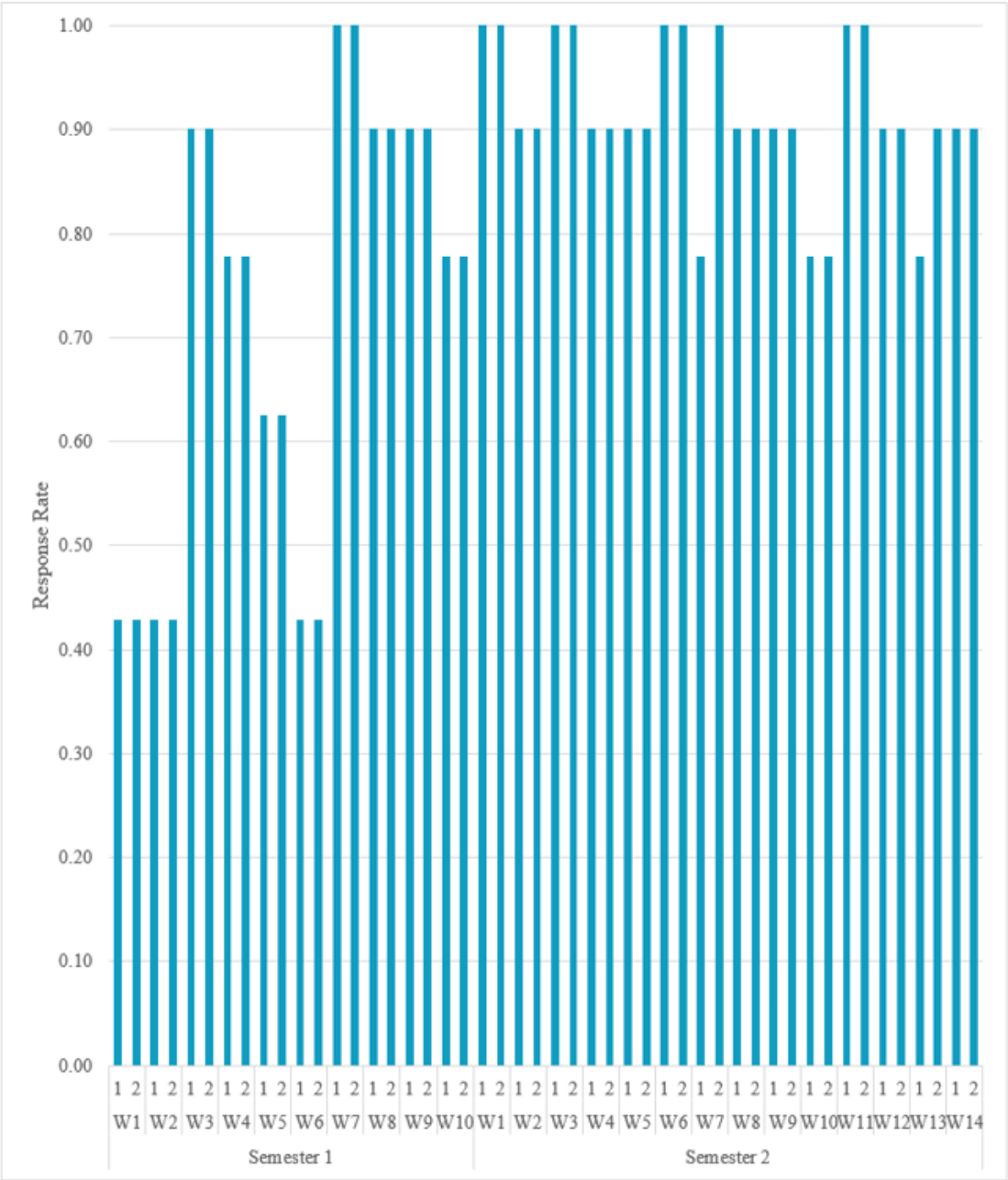

Figure 3.6: Response rate to each weekly diary prompt across the data collection period.

prompts, and to ensure that prompts were being understood by the participants. While word count itself is not a direct measure of participant understanding, low word count for a participant or a particular prompt led to additional scrutiny of responses to determine if a lack of understanding was indicated as the cause. The average word count for prompts ranged from 29 to 105 words, and a mean word count of 60.5 words per prompt, as presented in Figure 3.7. Prompts that consistently resulted in lower total word counts from all participants were re-examined before a second use. This process involved reading all responses to a given prompt to determine if it was eliciting the type of information that was expected and then reviewing and sometimes revising the prompt. These steps resulted in only one prompt revision. The fall prompt (*What was the most helpful classroom activity in your anatomy/physiology class this week? Be as detailed as possible in your description of the activity and why it was helpful to you.*) elicited short responses that the class consisted of lecture only. Therefore, I revised the prompt to the following: *What was the most helpful use of class time in your [anatomy and physiology] lecture or lab this week? Be as detailed as possible in your description of what happened and why it was helpful to you.* This prompt provided responses more similar in length to other prompts and with the expected type of information from the participants. Two participants (Angie and K Diddy) provided responses to all 24 pairs prompts during the data collection period. No prompts consistently provided low counts from participants during the fall semester, but one prompt was adjusted to be more clear to students and to elicit the desired information.

Course Artifacts I collected a variety of course artifacts from instructors and participants. These were used for triangulation purposes only. To facilitate collection of class artifacts, I created for each participant and instructor a shared GoogleDrive

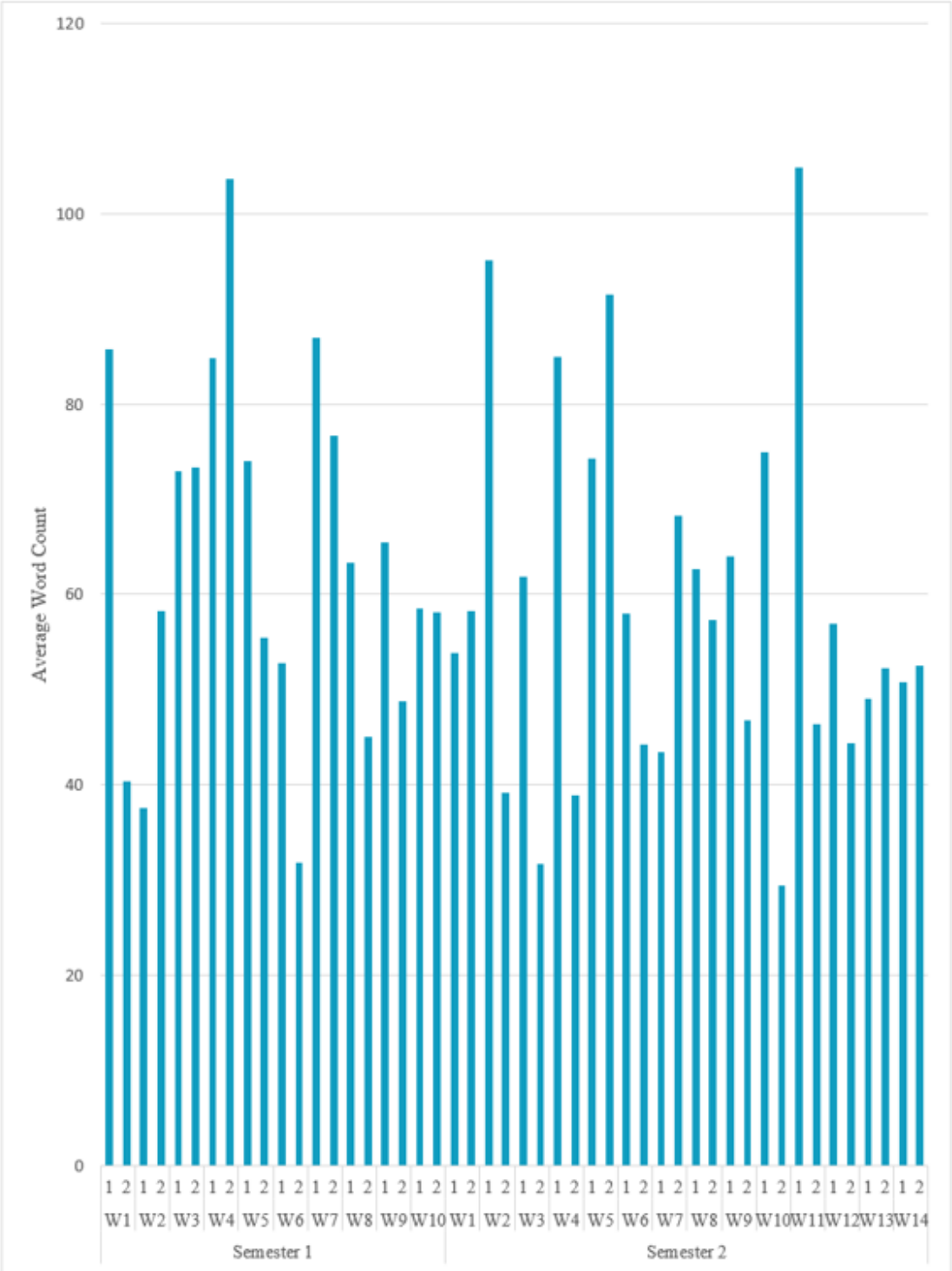

Figure 3.7: Average word count of each prompt across the data collection period.

folder. Participants were asked to upload course documents to the folder. For any hand-written or hard copy documents, I asked participants to scan them to a .pdf file (either on a personal printer or with a scanning app for their smart phone). This practice helped ensure process reliability of collecting and recording the data [Walther et al., 2013] since documents were captured digitally by the participants and shared directly with the researcher.

I received a total of 157 documents in hard copy format (1), email (4), and uploaded into the shared GoogleDrive folders (152). Three participants provided no documents and one participant provided 81 documents. These ranged from instructor provided PowerPoint slides, some with participant notes, to student-generated study guides.

3.6 Bracketing Prior to Analysis

Prior to the start of data analysis, I bracketed about my own experiences, ideas, and biases related to A&P courses, the participants and instructors, and the bounds of the study. The full list of prompts are presented in Appendix I. Between January 21 and February 2, 2019, I responded to no more than two prompts per day. In May 2019, I returned to my reflections and analyzed my responses with the research question of *What are the assumptions and biases of the researcher?* The first round of coding consisted of five open coding passes, with the first four passes focusing on a different area of the 3P Model and the fifth open coding pass looking for important themes that had not been coded in a previous pass. These open codes were then grouped into six overall themes listed below. The original bracketing responses were recoded using axial codes and a summary of each group is presented below. All codes and their definitions and bounds are also presented in Appendix I.

3.6.1 Researcher Assumptions and Biases

The main themes that emerged from analysis of the bracketing responses were student actions, meta-actions, and researcher awareness. In addition, the themes of outcomes, student traits, and R-SPQ-2F were also present. Analysis of these bracketing responses did not show bias or assumptions about the 3P Model specifically. However, each of the themes identified, with the exception of researcher awareness, have some connection to the 3P Model, and the following section describes areas of which I must be aware to ensure quality analysis.

Throughout my responses, the specific actions and perceived attitudes or approaches of the participants in the study or my own students were noted. For example:

> I am seeing students discuss how they work on the class and a mixture of good and bad shows up. So far, I have evidence of a lot of "good" actions. Most participants report going to class, re-watching lectures, taking notes in some form.

Most quotes relating to student actions are clear and unambiguous. However, quotes relating to meta-actions are more dependent on the researcher's perception. For example:

> I think overall, I am looking for a willingness to work and an interest in the topic as "good."

In both of these groups, I mention or make interpretations about student processes in learning. Many excerpts that were coded to meta-Actions were followed by or joined to excerpts related to researcher awareness. For example:

> I have felt like students were jumping through hoops rather than attempting a deep, meaningful learning experience that would benefit them later.

> I have hoped students would use class and lab time as an opportunity for learning. Perhaps I misinterpret a lot of what I see... My perceptions were greatly challenged by the info in the pilot study. My main impression of students has been of people who don't wish to work or put forth effort and then frustrate me a lot.

Based on these findings, I will need to make sure my interpretations of student meta-actions, those areas that relate to attitudes and feelings, must be grounded in the responses provided by the participant, rather than my own assumptions about the meaning of those attitudes or feelings.

A less common but related theme is my emerging assumptions about the categories of deep, surface, and achieving learners and the ways that students or my participants my be categorized, which specifically connects to the 3P Model traits of approach to learning throughout the course. For example:

> I feel like surface and deep groups are tricky and maybe not helpful. The SPQ has issues itself in trying to group students.

Again, this highlights my own assumptions about data that had not been fully analyzed at the time of this reflection. My conclusions about both student feelings and attitudes, as well as established instruments and theories, must be based in data and my processes of analysis should be careful about assigning my own meaning rather than that of the participants.

The theme of outcome, which is a specific area of the 3P Model in Product, centered on individual or group responses to the class structure and content. The following quote gives an example of a quote describing individual outcomes or responses.

> It seems [they] (Caitlyn) has done well in the class with less effort than some participants.

However, more quotes were attributed to group outcomes or responses. For example:

> I would say they (the instructors) have designed their courses in ways that are encouraging the students both through grades/ assessment and also content delivery methods (showing interest and enthusiasm) to increase/ keep a high level of motivation and engagement.

Based on these findings, I need to listen carefully to the voices of individual participants rather than be influenced by my own "instructor" role and mindset when viewing the outcomes described by the participants.

The recognition of student traits highlighted several superficial characteristics that are, in most cases, outside of the bounds of this study, but are also connected to the student characteristics in the Presage factors. For example:

> She has a small- almost lisp when [they] speaks that is really pronounced on the audio files.

Overall, this code captures impressions based on visual observations during the interviews or audio observations while verifying the transcripts of each interview. Almost all of these characteristics are not evident or present in the transcripts. However, this is important to note since I need to be aware of these items possibly impacting my analysis choices. The practice of removing real names and masking all pseudonyms from the transcripts prior to analysis should help to minimize biases or assumptions that arise because of positive or negative student traits that were observed.

Chapter 4

ANALYSIS

4.1 Participant Data Analysis

The process of coding began upon data collection. The interviews were transcribed verbatim by an automated transcription service (Descript [Des, 2017]), and I verified that the transcription had captured the participants' words accurately, making any needed changes and adding speaker labels. Pseudonyms were used at this stage rather than real names. This process of ensuring accurate capture of participant words provided an opportunity for communicative validation [Walther et al., 2013]. Transcripts and documents were uploaded into NVivo 12 software [NVi, 2018] which was used to store and view all data and course artifacts.

A visual representation of coding steps is presented in Figure 4.1 and explained below. A complete code book was developed during each coding pass (see Appendix J).

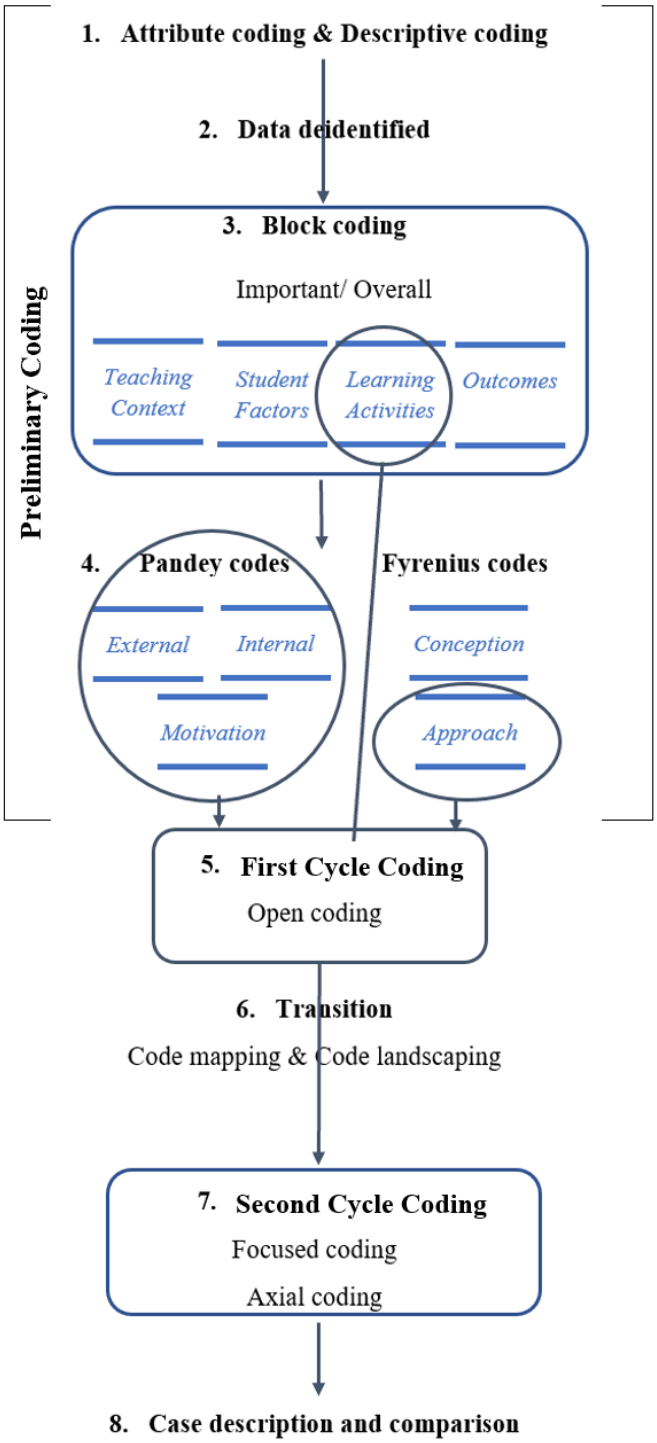

Figure 4.1: Steps undertaken to code all data and complete case descriptions and comparison. Areas are circled to indicate the content that was utilized in the step described by the arrow.

4.2 Attribute and Descriptive Coding

Coding began with *attribute coding* [Saldaña, 2016] noting participant, data type, and date and *descriptive coding* noting the prompt for which the data had been provided, as indicated by 1 in Figure 4.1. Details for these areas are presented in Sections J.1 and J.2, respectively, in Appendix J. Data was masked by changing all participant pseudonyms to "Participant" in the text of the artifact or transcript, as represented by 2 on Figure 4.1.

Block Coding Interview transcripts and diary entries were block coded (3 and 4 on Figure 4.1) using *a priori* themes and ideas from Biggs' 3P Model [Biggs et al., 2001], Pandey and Zimitat [2007], and Fyrenius et al. [2007]. These passes blocked chunks of information into the larger groupings of each framework. In the first step, all transcripts and diary entries were read and passages were block coded indicating to which of the four areas of the 3P Model they referred: teaching context, student characteristics, learning approaches, and outcomes. Some passages were relevant to more than one area, describing the interaction between two or more 3P Model groups. In these cases, a separate interaction term was not created, but codes were assigned for all appropriate groups. The code definitions were based on the descriptions provided by Biggs et al. [2001]. Only one category was expanded during coding to capture additional relevant data. "Important- Student Factors" was defined to include additional student characteristics presented in the data, such as age, motivation, and predictions of class success. Definitions and example quotes for this step of analysis are presented in Table 4.1.

Table 4.1: Codes assigned during the first pass for excerpts deemed important in relationship to factors of the 3P Model [Biggs et al., 2001].

Code Name	Definition/ Bounds	Example
Important- Student Factors	Excerpts explicitly mention or outline a student factor from the 3P Model [Biggs et al., 2001]. This may include information processing skills, personality, age, prior knowledge, motivation, or predictions of success in the class. In addition, excerpts referencing knowledge acquired outside of the A&P course, opinions about course policies, or personal definitions are also coded here.	"I'm on a pre-med track. And so I think this is the... One of the most more interesting classes I'm going to take- that like, really interests me. Some things that I like, I'm going to see in my future career someday. And so these are Concepts that I want to remember and like continue to grow and stuff." Angie, Interview 1
Important- Teaching Context	Excerpts explicitly mention or outline an area of the course or teaching context from the 3P Model [Biggs et al., 2001]. This may include references to the learning environment, course or exam design, teaching or assessment methods, or other traits of the instructor.	"So her teaching style is... [They're] very... Straightforward. Like her PowerPoint slides are cool like [they]... [they] puts information on there and leaves some information out. So like, if you're not there, you're going to miss it. So it keeps you like engaged. But yeah, [they're] straightforward. [They're] funny. So like that helps keeps you engaged. And I don't even know if [they know their] funny but [they are]... (laughing) And yeah that's pretty much... And [they're] just easy-going like... It's like an easy lecture to be in because you're not- like they're not yelling at you. You don't feel scared. Like you're just kind of there like absorbing information. And then the TA, we have like a small like mini-lecture at the beginning of lab and they actually go through a PowerPoint real quick and kind of like tell you what's going to happen. And then they just walk around for any questions that you have during the lab. So... And then [they]'ll also come through if there's like something we really need to focus on, like [they]'ll come through to each table and do like demonstrations and stuff like that. So... And if you don't want them, [they] won't force you to watch, which is good. But most people want them." Caitlyn, Interview 1

Important- Process and Learning Activities	Excerpts mention a student's ongoing approach to learning or specific pathways or actions related to learning course material, as outlined in the 3P Model [Biggs et al., 2001]. All excerpts indicate an action of some type which may have occurred physically or mentally. These actions may include those that have been completed by the student, those that they plan or wish to complete, or those that have been rejected and not used by the participant.	"I went to [Instructor 1] and [they] gave me some advice that I intend to take. [They] told me to seperate the powerpoints up and to study them in chunks. As I am doing so, I need to pull out key words and focus on them. To do this I have organized the slides and have started a word document that has key words in them. I am also going to go back to the chapters and look at the figures [they include] in her slides and read those sections to get some better understanding." K Diddy, Semester 2 Diary Prompts
Important- Product and Outcomes	Excerpts explicitly mention an objective or subjective outcome from the course. This may include course content, either quantitative or qualitative, or affective changes in the participant.	"The main idea and information we discussed this week were muscles and the organization of muscles of the body. We talked about the function of muscle tissues, organization of muscle tissues (which leads to creation of muscle), attachment sites of muscles, naming of muscles, etc. We also discussed the filaments within the muscle tissues, the neuromuscular junction sites, what happens at the cellular level when muscles contract, and characteristics of different muscle tissues." Sally, Semester 1 Diary Prompts

In the next step (Step 4 in Figure 4.1), all excerpts that had been coded as "Important/Overall" in the previous step were coded in two different coding passes corresponding to the additional frameworks. The first pass utilized *a priori* code groups from Pandey and Zimitat [2007] and was composed of three codes: external, internal, and motivation. The second pass utilized groups from Fyrenius et al. [2007] and was divided into two code groups: approaches and conceptions. A full description and example quotes are presented in Table 4.2.

The use of these *a priori* codes provided an opportunity for pragmatic validation [Walther et al., 2013] by providing information about the fit between the frameworks and the reality under investigation. However, this use also presented a threat to theoretical validation [Walther et al., 2013] and interpretive validity [Thomson, 2011] by possibly missing relevant themes present in the data that were not included in previous work. This process also provided an opportunity for and a threat to communicative validation [Walther et al., 2013]. Since these aspects of validity and reliability are concerned with producing theory that is meaningful and coherent to the social reality under investigation, it was important to remain open to emerging themes through the later steps of open coding to mitigate these threats.

Table 4.2: Codes assigned during the second and third pass for excerpts deemed important in relationship to factors described by Pandey and Zimitat [2007] and Fyrenius et al. [2007].

Code Name	Definition/ Bounds	Example
Important- Pandey	Excerpts reference one or more of the *a priori* codes from Pandey and Zimitat [2007]. Each excerpt references, either positively or negatively, one or more of the following: time on task/ hard work, memorizing/ good memory/ rote learning, understanding, visualizing, attendance/ preparation, constant revision, interest, using specimens, discussion with others, or note-taking/ drawing. "Using specimens" was used for living specimens (human subjects used in physiology labs), dissection specimens, or models.	"Because we get study guides for lab practicals, it really helps- even though they on the top of every study guide it says like "this is not everything that may be on this practical"- for the most part it is. And that's a really big help because I can make a PowerPoint slide with everything that's on that study guide and then just go through my... My lab notes anyway, and there's like little things that were like not included. But for lecture, it could literally be anything that were... That was on her Powerpoint or in her... [They have] recorded lectures, so I go through those but it's so much information at once, and there's no structure to it. So..." Angie, Interview 2
Important- Fyrenius.Approaches	Excerpts reference one or more of the *a priori* codes from Fyrenius et al. [2007]. Each excerpts references, either positively or negatively, one or more of the following: Sifting (received information, copying or condensing), Building (knowledge construction by developing understanding, reorganizing information, and evidence of a change in perspective).	"For the lecture portion of my physiology course I intend on learning the various mechanisms and processes by teaching them to someone else. If I am able to explain a certain concept to someone without looking at my notes, I will be able to answer a question pertaining to the process on the exam." Angie, Semester 2 Diary
Important- Fyrenius.Conception	Excerpts reference one or more of the *a priori* codes from Fyrenius et al. [2007]. Each excerpt references, either positively or negatively, one of more of the following ways of relating parts to wholes in anatomy and physiology: Linear (simple relationship), Competing (details are studied at the expense of understanding), Collaborating (details and understanding of whole evolves together).	"This week we have a test on Friday on mainly the nervous system and then senses/reflexes/pathways. So mainly that's what I have been focusing on, something of interest to me was that the spinal cord is no the full length of your vertebral column. This is because it generally does not grow much after birth, its about the length of an infant. I also learned about different pathways of somatic/sensory information and I didn't realize how elaborate they were, and how many things happened without us consciously knowing. I also didn't think that the information traveled in two different directions! This has been an interesting subject to study." Michelle, Semester 1 Diary

Pandey- External	Excerpts reference the presence or absence, either positively or negatively, one or more of the following external actions- attending class, discussing, drawing, note-taking, revising constantly, taking time on task, using specimens.	"To learn them better I think I am going to re-listen to the lecture videos and write out some process sheets for them. (I will give you all of my process sheets when we have our next interview since the tests aren't cumulative and that way you can see what I am doing)" Kate, Semester 2 Diary
Pandey- Internal	Excerpts reference the presence or absence, either positively or negatively, one or more of the following internal 'actions'- memorizing, understanding, learning, visualizing. If an excerpt referenced both an internal and external action, it was classified in the External category above.	"To learn them better I think I am going to re-listen to the lecture videos and write out some process sheets for them. (I will give you all of my process sheets when we have our next interview since the tests aren't cumulative and that way you can see what I am doing)" Sally, Interview 1
Pandey- Motivation	Excerpts reference the presence, either positively or negatively, one of more of the following - interest, enjoyment, or working hard.	"I really enjoyed learning about how different diseases arise when the body cannot maintain homeostasis. It is interesting how just one thing can throw the whole system off." K Diddy, Semester 2 Diary

4.3 First Cycle Coding

First cycle coding, indicated by Step 5 on Figure 4.1, consisted of open coding all passages that had been block coded with any of the codes appearing in Table 4.1 and 4.2 to categorize the learning approaches used in the data. Process codes [Saldaña, 2016], which connote action in the data, were assigned using an open coding process to allow the themes and ideas in the data to emerge. Code assignment began by reading the data excerpts and creating code names and definitions that captured the cognitive processes or pathways described. At the conclusion of each data file, I re-read each code group along with their definitions to ensure consistency of assignment and code definitions that appropriately described and bounded those excerpts. Passages could be coded to more than one process code during this step. For example, the following excerpt was assigned to *getting study advice* and *determining what's on the test*, as well as a negative affect code, due to the dual presence of advice from the instructor and instruction about using the book effectively.

> Something that is a little frustrating though is that... I mean, [they] did, not warn me, but let me know that the textbook does goes into more depth than [they] will ever go in. So if I have a question about something, [they've] told me that... if I never heard it in lecture, more than likely [they] didn't... You know, it was on purpose and it will never be tested. So try not to focus on those things. (Angie, Interview 3)

In another example, I struggled to determine what process was used by the participant. Time is certainly referenced, but no details are provided about what practices were actually used in the "time" being invested to prepare for the exam.

> So I wanted to spend a lot more time on this class, and I feel like I have. Like I feel like when it comes down to like test time, like I'm like really

> putting in the effort to understand things, even if it doesn't always turn out. But I feel like I'm putting in the time. I'm definitely putting a more times than I did with Anatomy. (Caitlyn, Interview 3)

This excerpts was coded with *using time* from version 1 of the code book, which was defined as "excerpts that reference 'time' and provide little or no information on how the time is used." In version 3 of the code book, the code boundaries had expanded to eliminate *struggling with time management* along with a note to compare this definition to other *effort* codes. By the final version of the code book, this excerpt was coded to *trying* which was a subcode of *endeavoring*. This was defined as follows: "Excerpts express a level of effort or time spent in a positive manner. They may also reference "working hard" or "spending time" on course assessments or learning tasks. This differs from the "Requiring effort" code because there is explicit or implicit reference to the participant's effort level rather than that which is required by the material." The final code book represents the fifth evolution of the document as code definitions were refined and code categories were combined or separated to capture the themes presented in the data.

In all, a total of 40 different codes emerged through the constant comparative method, with 13 of these groups subdivided further. A summary of the main codes is presented in Table 4.3. The full list of codes from this cycle are available in Table J2 in Appendix J. The themes that emerged from the data had both similarities and differences from those reported by Pandey and Zimitat [2007] and Fyrenius et al. [2007]. Similar practices of using specimens, memorizing, taking notes, and visualizing were expressed by the participants. The theme of *endeavoring* was very common and some of the subcodes could be thought similar to the idea or practice of working hard reported by Pandey and Zimitat [2007]. Participants discussed their level of effort in

Table 4.3: Summary of first cycle codes assigned during open coding. [a] denotes codes subdivided into additional categories.

Accessing explanations	Memorizing[a]
Attending class	Minimizing time
Changing it up	Needing and explanation
Comparing performance to expectations[a]	Planning
Comparing semesters	Ranking of processes
Completing assessments[a]	Remembering
Connecting lecture and lab[a]	Seeking effective study method
Cramming	Studying[a]
Creating a tool for study[a]	Studying with others
Desiring understanding	Taking notes
Determining what's on the test	Talking it out
Dividing and conquering	Timing
Endeavoring[a]	Using outside resources[a]
Engaging course material outside of class[a]	Using provided resources[a]
Expressing affect[a]	Using repetition
Facing distractions	Using specimens
Focusing on details	Visualizing
Getting study advice	Wanting to handwrite
Learning[a]	
Meeting with instructor	

many of these excerpts, but also described times when they did not put forth as much effort as they should or that their effort was not effective for meeting their goals in the course and they found themselves struggling. Overall, all of the approaches and intentions described by Pandey and Zimitat [2007] and Fyrenius et al. [2007] were evident in the participant data. However, a focus on grades or course performance was pervasive in many of these code categories. This included the specific categories of *completing assessments* and *comparing performance to expectations*. However, this emphasis toward assessment appeared in excerpts assigned to other themes.

> I will spend like more time on compared to other classes. Like... Like even like the lab quiz stuff, I've found... like I've found myself studying, like really like late into the night. Mainly because I didn't study earlier, but still like, instead of just like taking like a bad grade, I've been like

"no, I'm going to try and do like really well or like good." (**Trying**, Walt Owens, Interview 2)

I feel like if I really tried on the quizzes, it would be easier to study for practical but then that would require me to rem... Remember like three chapters a week. I feel like yes, in the long run, yes, that would help. That's what everybody keeps telling me. But I'm like, do you have a biochem test this week? No. No, you don't. So don't tell me what to do. (**Getting study advice**, K Diddy, Interview 2)

4.4 Transition

After open coding as indicated in Step 5 of Figure 4.1, I used the Matrix Coding option in NVivo 12 to view code overlaps and relationships. I reviewed overlaps to ensure that excerpts coded in multiple ways truly reflected both codes. For example, 21 of 67 excerpts coded to *accessing explanations* were also coded to *attending class*. I noted in my memo that most of these dually coded passages discussed attending the lab sessions rather than lecture. I also reviewed overlaps that were sparser than I anticipated. For example there was less overlap between studying with others and accessing explanations than I anticipated. This led me to review the excerpts coded to each of these themes to ensure the omission from the other code was warranted by the data. During this process, I made frequent use of my bracketing responses and continued memoing to ensure that my decisions were driven by the data rather than my own biases.

After finalizing the definitions for all open codes, I created a code map of all codes and did preliminary code landscaping to compare the words and themes from

Case 1a and 1b [Saldaña, 2016]. Code mapping and code landscaping are methods to "organize and assemble codes developed from first cycle processes" [Saldaña, 2016].

Code Mapping The process of code mapping began by listing all codes and sub-codes generated during first-cycle coding, as represented in Table 4.3. This resulted in a list of 77 total process codes. The second iteration of code mapping involved grouping these 77 process codes by similarities. This resulted in seven code groups:

- Actions linked to outcomes
- Identified shortcomings
- Outcomes
- Physical tasks or actions
- Cognitive tasks or actions
- Tasks or actions
- Feelings or affect

The complete second iteration code map is presented in Appendix K. As an example, Table 4.4 shows the first cycle open codes that were categorized to *tasks or actions* during code mapping. The third iteration of code mapping is best described by Saldaña [2016] as "categorizing the categories." In this step, the seven groups described above were also categorized together. This process resulted in three groups: Student Feelings and Desires, Student Actions, and Student Outcomes. The overall structure of this code map is presented in Table 4.5. After comparing the two code maps, I determined that the second iteration provided better explanatory power for second cycle coding passes.

Table 4.4: Example of code map for Tasks or Actions group.

Tasks or Actions
Cramming
Endeavoring: Increasing effort
Endeavoring: Requiring effort
Endeavoring: Under-endeavoring
Endeavoring: Trying
Engaging with course material: Engaging actively
Engaging with course material: Reviewing
Engaging with course material: Reviewing between classes
Determining what's on the test
Endeavoring: Linking effort with goals
Planning
Remembering
Studying: Action only
Minimizing time
Timing

Table 4.5: Third iteration code map.

3RD ITERATION GROUP	2ND ITERATION GROUP
Student Feelings or Desires	Affect
	Self-identified shortcomings
Student Actions	Tasks/ Actions
	Cognitive Tasks/ Actions
	Physical Tasks/ Actions
Student Outcomes	Outcomes
	Actions linked to Outcomes

Code Landscaping Code landscaping "integrates textual and visual methods" to view data, often as a word cloud. The word clouds were created by NVivo 12 by selecting all excerpts assigned a process code for participants in each course. Word clouds for resulted in no noted differences between Cases 1a and 1b. The word cloud for Case 1a is shown in Figure 4.2, while the word cloud for Case 1b is shown in Figure 4.3.

Figure 4.2: Word cloud generated for Case 1a from data analyzed by open coding.

Figure 4.3: Word cloud generated for Case 1b from data analyzed by open coding.

4.5 Second Cycle Coding

4.5.1 Focused Coding

Second cycle coding began with focused coding from the seven themes identified from the second iteration of code mapping followed by axial coding. Focused coding "searches for the most frequent or significant codes to develop the most salient categories in the data corpus" [Saldaña, 2016]. Focused codes were applied using the seven categories that emerged in the second iteration of the code mapping, as indicated by Step 7 in Figure 4.1. First, thorough code definitions were developed for each of the seven categories. Three of these categories related to tasks or actions. The creation of separate categories seemed appropriate during construction of the code map, since process code groups had indicated these distinctions between participant learning activities. *Physical tasks or actions* were defined as "excerpts which explicitly mention **physical** tasks or actions undertaken or completed by a student or the participant and are not associated with a specific outcome." *Cognitive tasks or actions* were defined in a like manner except they referenced on **cognitive** tasks or actions. The third category of *tasks or action* included those tasks or actions related to learning activities which were unknown in nature or included both a physical and cognitive component.

Focused coding then proceeded with seven coding passes, one for each of these themes, of all interview and weekly diary response data with all previously assigned codes masked. Masking previous codes provided an opportunity for evaluative validity since this step minimized bias in assignment of the new code groups [Thomson, 2011]. The constant comparative method was again applied during the process of code assignment, and code definitions continued to be refined. The following quote provides an example of a physical task, as a specific lab procedure is described.

> In lab we have been exploring what we talk about during lecture. We have used EEG's and EMG's after we learned about what they can tell and why they are used in a clinical setting. I think we sort of use concepts we learn in class on real physical examples that can be measured and observed. (Michelle, Interview 3)

In another example, a task or action is described in reference to the final outcome of successfully performing on an exam.

> For the lecture portion of my physiology course I intend on learning the various mechanisms and processes by teaching them to someone else. If I am able to explain a certain concept to someone without looking at my notes, I will be able to answer a question pertaining to the process on th exam. (Angie, Semester 2 Diary)

The final code definitions and example excerpts are provided in Table 4.6. At the conclusion of these passes, a coding matrix was constructed in NVivo. Any coding overlaps between *tasks or actions*, *outcomes*, *physical tasks or actions*, *cognitive tasks or actions*, or *actions linked to outcomes* were reviewed along with the code definition and codes determined to be erroneous were removed from the passages. The process for resolving these overlaps involved reviewing the code definition, re-reading the passage in question, and making a determination of the appropriate final code assignment. The following paragraphs provide three examples of this process.

Table 4.6: Focus codes assigned during second cycle coding.

Code Name	Definition/ Bounds	Example
Tasks or Actions	Excerpts include mention of tasks or actions, either physical, cognitive, or unknown in nature, undertaken or completed by a student or the participant and are not associated with a specific outcome. Tasks or actions must be related to acquiring or learning course material or doing activities that are required by the course.	"In lab we have been exploring what we talk about during lecture. We have used EEG's and EMG's after we learned about what they can tell and why they are used in a clinical setting. I think we sort of use concepts we learn in class on real physical examples that can be measured and observed." Michelle, Semester 2 Diary
Outcomes	Excerpts include mention of outcomes that are not associated with any specific action. Outcomes include products produced, such as completed assignments or content that is retold or shared. Stated goals are not outcomes in themselves, but may be mentioned in connection with an outcome.	"This week we only had 2 lectures due to our exam on Wednesday. This week's main concept was the central nervous system, which is comprised of the brain and spinal cord. The interneurons within the brain & spinal cord serve to "associate" appropriate motor responses with sensory stimuli, which serve in maintaining homeostasis. In the brain you also find the cerebrum, diencephalon, brainstem, and the different systems occurring within these parts. An example of an organ that has a direct role in homeostasis is the hypothalamus, a part of the diencephalon, which is essentially a collection of nuclei involved in a variety of homeostatic processes." Angie, Semester 2 Diary
Actions Linked to Outcomes	Excerpts include mention of something done by a participant, which could be physical, cognitive, both, or unknown, that is connected to an outcome. The action or task must be related to acquiring or learning course material but the outcome may or may not be.	"I feel like the book this semester has been more... I don't really use it as much... Cuz I really got it like for lab, I thought we would be needing it too. Because it was like essential and Anatomy lab like you had to have the book. Like... A lot of what we did came out of that, a lot of my studying was out of it. And then for this, it's like our pre-labs aren't really like... It's like we have like handouts that we take to lab and like with a whole bunch of background information. And that's like what we use to take the pre lab quizzes with, and like... I've used the book a couple times when studying. Like I used it a little bit for the lab practicals and stuff like that. But like, I haven't really used it for the lecture unless I need like clarification, like I really couldn't get from the video. But I feel like it definitely hasn't been as... You know, like instrumental so." Caitlyn, Interview 3

Self-Identified Shortcomings	Excerpts include mention self-identified shortcomings in approach or outcomes in the course. Description of wanting or needing something additional or different to meet intrinsic or extrinsic goals for the course is coded here. Shortcomings related to an outcome are always related to the participant, but shortcomings related to actions could be their own or someone else's.	"And then you'll be kind of like... We... Like I know that's like a cell but like do you want what's inside the cell? Because like that's what the thing is. And like we'll talk to the TA. And my TA's like "I don't know, you tell me." Like I can't tell you. Like that's why I'm asking you. Like do you want like the certain cell types? Like when you get like a slide of blood, there's like four different cell types in there. There's probably a lot more than 4, obviously. I don't know what I'm talking about. But if, you know,... So like if it's pointing to a... What are those... Macrophages are like really big, right? So its pointing to like a macrophage, do you want... Do you want to know the type or does it want to know like the inner layer of the macro... I don't know if that's really true or what not. But like we have talked about this, right? (laughing) Yeah, but you know." K Diddy, Interview 2
Feelings or Affect	Excerpts include mention of feelings or affect toward content, course structure, or an instructor. This code does not include affect about the future or outside things unrelated to the class. However, if the affect is related to content, or the instructor along with some outside entity, it is coded here.	"I like... Enjoy going to this class I think a lot more than I thought I would, as well. Like sitting through lecture, like today, it was just a lot of information and the room was like warmer than it usually is, like almost uncomfortably. But for the most part like I enjoy going to lecture, like lab. Like anatomy lab, even if we have like a quiz or something like I still enjoy going to it. I don't really find myself stressing too much, even if I like stress about studying. But like at the end of the day, it's like, "okay." This is still like an enjoyable class and lab, so." Walt Owens, Interview 2

Example 1 Consider the following quote:

> Participant: I think the objectives are very spot on with what I want to get out of it. They all include some of the words that you showed me- understanding. Understanding is really important. So yeah- more like the major topics like the all the body systems, the body's design, functionality... Appreciation- that's a good word- because you don't want to like take a course and then just feel like "oh, well I had to take it," but appreciate like you... Yeah....Yeah.
>
> SNJ: Okay, do you see one of these being more beneficial to those goals than others like the lab ones, or the lectures ones, or one in particular really stands out?
>
> Participant: I think for me the lab learning outcomes where it says "be able to identify"- that's like actively using everything you've learned to like, to like actually... I guess do it. So I think that's really important. Being able to use the information you learned and like identify this- or yeah.

This excerpt was initially coded as *actions linked to outcomes* based on the mention of specific actions from the course objectives and also as *outcomes*, based on the emphasis on the end product. When reading the quote, I first noted that the participant is discussing understanding content, an outcome in the 3P Model. Second, I noted that the participant provides no specific actions or tasks that they plan to use while working with the described content. Finally, I noted that the participant references their desire to "understand." The inclusion of this term (understanding) led me to reference this participant's provided definition of "understanding." All participants defined this term as related to an outcome with no reference to actions or tasks, as

described in Chapter 5. Each of these pieces of evidence suggest that the participant is not linking an action with an outcome, but is describing an *outcome* only. Given these traits of the excerpt, the passage was coded as *outcome* with the *actions linked to outcomes* code being removed.

Example 2 The following quote was coded with the same two codes (*actions linked to outcomes* and *outcomes*) but the reasoning for final code assignment differed.

> SNJ: Okay, so have your goals changed since last September?
>
> Participant: In theory, no. I really do want to learn everything about the human body. However, my hope for the goals has definitely changed. (laughing)
>
> SNJ: Okay. Talk to me about that.
>
> Participant: I just don't think it's possible. If I... If this was my primary focus, like in PT school, I'm sure this is going to be like one of my primary focuses. It's going to be tested on a lot heavier. You're not gonna have to worry about things like Genetics or Plant Biology or all that kind of stuff. Then I think I'll definitely be able to achieve that goal. But just in the environment that I'm in and all the school work that I have to do, I just don't have time to memorize all of it. And I'm also memorizing so much other information that I feel like I just got to expel some of it. (laughing) Kick it all in there.
>
> SNJ: Okay. Okay. It hasn't actually changed. But practically, not happening.
>
> Participant: Yep.

In this situation, when reading this text in isolation, the participant seems to be pointing to *outcomes* as their main focus. However, the participant specifically dis-

cusses "memorizing." As before, I referred to the definition of the term provided by the participant. In this case, the definition of "memorizing" provided carries an *action leading to an outcome*. To code this passage in a manner consistent with the participant's own word meaning, the entire passage was assigned the code *action linked to outcome* and the *outcome* code was removed.

Example 3 The following quote was coded with three separate codes- *actions linked to outcomes*, *outcome*, and *task or action*.

> SNJ: So can you talk to me about more about why those you feel like are not important to you?
>
> Participant: They're really easy. They're straight out of the book, and they don't really cue you in to what we're doing in lab. So like I could do it in five minutes, and still have no clue what we're doing.
>
> SNJ: Okay.
>
> Participant: Obviously, I'll know the topic like, okay. Yeah we're doing. (pause) What did we do this past week, I'm trying to remember... The respiratory system. I know that. And I... and like a lot of times, its stuff from lecture because it's more like concepts and stuff. But- easy. Just don't forget to do it, kind of thing. But then if it's a lab where like you're doing a dissection, that you actually have to read the steps, like this doesn't help. Like maybe it's like... For one of the cat dissections, you did have to say like, okay, these are where we'll make the cut. But then you get to lab and your lab TA says something different, because it's... They've done it more times, and like it just works better or like works for that class better, like... Whatever so, I wouldn't say they're useless but I wouldn't say they're important either.

In the separate coding passes, I had focused on the specific code. For instance, while making the *tasks and actions* coding pass, I had looked for specific tasks or actions, noting reading course materials and completing dissections, but missed the *outcome* of *memorizing* that was present. In review, the *tasks or actions* and *outcomes* codes were removed, leaving only the *actions linked to outcomes* code associated with this passage. By making separate passes and then resolving any coding overlaps, the emerging themes were better aligned with the processes displayed by participants and the research process was less influenced by thoughts less aligned to the code definitions. These actions represented additional opportunities for procedural validation and process reliability [Walther et al., 2013].

4.5.2 Axial Coding

Axial coding is intended to extend the analytic work of focused coding by reassembling the data that was "split" in a previous coding cycle. Overall, this method seeks to determine the relationship between categories [Saldaña, 2016]. Once axial coding began, the emerging categories from *physical tasks and actions*, *cognitive tasks and actions*, and *tasks and actions* were found to be redundant, with several categories appearing in more than one group. Two codes were present as *cognitive tasks or actions* and 22 codes were found in *tasks or actions*, with one of these codes appearing in both groups. *Absorbing information* emerged with a nearly identical definition in both groups. However, 18 codes were identified for *physical tasks or actions* and 13 of these overlapped with codes identified in *tasks or actions.* For example, *re-write notes* and *conduct experiments* emerged in both of these categories and, the following quotes describe *using instructor provided resources*

> But after, that people stayed longer. People stayed to like use the time. They would go through the lab and you know, we still have like an hour and a half left. People would stay and like review models. (Angie, Interview 2)
>
> Yeah, if like... I liked it when so like [Instructor 1] would give us a... Basically study guide almost, I liked it if I could look at my study guide and hit most of the points. And I wouldn't have to like study extra. (K Diddy, Interview 3)

In both quotes, the participant is describing *using an instructor provided resource*. However, Angie is describing a physical action of using a model, while K Diddy is describing the action of using a study guide to prepare for course assessments. Because of this redundancy, these three code groups (*tasks or actions*, *cognitive tasks or actions*, and *physical tasks or actions*) were collapsed into a single code, named *Task or Action*. The final bounds for this code category are defined as "Excerpts include mention of tasks or actions, either physical, cognitive, or unknown in nature, undertaken or completed by a student or the participant and are not associated with a specific outcome. Tasks or actions must be related to acquiring or learning course material or doing activities that are required by the course."

Axial coding then proceeded using the constant comparative method. This involved writing a thorough code definition as each code was created and referring back to these definitions and previously coded excerpts to check for agreement. At times, two codes were collapsed together and the definition revised to reflect the theme represented in all excerpts of that new category. Several participant quotes used terms that were defined during the interviews by each participant (learning, understanding, studying, memorizing). Therefore, data from participant definition

of terms was also used to determine final code assignment for each relevant excerpt. The five code groups yielded at least eight themes each that are summarized in Table 4.7. For the *actions linked to outcomes* code category, the existing *tasks or actions* themes were linked to one of the *outcomes* themes. The final definitions of these codes are presented in Table J3 in Appendix J. Passages were also coded broadly, which sometimes captured multiple codes. In these cases, the predominant theme or most obvious action was coded rather than splitting the excerpt to multiple codes. I provide the following excerpt, assigned the code *time crunch to completed assessment* as an example:

> To prepare for exam 1 *I made flashcards, process sheets, reviewed power-points, and studied with a friend for about an hour.* **In total I probably studied for around 8 hours. I did not get enough time to study as much as I would have liked to** and I definitely thought that the exam was challenging, but at the same time I went into it feeling like I knew a lot of the information that was going to be on it. I ended up getting an 83 which is 10 points higher than the average, but I am still mildly disappointed because I would really like an A in physiology.

This quote mentions events that would be coded as *engaging with material* which is highlighted in italics. However, the main theme of this passage is the limitation of time, shown in bold text, so the *task or action* of this excerpt was coded as *Time Crunch*.

4.5.3 Results

The analysis described above uncovered five main ideas from which additional specific themes emerged. The central themes for answering my research question are

Table 4.7: Summary of axial codes.

Focused Code	**Axial Code**
Affect	Amused
	Determined
	Confused
	Discouraged
	Frustrated
	Not fun
	Overwhelmed
	Worried
	Enjoyment
	Encouraged
	Interested
Outcomes	Application
	Awareness of discipline
	Completed assessments
	Confusion
	Fascination with content
	Less than hoped class performance
	Remember
	Remember/ Understand
	Successful class performance
	Understand
Self-Identified Shortcomings	Following along
	Lacking focus
	Lacking help
	Mastering content
	Less than hoped performance
	Recognizing important content
	Remembering
	Study method
	Understanding assessment questions
	Time management
Tasks or actions	Absorbing information
	Altering study habits
	Engaging with material
	Getting outside help
	Doing hands on tasks
	Opting out
	Timing crunch
	Using instructor provided resources
Actions linked to outcomes	Any combination of Tasks or actions and Outcomes

Table 4.8: Codes mentioned in narrative, organized by coding cycle. The full code book is available in Appendix J.

CODING CYCLE	**CODE EXAMPLE**
Attribute (Step 1 in Figure 4.1)	Participant Data type
Descriptive (Step 1 in Figure 4.1)	Prompt
Block/ 3P Model (Step 3 in Figure 4.1)	Teaching context Student factors Learning activities Outcomes
Block/ Other models (Step 4 in Figure 4.1)	Pandey: External, Internal, or Motivation Fyrenius: Approach or Conception
Open coding (Step 5 in Figure 4.1)	Process codes described in Table J2 in Appendix J.
Focused coding (Step 7 in Figure 4.1)	Actions linked to outcomes Cognitive tasks or actions Feelings/ affect Outcomes Physical tasks or actions Self-identified shortcomings Tasks or actions
Axial coding (Step 7 in Figure 4.1)	Absorbing information Engaging with material Time crunch to completed assessment

those that describe tasks or actions in the data related to learning activities. These themes are parallel due to the broad coding approach described above.

Two common themes that emerged as participants discussed their approach to course information were absorbing information and engaging with course material. Absorbing information is most closely related to the theme of "Sifting" introduced by Fyrenius et al. [2007]. This idea includes any action where information is absorbed or collected from an outside source, and there is no cognitive engagement to shape or work with that information. For example, this quote describes being exposed to the information without indicating any cognitive task beyond accepting or holding the information as recorded lectures provided by the instructor were used.

> recorded lectures for people that miss lecture and although its the same thing... Maybe you like just want to hear [them] say it again.They have (Angie, Interview 1)

In contrast, engaging with material moves beyond simply taking in course information to active manipulation of the information or construction of knowledge. This can involve physical or cognitive tasks like drawing, summarizing, or quizzing. This can also include mental processes where a participant is mentally manipulating the information to extend their mastery of the subject, as described in this quote.

> Just kind of going through the process that I told you about. Like, like reviewing it... A lot. Getting that understanding, pulling it apart, putting it back together, relating it all to each other. (Waterskier, Interview 3)

The difference between these ideas is not found in the idea of active versus passive behaviors, but in the difference between receipt of information versus construction of information.

Other tasks or actions described by participants were more easily observable by an outsider. The practice of altering one's study habits was defined as either the action or intention to change or switch study habits during the course. Sometimes specific descriptions of these changes were included, but this detail was not required. The changes described could have been accomplished in a short or semester-long time frame. This example provides an example of how a student might describe changing their study habits.

> I found that using a big study guide was the most effective for the course material of this class because it broke down the information into sections with plenty of content. This helped me study all the material in each section but also breaking it up so that it was not too overwhelming. For exam 1 I used the powerpoint slides and my notes, and for exam 2 I used the notes and the book, but I think from exam 3, the study guide was better because I included more information and went over the information

> multiple times instead of slowly working through the material and getting through it once or twice. (London, Semester 1 Diary)

Another practice of participants was to use hands on tasks. These examples usually occurred in a lab setting, and involved dissections, working with specimen, or conducting experiments. Photographs of specimens were not included in this group nor were active learning activities that may have occurred in a PAL session or other setting. Caitlyn gives an outline of the various hands-on activities that were accomplished during a single lab period.

> Sometimes it'll be even like a couple within each. Like when we did a vision, we did after image. We did like one of those. We did blind spot. We did, I want to say we did something with like light and pupil dilation, which could have been one of the reflex ones? I can't completely remember. And then with like... Like it was like learned responses and reflexes. Like we did multiple, like we did like auditory cues. We did visual cues. We did like all that. For like touch we did 2 point threshold. We did sensory localization or tactile localization. We did sensory adaptation. We did two different auditory things, like it was just everything. Like everything that [they] touched on in lecture, like there's a part for it lab. (Caitlyn, Interview 3)

A similar theme also emerged of using instructor provided resources that were available outside of the lab time and space. Participants had access to and used textbooks, course documents or lecture recordings on the Canvas learning management system (LMS) page, Library Reserve items, PAL sessions, or photographs of specimens. These tools were popular with most participants and were reported to be used

frequently. The following quote describes participant use of lecture objectives, in this case to replace actually attending class.

> Sometimes- full disclosure, I'm very bad at going to class. So, especially Physiology, because it's like early and that's my only class on every single one of those days. So I'm just like, there's recorded lectures... [they post] like Monday, Wednesday, Friday- like on Friday after class. So... I'll usually like catch up... Like I'll watch them for the first time that... Like each Friday. (Caitlyn, Interview 3)

Participants also described getting outside help. This was usually solicited, but also included examples of assistance received that was not requested. In all cases, participants received some type of outside assistance to master the course content. Angie describes getting help from Instructor 1, but other participants described help from classmates, graduate TAs, or friends who had taken the course previously.

> So I would go into [their] office and I go through everything I starred. And then I would hit on not only lecture things... I had questions for lab as well. So I would just do both. (Angie, Interview 2)

Other tasks that emerged were less obvious to an outside observer but important to participants were the ideas of opting out and dealing with time constraints. Participants described instances where they did not use specific tools provided to them or did not give attention to specific course content. These instances occurred in a variety of settings and could include choices made in individual or large group settings. Sometimes this was due to forgetting about a resource or preferring different study methods.

> I haven't looked at [the instructor's YouTube channel] a single time. I kind of forgot about it. (Caitlyn, Interview 3)

The practice of managing time for the anatomy and physiology course was a commonly described task. Some participants shared specific actions or struggles for that management. Other times the participants expressed a wish to have more time to complete course tasks or to master the course material. The hurdles to having enough time expressed by participants included requirements of other courses, as well as employment or extra-curricular campus activities.

> I have had to balance studying for this class along with studying for other classes. I have a job and am part of a couple of on campus organizations. These have given me less time to study for the class. However, they have improved my time management skills for studying. (Shay, Semester 2 Diary)

The data yielded a number of specific outcomes described by the participants. In fact, almost all of the outcomes listed in Table 4.7 were connected to each of the tasks or actions just described. In addition, outcomes were sometimes described as unconnected to the learning activities of the course. These findings point to a significant outcome orientation by the participants of this study.

The theme of *completed assessments* was the most commonly described outcome emerging from this analysis. In the study the theme of *completed assessments* is defined as an excerpt that references completion of an assessment and may involve a discussion of performance on that assessment. This outcome is certainly connected to the 3P Model areas of Teaching Context, which includes assessment. As described in Chapter 2, Biggs et al. [2001] included assessments as an area of Teaching Context and defined this as a Presage factor, which are course components or practices which affect learning that exist prior to or independent from engagement by students. This classification of assessments as a Teaching Context factor has been maintained in this

study. For the present data, assessments are considered the content and structure of a test, quiz, or other graded assignment. However, participants in this study frequently refer to these assessments along with the processes they have used to complete or navigate the assessment. They also refer to the outcome that a particular assessment has been completed. Therefore, the theme of *completed assessments* is not a Presage factor, but the *outcome* of the interaction between the assessment itself and the participant's approach to the assigned task. This relationship is evident as participants describe the processes or actions that they use to complete or work through a particular assessment, as displayed in the following excerpt which was coded as engaging course material to completed assessment.

> I... So I like go through a chapter and then I will take the quiz on the chapter and I like don't look at anything. I just like try to take it like it was an exam. And so I do that and then see how I did. You know, then it's like you can see what you got wrong. So you can like go back in the notes and like look at what you got wrong and fix it. But I mean the first time I always try to just like.. I'll go over all the information first take the quiz on it, see what I got wrong, and then I'll go back and look at that. But yeah, I mean I've been doing like pretty well on the first try for all of them. But I find them really helpful because it's just like how [they] would write a question on the quiz so.. Or on a test. So it's kind of like a pretest type of thing, which is nice. (Caitlyn, Interview 2)

The theme of completed assessments emerged from the current data during both first and second cycles of analysis.

The participants in this study provided data that highlight their focus on completing assessments as course outcomes, as well as the outcomes that might be

expected as connected to mastery of course material. The related themes of describing course performance, either as successful or less than hoped, was also noted by participants. These excerpts focused on the grades received by the participant for either a specific assessment or for the course as a whole. A *successful performance* was one defined as successful or meeting a goal by the participant or one that received a grade of A in the absence of goals or expectations by the participant. Similar to other outcomes, this one was frequently connected to a particular task or action. The following example shows the participant connecting altering their study habits to a successful performance on an exam.

> Also for this last test I went back to my old method of rewatching all the video lectures and making a study guide and I did significantly better on this test than the last one so I think I am going to keep doing that. (Kate, Interview 3)

A *less than hoped course performance* was defined as one that did not meet the participant's expectations or goals or one that received a grade lower than A if the participant provided no other information about their opinion of the performance. This could include performance on a specific assessment, the overall performance in the class, or not meeting one's expectation in mastering the material. Many excerpts discussed expectations related to specific grades on assessments, as demonstrated here.

> I put a lot of time into it and I ended up getting an 80. I should be happy about that because it was well above the class average, however for the amount of time I put in and the amount of information I felt like I learned for that test I thought I was going to get a better grade. (Kate, Semester 2 Diary)

Outcomes related to mastery of course content were described by participants as *remembering*, *remembering and understanding*, *understanding*, and *application*. These outcomes correspond to Bloom's Revised Taxonomy levels 1 to 3 [Anderson et al., 2001] although participants may not have used these specific words in their description, but the excerpts were classified due to the participant's definition of learning, studying, memorizing, or understanding provided during Interview 1 or 3. All of these types of outcomes could be due to individual tasks or actions described above or a result of content mastery. *Remembering* was defined as mental storage of information with the ability to recall. *Remembering and understanding* gave evidence of recall by providing specific details about a course concept. The presence of course content details differentiated this idea from remembering alone and is evidenced when participants articulated more complex course topics.

> This week in lecture we mainly focused on some of the more prevalent and specific functions of the lymphatic and immune system. The main functions of both included fluid balance, fat absorption and defense which all serve to maintain homeostasis in some form. In an overview, we tried to differentiate this into 2 main points of innate and adaptive defenses. From this we broke it down further into surface barriers and internal defenses for innate defenses, humoral and cellular immunity for adaptive defenses. For the rest of lecture we discussed each in detail with subtopics in each. My favorite part of this lecture is when we discussed the process of inflammation, a protective response designed to contain and eliminate harmful intruders and a way of maintaining homeostasis when the body experiences injury of some sort. (Angie, Semester 2 Diary)

The outcome of *understanding* was only present when connected to a specific task or action, and this was most commonly connected to absorbing information. *Understanding* was defined as the state of being able to explain course material to someone else, but the action of explaining to someone else was not a requirement. Participants sometimes talked about working with others in this way, but also would describe an internal dialogue as they explained to themselves.

> Like it'll ask me like "what are the properties of muscle?" And then like obviously... Like there's like four properties, like such as like heat production, movement, stuff like that. But then you also need to like... But then you should know to like elaborate... Heat production- how? So it's like, "oh by contracting. That produces heat." So it's kind of like general, but then like when you fill out the four... Okay, well, I need to be able to know how to explain those. (Shay, Interview 2)

The outcome of *applying* was the highest of the Bloom's Revised Taxonomy categories to appear in the data. In addition, it was the second most common way participants described their mastery of course material. *Applying* was defined as referencing a knowledge object that had been formed from the combination of previous knowledge, course content, real-world experiences, or career aspirations. Participants described applying information broadly by thinking of how the full body of course content applied to another area, but also very specifically as they described anatomy or physiology concepts and their relation to concepts learned in other courses or through some personal experience. Previous work in anatomy and physiology education has reported processes of learning or understanding and defined the categories of Remember and Understand in that context [Pandey and Zimitat, 2007] in contrast to the description as an *outcome* reported in this study.

Additional outcome groupings included *awareness of the discipline*, *confusion*, and *fascination with the course content*. Participants described new knowledge of anatomy or physiology in terms of surprise of the depth and breadth of the subject matter, but also provided examples of interest and fascination with the course content. These ideas were separate outcomes, not described concurrently by participants. In addition, participants sometimes described the outcome of their tasks or actions to be a state of confusion or difficulty with mastery of the course content.

The awareness of the discipline was the only outcome category that was not linked at some point to a specific task or action. These connections are represented in Figure 4.4. Again, the prevalence and breadth of outcome discussions throughout the data seems to point toward a focus by the participants on the outcome or destination of the course.

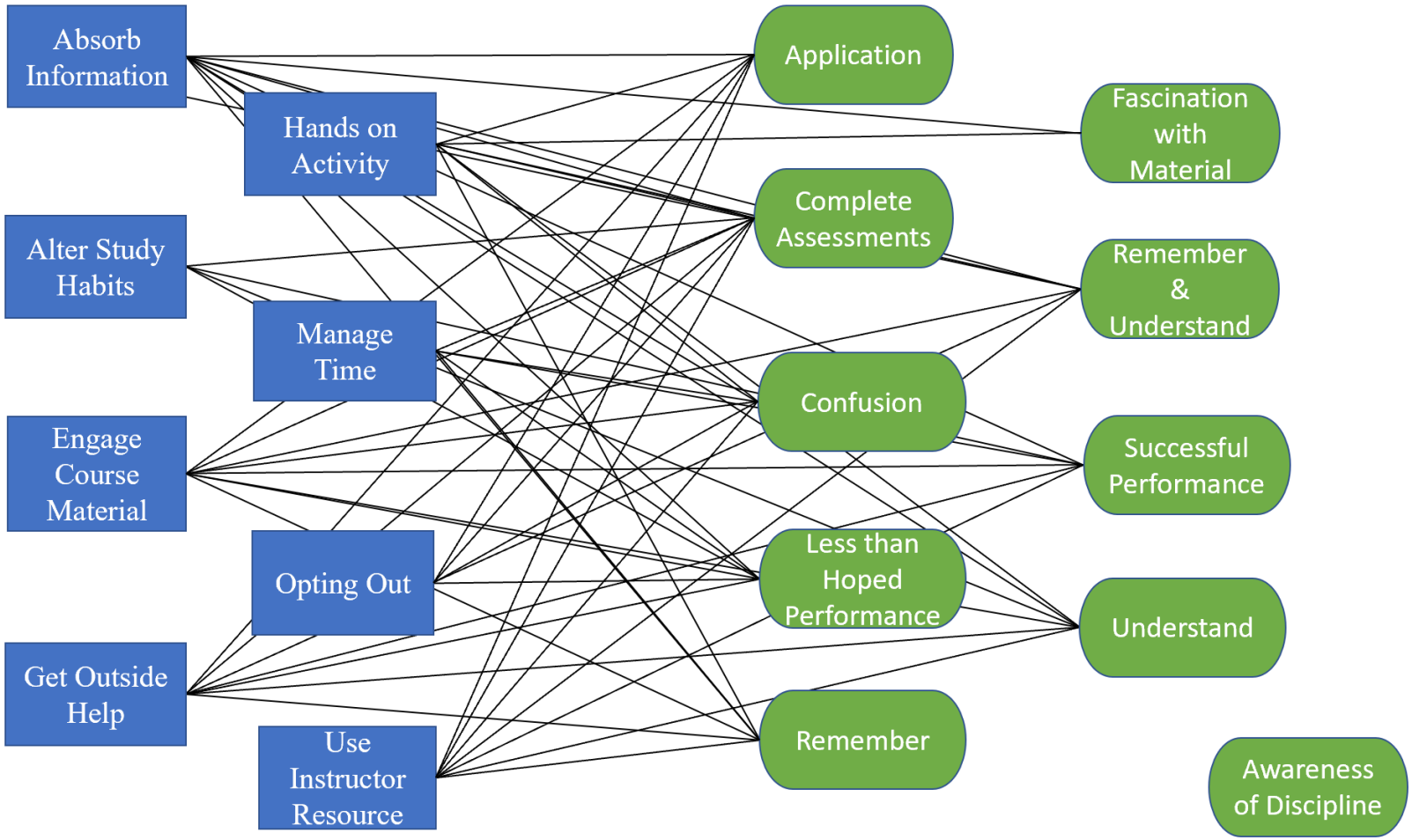

Figure 4.4: Connections evident between tasks or actions and outcomes.

Two other main themes emerged from the data and are connected to the tasks or action or outcomes reported by the participants. Feelings or affect were displayed throughout the study, while shortcomings of various types were reported by the participants. Overlap of coding between these areas and those for tasks or actions and outcomes were not resolved and these patterns of overlap provided information about the experience of the courses for the participants.

Positive affect in the form of amusement, determination, encouragement, enjoyment, and interest were displayed. Interest was the most commonly described type of positive affect. Excerpts included in this theme were those that explicitly expressed interest in the course material in general or specific content related to the course.

> The material is definitely more interesting to me. I guess it's something that I'm like, I'm going to need to actually know. Forever, you know. So I think... it's easy. It's a lot easier for me to study when I'm interested in it. (Michelle, Interview 2)

Negative affect was also evident in many participant excerpts and included discouragement, frustration, not having fun, feeling overwhelmed, and being worried. Sometimes this was in reference to the content itself, as confusion about course material was also expressed. This area of negative affect was similar to the outcome of confusion. However, in these examples, the state of confusion was not the stopping or end point, rather an affective state that was experienced during a task or action or while accomplishing a specific outcome. As an example, participants often admitted to being confused while they were undertaking another task. In this example, a physiology lab activity is described and K Diddy describes their confusion during and after the activity.

> But like we had to like stick your foot in ice and we had to... There was like exercises and stuff. And most of us knew, like, yeah, your blood pressure's going to go up. But I didn't know about the ice- was my blood pressure going to go up or was my blood pressure going to go down? Because I didn't know. I was like, this is kind of like weird. Like... But honestly I figure out... Figured it out later. But I don't... I still had to write a lab report on it. And I don't know why it went up. But um... So... but the ECG stuff is connected to the computer and you have to do all this stuff to read the wave, which is really confusing. (K Diddy, Interview 3)

The two most common forms of negative affect to be expressed in the data were frustration and being overwhelmed. Frustration was defined as either explicit or implicit expression of frustration, annoyance, or anger toward any aspect of the course. Excerpts which described an event or situation as "unfair" were also included here. Participants described their feelings of frustration about areas of Teaching Context, including instructor practices and amount of content covered on exams. Other examples showed frustration over the interaction between their own practices in mastering course content and the components of Teaching Context. This sentiment is evident in this example where a participant is describing their study practices and less than hoped for course performance. This participant used a tutor and learned that the course instructor just believed more time should be dedicated to preparing for the assessments.

> It's well... I think I was getting frustrated, probably because I do spend a lot of time in this class. And I'm not really getting the grades I really want in this class. And my tutor- is really, really close with my professor. And [they] mentioned, you know, like "[they] knows the stuff and I don't

> know what's happening." And basically my professor told me I need to kind of stop my extracurriculars. Which I'm not really kind of willing to do, so... Yeah, it was kind of frustrating, because I already feel like I've kind of put a lot of time aside for this class, and to be told to put more time to this class was really annoying and frustrating. So... (K Diddy, Interview 3)

Being overwhelmed was defined as an explicit or implicit reference to being overwhelmed or stressed by some aspect of the course. This was sometimes manifested by a participant stopping an activity they determined they could not keep up with or by describing some aspect of the course as "too much." This type of affect was most commonly related to satisfying course requirements in terms of depth or breadth of the content mastery required for the desired course performance or success in a future career. At times, being overwhelmed was described to interfere with effectively implementing other tasks or actions in the course, as is evident in the following passage.

> So again, because lectures are very material heavy, I almost feel so overwhelmed that I go into an exam feeling like I need to know every single detail. I started to confuse processes or like unclear about something and so, I started to doubt myself during questions. You know, I look at the slide and I'm like, you know, I feel like there's a detail missing. And so I focus on like what could be missing instead of like trying to really understand the material well. And so that's how it affects me. (Angie, Interview 3)

In terms of shortcomings that participants identified, these ranged from a general sense that their grade or practices related to the course were deficient to

specific areas where they believed their behaviors should change. Similar to the previously mentioned task of being able to manage their time, participants expressed their struggle with or inability to appropriately manage their time to complete the work of the course in the time frame set forth by the instructor or the university as a whole. The most common issue cited was the impact of their overall course load and managing the requirements for each class. This was mentioned to be especially challenging since so many of their course assessments occurred in the same week, and this pattern was reported to repeat for almost every exam in their anatomy and physiology course. Participants also mentioned the impact of employment or on-campus extra-curricular opportunities on their available time, but these were less frequent when compared to the demands of other courses.

The majority of self-identified shortcomings related to specific outcomes. While participants did mention instances where their performance fell short of their expectations, there were also many instances where specific details in assessments caused trouble. Participants sometimes described how their study method was not sufficient to allow for an acceptable performance in the course or on a particular assessment. At other times, participants described their specific struggle to know what information they should focus on while completing or preparing for a specific assessment, as is described in this passage.

> The most difficult thing so far this week is trying to memorize everything from last week. We have to learn all of these different muscles and muscle attachments and I found it to be relatively unclear how specific we have to be with the muscle attachment sites on the anatomy lab practical. Lecture has been relatively straightforward but I am definitely struggling trying to memorize everything for lab. (Kate, Semester 1 Diary)

The last area specifically related to outcomes that was described as a shortcoming was the ability to decipher or understand questions on exams or quizzes. Participants sometimes described "trick questions" or the wording on these assessments to be confusing. Participants were not able to provide much detail on this specific area, as they couldn't recall the wording or details of specific questions to share in their diaries or during interviews. However, this theme was described by K Diddy saying that this issue was so great that [they] viewed the course assessments to not test for actual knowledge from the class.

> I wish you could look at our tests. So you could understand... Like when I... The, the way the questions are asked. (pause) It's really hard to understand the questions... A lot of times. Which is really... It's not, that's not testing what we know. That's testing if we can take a test. (K Diddy, Interview 3)

Some other shortcomings were described in relation to their impact on carrying out the tasks or actions in the process of mastering the course content. Participants describe their struggles with mastering or remembering the course content. A shortcoming of mastering course content was defined as the description by the participant of not yet understanding or mastering a specific process. In contrast, excerpts defined as a shortcoming of remembering where those where participants indicated that they "forgot" information or were unable to recall specific details that they had worked to remember. These ideas differ from one another by whether the participant believed they had retained or mastered the information at some point or not. When the information was believed "learned" but not recalled, this was classified as a shortcoming in remembering. Other shortcomings referenced by participants included difficulty following the train of thought, often in a lecture period, lacking focus, or a lack of

help to accomplish the task or goal at hand. Participants in course 1 described a frequent use of lecture recordings to compensate for their issues with following along during class. In fact, they mentioned frequently needing to pause the video to be able to keep up while re-watching the lecture.

> Okay, so for lecture, I've found that going through and watching the recorded lecture, I can, of course, pause the video. And because [they] like will go through something really fast, I can backtrack and like replay it and replay it until I understand what [they were] really saying. While you know, like I can't do that in the moment in lecture. Which is why it's least important for me- to I still... I attend lecture but I don't think I captivate as much sitting there, as well as I can like sit in the library and go through it like a recorded lecture at my own pace and understand each section of what [they] said. (Angie, Interview 2)

Overall, participants provided eight main type of tasks or actions that they engage in during their anatomy and physiology courses, *absorbing information, engaging with course material, altering study habits, getting outside help, doing hands on activities, managing time, using instructor-provided resources, and opting out.* They also display a strong outcome-orientation as these tasks or actions are commonly connected to one of nine different course outcomes. These outcomes include *applying, remembering, remembering and understanding, understanding, completed assessments, successful course performance, less than hoped performance, confusion, awareness of the discipline, and fascination with course content.* Participants note their awareness of areas in which they are struggling in the course, by describing a number of self-identified shortcomings related to their performance in the class, specifically *recognizing important content, following along, mastering course content,*

managing their time, using appropriate study habits, and remembering. These shortcomings are often associated with various types of negative affect experienced by the participants. However, positive affect is also noted in relation to both learning activities and outcomes for the course.

4.6 Quantitative Analysis

Quantitative data from the R-SPQ-2F and HCI provide additional data in the case study analysis. Due to the small numbers in each case, inferential statistics have not been calculated. I used initial scores and change in score for the HCI within the case description. Since participants were able to provide broader information than allowed in the survey, any weaknesses in these instruments could be captured by the qualitative responses [Onwuegbuzie et al., 2011]. As the specific *outcomes* data is analyzed more deeply, this relationship may be realized as reciprocal, but there is currently no evidence that would allow such a claim.

4.7 Summary of Quality Considerations

Throughout this chapter I have described research decisions and additional actions taken to ensure quality in this project. These have followed the recommendations of Walther et al. [2013] by giving attention to validity and reliability considerations in both the "making of the data" and the "handling of the data."

In addition to the steps that have already been outlined, I kept a log trail of thoughts and knowledge about available frameworks to ensure that I had not "forced" case data into pre-conceived groups. Throughout this process I also memoed about data collection processes, the development of code categories and definitions, and any

other decisions or findings of this project. I bracketed my own thoughts about student responses to both written and interview prompts throughout the data collection and analysis phases. These steps present an opportunity for both process reliability and procedural validity [Walther et al., 2013] by producing conditions in the study that kept the research processes as independent from random influences as possible while also working to improve the fit between the theories I used and the reality under investigation. Finally, I provide thick, rich description of the data in all dissemination of the work.

To ensure the appropriate breadth of topics, I used recommended memo prompts from Saldaña [2016]. For example, I wrote this memo in mid-October 2018 after initially reviewing the word counts of weekly diary prompts.

> I feel like the depth or length of response of some prompts is less than my initial impression [when copying from student document to my storage document]. Some prompts seem to evoke more words. I think those asking specifically about exams and such as giving this, but I want to look more closely at that. All but 4 [participants] have already responded this week (week 4). Two of those have responded every week and one has responded both weeks [they have] been in the study. But I reminded anyway. My "goal" for the NSF study [this proposal was submitted to NSF but did not received funding] was 70% response rate. So far, I'm 5 for 26 missing (not counting Tigers123) or 8 for 29 if all are counted. (10/21/2018)

This memo provides information on several study parts. I utilized this memo to monitor response rates of participants and to ensure that data was being collected in a timely manner. In addition, my thoughts about how appropriate the diary prompts

were for collecting the data needed to answer my research question (monitored by both word counts of responses and depth of reflection provided) are also present.

A summary of research decisions and actions taken to ensure reliability, validity, and legitimation in this project is presented in Table 4.9.

Table 4.9: Steps taken throughout the planning and conducting of this study to ensure quality using the Q3 Framework [Walther et al., 2013] and Legitimation Framework [Onwuegbuzie et al., 2011]. Th= Theoretical Validation, P= Procedural Validation, Co= Communicative Validation, Pg= Pragmatic Validation, E= Ethical Validation, I= Interpretative Validation, Pr- Process Reliability, IOL= Inside-Outside Legitimation, WM= Weakness Minimization, O= Opportunity, T= Threat

Research Decision or Action	Th	P	Co	Pg	E	I	Pr	IOL	WM
MAKING THE DATA									
Complete pilot study	O								
Plan to recruit four participants to each block							O		
Recruitment of two or three participants to each block							T		
Collect data using written prompts and interviews	O						O,T		
Use SPQ instrument	O,T						O		
Use HCI instrument	O,T						O		
Interview instructors in their office		O	O				O		
Interview 2 and 3 prompts designed to allow each participant to expand and clarify	O		O				O		
Use semi-structured interview protocols			O					O	
Digital recording and verbatim transcription		O	O		O		O	O	
Prompts designed for seeing cognitive processes	O	O							
Using same core prompts to student interviews	O						O		
Build rapport with participants		O,T							
Prompt responses collected in shared GoogleDoc		O	O		O		O		
Repeat diary prompts across 2 semesters	O								
All participants asked same prompt in a given week	O						O		
Prompts similar to those reported in literature		O		O			O		
Use *a priori* codes from previous studies	T		O,T	O	T	T			
Each cycle of interview 2 and 3 conducted in 2 week time frame							O		
Multiple data collections		O	O				O		
HANDLING THE DATA									
Remain open to emerging themes during coding	O		O		O	O			
Keep log trail of thoughts during data collection and analysis	O	O					O		
Memo about codes and their definitions		O					O		
Bracket following data collection and during analysis		O					O		
Use constant comparative method in coding		O		O			O		
Accurately record and interpret participant words					O				
Use thick descriptions in handling and dissemination					O				
Mix results from validated instruments and qualitative data collection									O

4.8 Case Analysis and Comparison

Individual Case Analyses The main data sources for each case are the interviews and weekly diary entries pertinent to that case. At the conclusion of each coding cycle, I compiled data and codes forming each case, as well as completed analytic memos to reflect on each individual case. The codes and themes that emerged were synthesized as individual case descriptions. Specific information for each case was outlined using the structure of the 3P Model by including Student Factors, Teaching Context, Learning Process, Outcomes, and any interactions that were present. To accomplish this, I first examined which Axial Codes (see Table J3 in Appendix J) appeared in the case by constructing a Code Matrix in NVivo 12. After viewing the codes that were present for each case, I created a concept map showing connection between Tasks/ Actions, attributed to the Learning Actitivies space, and Outcomes following the pattern of the 3P Model [Biggs et al., 2001]. Overlaps and interactions between Shortcomings and Feelings/ Affect with Task/ Action and Outcomes codes was also queried in NVivo 12 to determine proper placement of these ideas on the concept map. All of these relationships were diagrammed, previous analytic memos about the case were read, and new analytic memos were written. Course artifacts were used for clarification of diary or interview data and triangulation. The complete case descriptions are presented in Chapter 7.

Comparative Case Analyses Once each individual case analysis and description was completed, I compared cases to identify similarities and differences between them. This case comparison is presented in Chapter 7.

Chapter 5

STUDENT DEFINITIONS OF KEY TERMS

Johnson, Staci N., Gallagher, E. D. (2019). Undergraduate Anatomy & Physiology Student Definitions of Learning, Memorizing, Studying and Understanding. CBE-Life Science Education (under review).

This chapter is a nearly verbatim version of a manuscript draft submitted for review to CBE-Life Sciences Education. As such, it contains a repetition of some of the background and methods appearing in earlier chapters of the dissertation.

5.1 Abstract

Biology education research often uses the terms learning, memorizing, studying, and understanding without providing specific definitions for these terms. When definitions are provided, they are often inconsistent across publications. As part of a larger research study, we interviewed 11 participants on two occasions while they were enrolled in a sequence of anatomy and physiology courses. The interview protocol

included prompts for the participants definitions of learning, memorizing, studying, and understanding, followed by a prompt to rank these terms based on perceived importance for success in the anatomy and physiology course. Definitions were isolated from the transcript, de-identified, and sorted by qualitative similarities. The research team developed code categories and assigned definitions to these groups after discussion of any coding differences. Multiple definition groups emerged for each term. Learning, memorizing, and studying had definition groups which highlighted processes, outcomes, or a combination of both a process and outcome. Understanding definition groups focused solely on an outcome. These findings highlight the need for communication between students and instructors in regard to the use of these terms. In addition, future research in biology and physiology education should be careful to provide working definitions of these terms to ensure communicative and interpretive validity and to promote transferability and repeatability of findings.

5.2 Introduction

The themes of learning, understanding, memorizing, and studying have been used to describe the processes and outcomes of student interaction with anatomy and physiology (A&P) concepts and information [Michael, 2007, Michael et al., 2017, Pandey and Zimitat, 2007, Slominski et al., 2019, Wilhelmsson et al., 2010]. Recent work has highlighted the beliefs of undergraduate instructors about how students view and employ memorization [Michael, 2007, Slominski et al., 2019]. However, few of these articles provide explicit definitions for these terms, which may lead to confusion or misapplication of research findings. Much of the literature about student learning uses survey data from large populations of students, with items incorporating the terms in question to quantify student behavior. In contrast, this paper

provides qualitative information regarding student interpretation of these terms, as well as a rank for perceived importance of the terms for course success. This use of qualitative data can provide richer, context-dependent examples from the environment in question [Gay et al., 2015]. The goal of this project was to understand the ways students in undergraduate anatomy and physiology courses define and interpret terms commonly used terms in educational research (learning, memorizing, studying, and understanding). Our results indicate threats to the communicative and interpretive validity of prior work in biology education research and perhaps to discipline based education research, more broadly. Communicative validity is concerned with ensuring that knowledge is socially constructed within the relevant community and that researchers utilize [Walther et al., 2013]. Interpretive validity is concerned with ensuring that participant words, behavior or perspective are interpreted in a way to capture the participant's perspective [Gay et al., 2015].

5.2.1 Revised Bloom's Taxonomy:

The Bloom's Revised Taxonomy (BRT) is a widely known and cited description of types of learning desired by instructors for their students. In BRT [Anderson et al., 2001], six cognitive process categories are outlined: Remember, Understand, Apply, Analyze, Evaluate, and Create. These categories may be visualized as shown in Figure 5.1.

These broad categories are further subdivided into 19 cognitive processes. The editors of BRT state "To be useful, the definitions of knowledge types and subtypes and the process categories and specific cognitive processes must be understood clearly and precisely" [Anderson et al., 2001, pg. 36]. In keeping with this statement, the

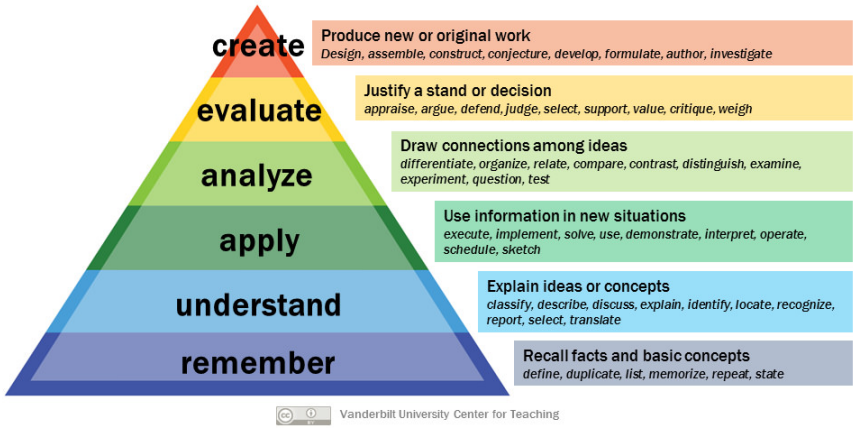

Figure 5.1: Visual representation of Bloom's Revised Taxonomy (BRT). Used by permission of Vanderbilt University Center for Teaching.

authors define each of the process categories and individual processes. As an example, the following information is provided about BRT categories 1 and 2.

- BRT Category 1: Remember is defined as "retrieving relevant knowledge from long term memory" [Anderson et al., 2001, pg. 67]. Subcategories include "Recognizing or Identifying" and "Recalling or Retrieving."

- BRT Category 2: Understand is defined as "constructing meaning from instructional messages, including oral, written , and graphic communications." [Anderson et al., 2001, pg. 67] Subcategories of category 2 range from "Interpreting" to "Summarizing" to "Comparing."

In Chapter 5 of Bloom's Revised Taxonomy, the authors provide this excerpt:

> Two of the most important educational goals are to promote retention and to promote transfer (which, when it occurs, indicates meaningful learning) ... In short, retention requires that students remember what they have

> learned, whereas transfer requires students not only to remember but also to make sense of and be able to use what they have learned. [Anderson et al., 2001, pg. 63]

This quote indicates that the authors assume that their readers have a clear and consistent conception of how learning is defined despite the fact that they do not provide such a definition in the BRT.

Ultimately, BRT is focused on student outcomes, but provides no direction or connections to processes or actions to reach those outcomes. Because of this focus on outcomes, "studying" would not seem to fit in a discussion of BRT. However, students and their instructors use this term frequently to indicate some process by which learning is occurring.

5.2.2 Use of Terms in the Literature:

Within BRT, "learning" is the overarching concept which is only defined through inference from the taxonomy levels. However, a clear and succinct definition of "learning" is essential in anatomy and physiology education and associated research. However, coming to a definition is a difficult task, since many are used in the literature. In contrast, a number of studies provide no specific definition of the term "learning" despite utilizing the term frequently. While definitions are provided in other publications, these are not always in agreement. In the final chapter of the book *Improving Learning: New Perspectives*, Marton and Ramsden [1988] state:

> Learning should be seen as a qualitative change in a person's way of seeing, experiencing, understanding, conceptualizing something in the real world - rather than as a quantitative change in the amount of knowledge someone possesses. It is logically impossible for learning defined in

> this way to be content- and context-free. Learning techniques and instructional strategies are inextricably linked to subject matter and the students' perceptions. ([Marton and Ramsden, 1988, pg. 271])

Roth and Anderson [1988, pg. 139] use a similar definition, saying that learning is a "difficult and complex process of conceptual change, not a process of acquiring and memorizing facts." These definitions are in agreement with each other and the BRT that learning is a process that changes the learner and is not a process of acquiring facts or information, but instead focuses on higher order levels in the Taxonomy. More recent work in biology education research has adopted a definition of learning to include both acquisition of facts and conceptual change. Southard et al. [2016, pg. 3] have defined learning as "a dynamic process involving the acquisition of new ideas, the development of connections between ideas, and the reorganization of prior knowledge." In the A&P literature, Wilhelmsson et al. [2010, pg. 154] define learning as "the ability to identify structures with their internal relationship and the talent to compile details into a three-dimensional whole." All of these studies and others [Bailin, 2002] are in agreement that learning is context-dependent and may take many forms, but they disagree about the inclusion of quantitative changes or knowledge acquisition. Regardless of the definitions of researchers or instructors concerning learning, there is a potential disconnect or contradiction with the way that students interpret and carry out the learning.

"Understanding" has been defined in multiple ways in the literature as well, and most of these definitions differ from that provided by BRT [Anderson et al., 2001]. Kember [1996, pg. 343] provided the definition most closely aligned, defining understanding as "the intention of seeking inherent meaning." In the anatomy and physiology literature, Fyrenius et al. [2007, pg. 151] defined the term to mean "ca-

pability in application." Wilhelmsson et al. [2011, pg. 154] provide a more detailed definition, stating that understanding is "the mental act of connecting parts into a coherent system, as well as decomposing larger objects into sub-parts." Interestingly, Wilhelmsson et al. [2011] definition is incongruous with that provided by Kember [1996], yet makes use of similar themes present in the subcategories of Understanding provided by BRT's such as Comparing or Inferring [Anderson et al., 2001, pg. 31].

In addition to a lack of agreement on the definition of "understanding," there is also a lack of consensus on the appropriate method to measure this state. Nonetheless, previous studies consistently indicate that instructors believe that understanding is the desired end-point or "destination" of student learning, while also noting that memorization is frequently employed by students as a course strategy [Entwistle and Entwistle, 1991, Kember, 1996, Michael, 2007, Pandey and Zimitat, 2007, Wilhelmsson et al., 2010]. In addition, the term "understand" appears in multiple descriptions of the Core Competencies described in Vision and Change [Vis, 2009], but is not clearly defined in the document.

"Memorizing" and "studying" are rarely defined in the literature despite their frequent use. Memorizing is usually described as an inferior or undesirable outcome in college courses. Both Michael [2007] and Slominski et al. [2019] report instructor belief that physiology is hard for students because of confusion between memorization and learning. The definition of studying may be inferred to mean the processes utilized by students in their quest for learning, memorizing, or understanding. However, much of the literature seems to assumes that readers hold a similar definition to that of the author by not providing a definition at all [Barattuci, 2017, Bonsaksen et al., 2017]. Our results indicate that even if that were true, the interpretations of these words by students vary considerably.

5.2.3 Research Questions

Regardless of definition, there is an interest in the processes and improvements of learning, studying, and understanding in our undergraduate biology curriculum. It is important to know how students conceive and use these important terms to avoid misapplication of research results by strengthening communicative and interpretive validity of this work. This qualitative study attempts to answer the following questions:

1. In what ways do undergraduate anatomy and physiology students define the terms learning, memorizing, studying, and understanding?

2. Which of these ideas do undergraduate anatomy and physiology students believe are most important for success in the anatomy and physiology classroom?

5.3 Methods

5.3.1 Methodology & Methods

This study was conducted as a small part of a larger comparative case study investigating the cognitive processes and pathways of A&P students during a two-semester sequence of anatomy and/or physiology courses. The research was reviewed and approved as exempt by the Institutional Review Board at Clemson University (2018-310) prior to the beginning of the project.

5.3.2 Sample Selection

In Fall 2018, students enrolled in three sections of anatomy and physiology were contacted to complete a short survey. Of these sections, two were a sophomore

level anatomy & physiology course (Anatomy & Physiology I) which led to a second semester in the sequence (Anatomy & Physiology II). The remaining section was a junior level course of functional human anatomy followed by a human physiology course. From this survey, we recruited eleven participants for a two-semester project. Complete details about this recruitment at presented in Johnson and Gallagher (n.d., under review). Data collection began with seven (7) students from the Functional Human Anatomy course (A→P) and four (4) students from Anatomy & Physiology I (A&P). Interviews The eleven participants were interviewed in September/ October 2018 and eight of those participants (5 from A→P, 3 from A&P) were interviewed again in April 2019. This provided a total of 19 interviews. During both interviews, participants were asked the following questions:

1. How do you define learning? memorizing? studying? understanding?

2. How would you rank these (learning, studying, memorizing, understanding) in terms for success in this A&P course?

Interviews were digitally recorded and transcribed to accurately capture participant words. Prior to analysis, the definition excerpts from each interview were unitized and all identifying information (participant identification and interview number) was removed from the excerpt.

5.3.3 Analysis

Participant definitions for each term were grouped by qualitative similarities by one of the research team members. This coder developed a complete description or definition of that definition group. A second research team member then sorted the definitions according to the provided descriptions. All discrepancies between

group assignment were then discussed and both group assignment and definitions were revised to determine the final categorization, as agreed on by both researchers. This final code book is available in Table J1 in Appendix J.

5.3.4 Validity & Reliability in Qualitative Research

Several steps were undertaken to ensure validity and reliability of the data, giving attention to the collection and analysis steps of this project. Our method of participant selection involved sampling from two different courses which serve different groups of student majors. These choices provided opportunity for theoretical validity, which is concerned with capturing the full extent of the social reality under investigation [Walther et al., 2013]. The use of open-ended questions provided supported both theoretical and communicative validity. All interviews were captured by digital recording and transcribed to ensure accurate capture of participant definitions, supporting process reliability, which is defined as making the research process as independent as possible from random influences [Walther et al., 2013]. Prior to coding, identifiers were removed from the definitions to reduce researcher bias and further support communicative and interpretive validity. Open coding was utilized during the initial coding pass [Saldaña, 2016] which provided an opportunity for communicative validity. In addition, two coders grouped and discussed all definitions and coded to agreement. These steps in analysis also provided an opportunity for procedural validity, which concerns itself with ensuring that the research design improves the fit between theory and reality [Walther et al., 2013].

5.4 Results

Information relating to Research Question 1 *(In what ways do undergraduate anatomy and physiology students define the terms learning, memorizing, studying, and understanding?)* is provided first and then followed by data related to Research Question 2 *(Which of these ideas do undergraduate anatomy and physiology students believe is most important for success in the anatomy and physiology classroom?).*

5.4.1 Student Definitions of Terms (Research Question 1)

LEARNING: Three main definition groups emerged during analysis, with one group divided into additional subcategories. Definitions focused on the process for learning, a specific outcome, or a combination of process and outcome. The process for learning identified in definition groups was "acquisition of information," but the outcomes used by students varied. As noted earlier, BRT focuses on outcomes only, but participant definitions incorporate processes or actions to achieve that outcome.

1. *Learning is acquisition of information. (Outside bounds of BRT)* Four of the 19 definitions were categorized into group 1, but one of these was grouped with conditions. In this case, the participant stated that they were providing a definition from their Psychology course. Because of this comment, we were concerned that this definition provided head knowledge, but not a definition based on their practical engagement with course material. For the other definitions that were grouped to this category, the definition focused solely on the process of learning which was defined as acquisition of information. As stated by Walt Owens in interview 1:

> Acquiring new information on a topic or attempting to acquire information on a topic that you were not previously familiar with.

2a. *Learning is acquisition of information that leads to recall. (BRT: Remember)* Five of the 19 definitions were categorized into group 2a. This definition focused on both a process, specifically acquisition, leading to the specific outcome of information recall. These definitions may mention additional outcomes for learning, but specifically include recall of the information in their definition. Sally provided this definition in Interview 1 which summarizes both of these themes clearly:

> Typically learning would then mean knowing it and you point it out after that. Or at least knowing about it after that... a big part of learning is actually understanding, remembering, and being able to recall the information.

2b. *Learning is acquisition of information that leads to understanding. (BRT: Understand)* Six of the 19 definitions were categorized into group 2b. These definitions focused on both acquisition leading specifically to the outcome of understanding along. Several of these definitions also expanded the outcome of understanding to describe this state as being able to explain the information to someone else. Kate provided this definition at interview 2:

> I think to hear something and internalize it, and kind of like understanding how it works. Be able to describe it to somebody else.

2c. *Learning is acquisition of information that leads to application. (BRT: Apply)* Two of the 19 definitions were categorized into group 2c. These definitions

focused on acquisition of information leading specifically to the outcome of applying the information. For example, Angie provided this definition at interview 1:

> Taking in information and applying it... to everyday life things... consistently.

3. *Learning is the recall or application of information. (BRT: Remember/Understand/Apply)* Two of the 19 definitions were categorized into group 3. These definitions omitted any reference to a process or procedure for learning but focused solely on the outcome or results of learning. Shay provided this definition at interview 1:

> Being able to explain the material without notes. And in like a thorough manner. You're not just like spitting out like, something.

Figure 5.2 summarizes the relationship of each definition group to BRT. Group 1 represents an action or process by an individual and falls outside of the outcomes of BRT. However, each of the Group 2 definitions include the process or action or acquisition as part of their definition. In contrast, Group 3 defines Learning solely as an outcome, but this could include any or all of the first 3 BRT levels.

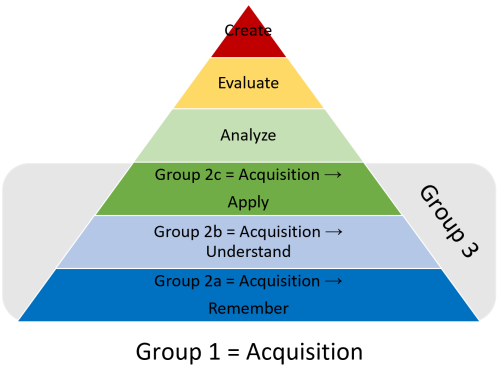

Figure 5.2: Participant definitions of Learning, showing their relationship to Bloom's Revised Taxonomy (BRT).

While only four of eight participants provided definitions in the same group in interviews 1 and 2, the changes were very

small. Changes involved providing a different outcome for Learning in the interviews or moving solely to a process or outcome-based definition. Three participants, Michelle, Walt Owens, and Waterskier, provided a definition with both a process and outcome at interview 1, but moved to a process only definition (group 1) at interview 2.

UNDERSTANDING: Three definition groups emerged during analysis that focused solely on an outcome. These definitions ranged from knowing or retelling details to having an ability to teach or explain the information to others.

1 *Understanding is the ability to teach or explain information to others. (BRT: Understand)* Eight of 19 definitions were categorized in group 1. This definition was centered on the ability to teach or explain the information in question. This is evidenced in Shay's definition at interview 1 where they defined understanding based solely on the ability to teach or explain:

> If someone is able to ask you a question about it, and you're able to give them like an example or an answer that they understand. Or if you're telling them something and they ask a question to like, build off of it, you know the answer to that.

2. *Understanding is the ability to apply or connect knowledge. (BRT: Apply/Analyze)* Four of 19 definitions were categorized in group 2. This definition group is more centered on the learner but defines understanding as a higher order cognitive process. As an example, Walt Owens provide this definition that focuses on how knowledge connects:

> Studying for like long-term... Knowledge of the topic or skill. So rather than just memorizing it but knowing how it fits in with like everything else.

3. *Understanding is knowing details or being able to retell in depth. (BRT: Remember/Understand)* Seven of 19 definitions were categorized into group 3. These definitions focused on the knowledge itself rather than an outcome that could be easily observed, like in groups 1 and 2. K Diddy highlights this internal use and change regarding information in this definition provided at interview 2:

> Understanding would be taking a concept and being able to... reword it in your own language or your own... Yeah, in your own way.

Figure 5.3 summarizes how participants define Understanding very differently than BRT. Only Group 1 defined this term consistent with the taxonomy, while Group 2 actually defined this term as higher order cognitive levels.

Three participants had definitions that remained in the same category across the academic year, but most shifted to a new category. For example, K Diddy and Shay shifted from group 1 to group 3 and Michelle and Walt Owens shifted from group 2 to group 3. These changes indicate an increased focus on their own knowledge rather than what they could do with that knowledge. In contrast, Kate showed the opposite shift, moving from group 3 to 1 at the end of the year.

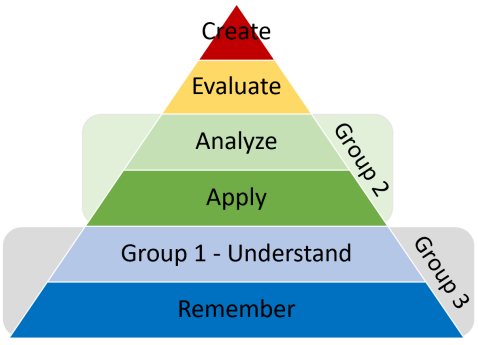

Figure 5.3: Participant definitions of Understanding, showing their relationship to Bloom's Revised Taxonomy (BRT).

MEMORIZING: Five definition groups emerged during analysis. These definitions centered on outcomes achieved through memorization or a combination of a process and the outcome. While the processes related to memorization centered on repetition, outcomes varied from simple short-term memory to a lack of understanding.

1a. *Memorizing is short term memory. (Outside the bounds of BRT)* Two of the definitions were categorized to group 1a. These definitions focused on the outcome of short term memory but gave no information about how this is attained. In their second interview, Kate provides this definition highlighting a focus on time:

> This word to me is short term... And it's often something that I don't care about or if it is, I'm just trying to get a good grade and I don't have a lot of time.

1b. *Memorizing is repetition resulting in short term memory. (Outside the bounds of BRT)* Two definitions were categorized into group 1b. These definitions also highlighted the process of repetition but focused on the outcome of short-term memory. In their first interview, Kate provided this definition which clearly describe repetition and short-term memory:

> It's just shoving as many things into my brain with, like repetition. And then I usually forget it pretty soon after.

2a. *Memorizing provides recall. (BRT: Remember)* Six of the 19 definitions were categorized into group 2a. These definitions focused on a possible outcome of memorization- information recall. Consider the following quote from Tigers123:

> e able to recognize what you learned... you would be able to draw it back up. You wouldn't have to just look at something and you wouldn't be reading it. It would be coming out of your head. (B)

2b. *Memorizing is repetition resulting in recall. (BRT: Remember)* Three of the definitions were grouped into group 2b. These definitions focused on both the process of memorizing, referencing the use of repetition, as well as the outcome of being able to recall or reproduce the information. Shay provided this quote that highlights both the process and outcome:

> Continually going over information, until you know it like front and back... But just like through repetition.

3. *Memorizing is not understanding. (BRT: Not Understand)* Six definitions were categorized into group 3, which focused on a lack of understanding when information is memorized. Some of these quotes provided a process or outcome related to information, but clearly associated memorizing with a lack of understanding. Walt Owens defined it this way:

> Being able to... look at information and then repeat it back... without necessarily understanding of that information.

Figure 5.4 summarizes the relationship of participant definitions to BRT. Short term memory falls outside the Taxonomy as an outcome. Groups 1b and 2b have included the specific action or task of using repetition to achieve an outcome of either short term memory or remembering. This is in contrast to Group 3, which simply defines memorizing as a lack or understanding.

While only three of the eight students had definitions that remained in the same group, the majority of the changes were minor. For instance, Caitlyn's definition

at the first interview emphasized repetition resulting in recall (group 2b) which shifted to repetition resulting in short term memory (group 1b) at the second interview. Only one student had a significant change (Angie) who shifted from memorizing as short-term memory (group 1a) to the process of repetition leading to recall (group 2b).

STUDYING: Four definition groups emerged during analysis with one group subdivided into an additional three subcategories. Like the definitions of learning and memorizing, these definitions centered on either a process or action or were a combination of process and outcome. The outcomes mentioned ranged from extrinsic to intrinsic factors. One definition (London, interview 1) provided very vague information and was excluded from further analysis.

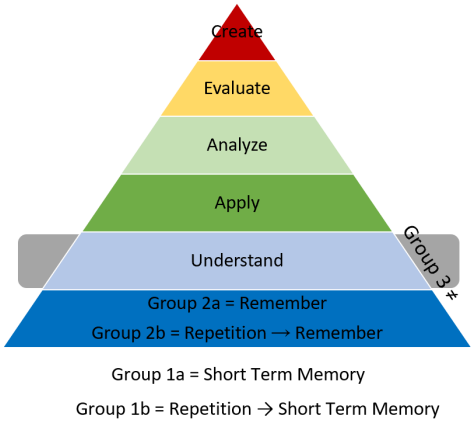

Figure 5.4: Participant definitions of Memorizing, showing their relationship to Bloom's Revised Taxonomy (BRT).

1. *Studying is a "process." (Outside the bounds of BRT)* Four of 18 interviews provided a definition that was categorized to group 1. These definitions all defined studying as a process. While the outcome of this process varied, these definitions explicitly defined the term as a process. K Diddy provided this quote at interview 2:

   > Studying is... basically the process of learning the material that was discussed in class on your own time outside of class... in your own way... through just whatever mechanisms you find most helpful.

2. *Studying is a use of time. (Outside the bounds of BRT)* Two of 18 interviews provided a definition categorized in group 2. These definitions focused on the requirement or need for time to study. No information was provided about how the time was used. As an example, Michelle provided this definition at interview 2:

   > I guess [studying is] dedicated learning time.

3. *Studying is an action leading to an extrinsic act, e.g. test. (Outside the bounds of BRT)* Three of 18 interviews provided a definition in group 3. These quotes specifically tie the action of studying to a test, although other extrinsic outcomes may be mentioned. As an example, K Diddy provided this quote at interview 1:

   > Taking what you learned in class... so that you master the topic... for an exam or whatever.

4a. *Studying is an action leading to memorization. (BRT: Remember)* Two of 18 interviews provided a definition in group 4a. These quotes indicate specific actions, but tie those to simple information recall or memorization. Caitlyn provided this quote in interview 1, defining the term based on their normal practice:

   > I rewrite all of my notes to study and compare like multiple sources together, like get all the information that I need. And then just repeat it over and over again until I remember it.

4b. *Studying is an action leading to understanding. (BRT: Understand)* Four of 18 interviews provided a definition in group 4b. These quotes provide evidence of

the requirement for both an action and an outcome, and specifically mention understanding as an intended outcome of the process. At interview 2, Caitlyn demonstrates change in their definition of studying, by providing less information about their process and highlighting their intention to understand the material:

> Studying is... sitting down and... I guess, really like engaging in all the material that you're given. And like working to understand it.

4c. *Studying is an action leading to both understanding and memorization. (BRT: Remember/ Understand)* Three of 18 definitions were classified to group 4c. These definitions specifically mention a process but include multiple specific outcomes of memorizing and understanding. Shay provided this quote at interview 1:

> Knowing the material enough to be able to like, answer questions without notes. But its being able to like go in depth and provide examples. So yeah, it's like reviewing the material enough times to be able to do that... in order to study, I have to be learning material, understanding it, and memorizing it at the same time.

When comparing the changes of definition groups of participants, none remained in the same group over time, but most of these changes were minor. Most changes involved a change in the outcome following studying, with all progressing from extrinsic or surface outcomes toward understanding. For example, Angie provided a definition in group 2 at interview 1, but moved to group 4b at interview 2 when they provided this quote:

> Taking the time to understand materials, again in detail and then... not from memory like being able to... Being able to explain something to someone else.

Figure 5.5 represents the relationship of each definition group to BRT. Again, participants frequently describe tasks or actions they take to achieve different outcomes as part of their term definition.

5.4.2 Student Ranking of Perceived Importance of the Four Terms for Course Success (Research Question 2)

In terms of the ranking of "learning" for success in their course, all but one participant ranked learning as 1 or 2 across the study duration. This term was relatively stable, but did drop in importance during the study, overall. These changes can be visualized on Figure 5.6.

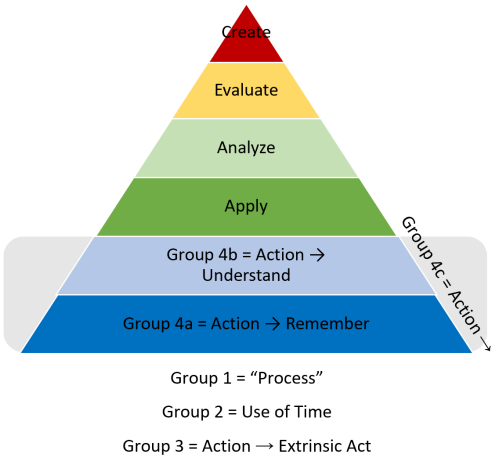

Figure 5.5: Participant definitions of Studying, showing their relationship to Bloom's Revised Taxonomy (BRT).

In terms of ranking, participants showed a growing preference for understanding from the beginning to the end of the academic year. While four students recognized understanding as most important for success in their anatomy & physiology course during interview 1, all students promoted understanding at the end of the semester. This pattern is evident on Figure 5.7.

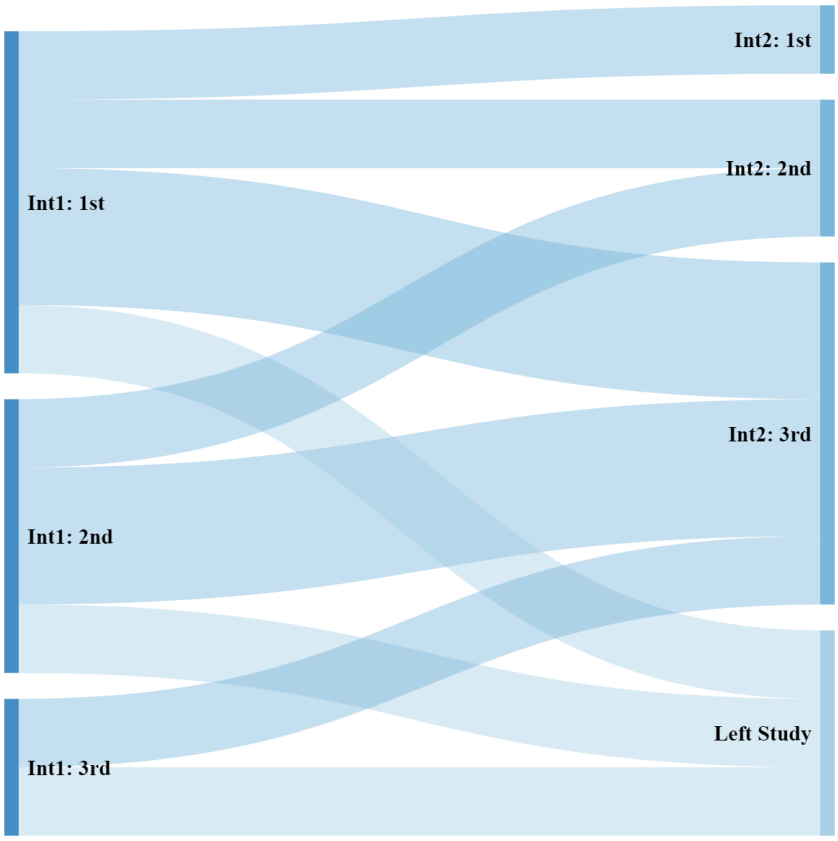

Figure 5.6: Diagram representing the change in participant ranking of LEARNING as a strategy for success in their anatomy & physiology course between interview 1 and interview 2.

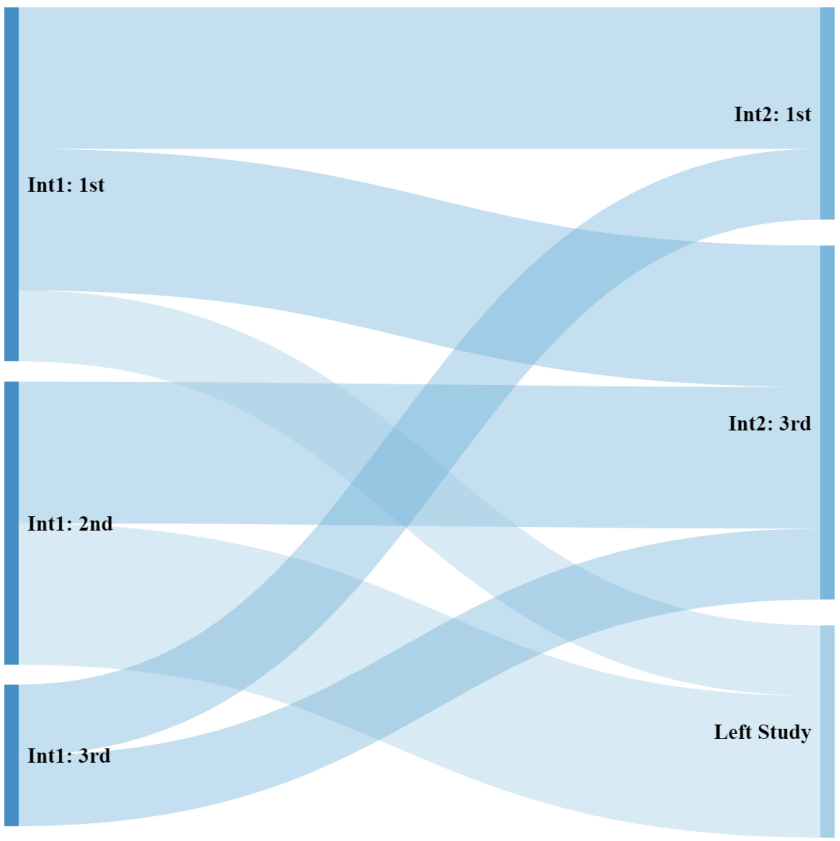

Figure 5.7: Diagram representing the change in participant ranking of UNDERSTANDING as a strategy for success in their anatomy & physiology course between interview 1 and interview 2.

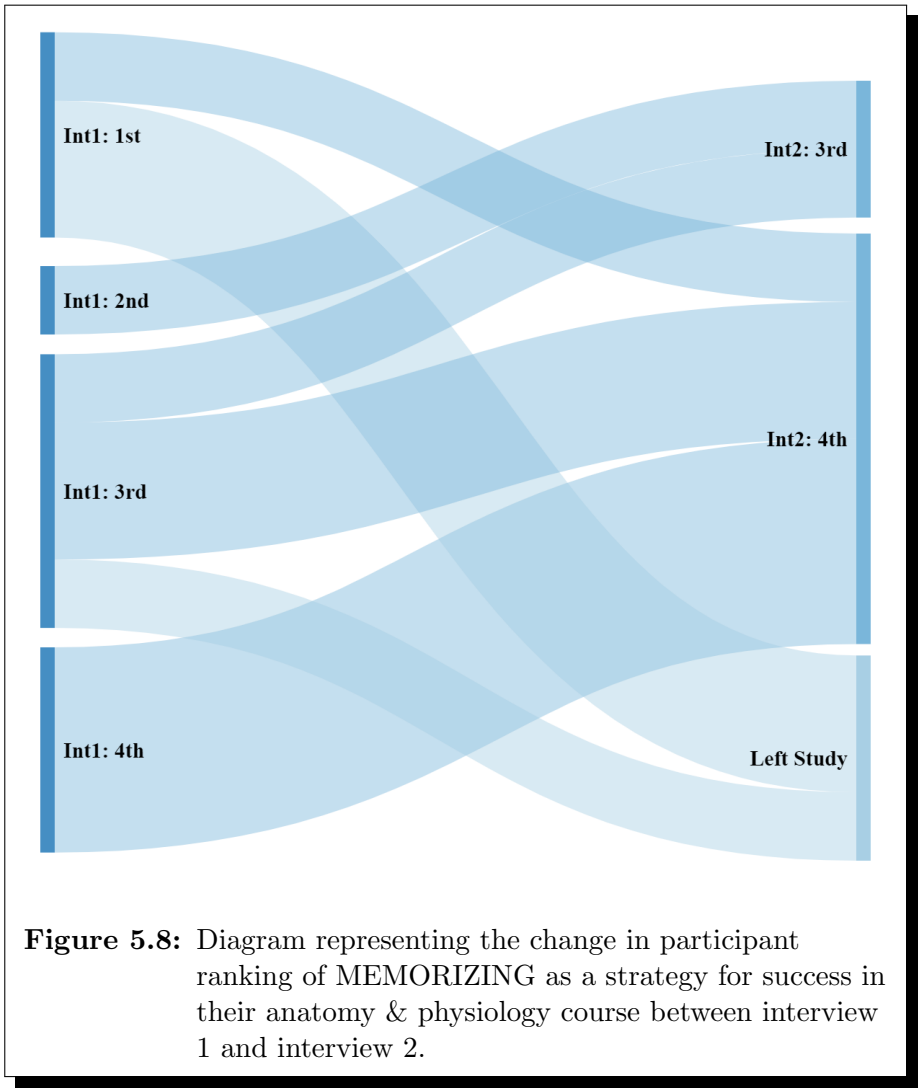

Figure 5.8: Diagram representing the change in participant ranking of MEMORIZING as a strategy for success in their anatomy & physiology course between interview 1 and interview 2.

In terms of student ranking of the importance of memorizing, only two students placed memorizing higher than third at the first interview. Six of eight participants ranked memorizing as fourth at the second interview. Overall, none of the participants increased their ranking of memorizing at the second interview. These shifts are graphically represented in Figure 5.8.

In terms of student ranking, studying was mainly ranked as either second or third in importance, with very limited movement across the academic year. These changes are presented in Figure 5.9.

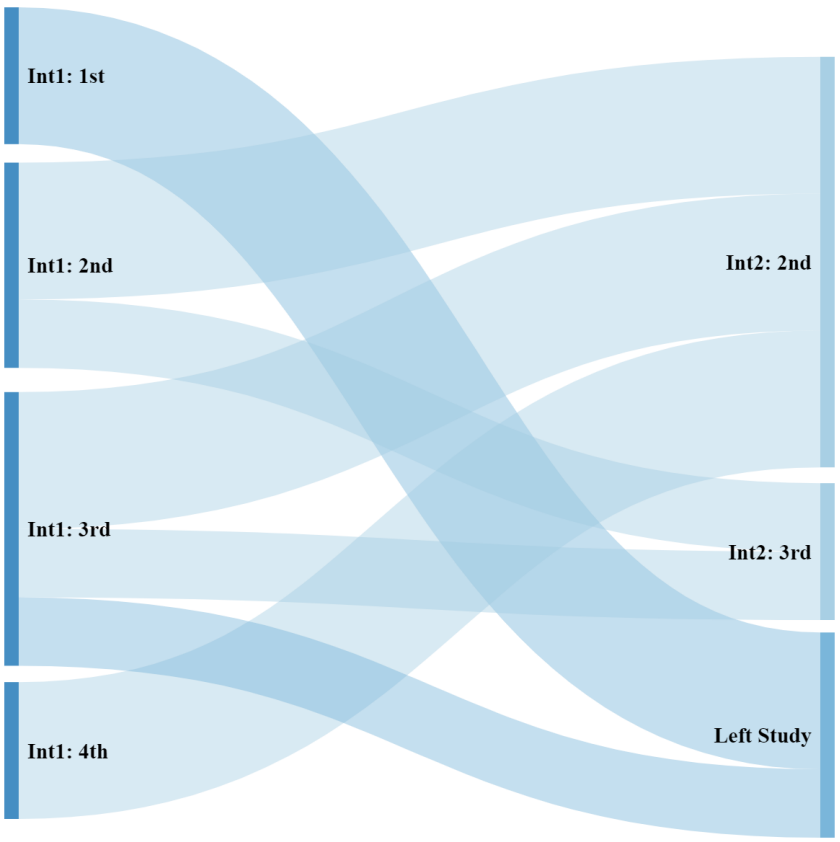

Figure 5.9: Diagram representing the change in participant ranking of STUDYING as a strategy for success in their anatomy & physiology course between interview 1 and interview 2.

5.5 Discussion

When comparing participant definitions to that of BRT and previous literature, there is some consistency with noted differences. For Learning, participant provided definitions encompass a broad range from BRT, but not all categories are present. Notably, the highest category to appear in the definitions is Category 3: Apply. While Memorizing is not part of BRT, three of the definition groups make a connection to Category 1: Remember. Some participants equate memorizing with recall of information, while other definition groups equate memorizing with short term memory. However, these definition groups would fall outside BRT and its description of learning since Remember is defined as "retrieving relevant knowledge from long term memory." (emphasis added) [Anderson et al., 2001, pg. 30] For Understanding, participant definitions provide connections to multiple BRT categories. Group 1's definition (Understanding is the ability to teach or explain information to others) is consistent with BRT, referring to the cognitive process of explaining. However, the remaining groups are not consistent with BRT's Level 2: Understanding and related subcategories. Group 2 (Understanding is the ability to apply or connect knowledge) shows a mix as the intention to connect could be viewed as similar to Comparing. However, BRT's Level 3 is Apply, which would indicate that these participants view understanding more broadly than researchers or educators. In contrast, Group 3 (Understanding is knowing details or being able to retell in depth) regresses with their definition to provide a definition which is consistent with BRT's Level 1: Remember.

When comparing the definition groups to each other, there is a similar structure in the definitions of Learning, Memorizing, and Studying. Each of these groups include, processes or actions, outcomes, and a combination of processes and outcomes

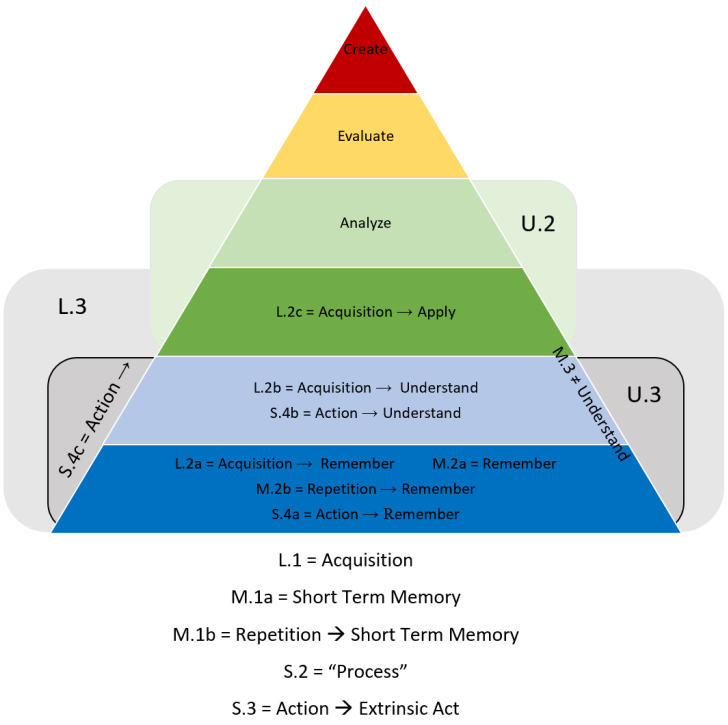

Figure 5.10: A summary of all definition groups and their connection or overlap with BRT.

in the definition groups. However, Understanding was defined solely as different outcomes with the new knowledge or information.

Between the definition groups, there is no overlap in the description of the process or action to reach learning or memorizing. However, there are overlaps in the outcomes for the terms. For instance, memorizing is an outcome for Studying groups 4a and 4c and understanding is an outcome for Learning group 2b and Studying groups 4b and 4c. Interestingly, Learning groups 2c and 3, as well as Understanding group 2, identify Application as an outcome. Application is a BRT's category 3 task and is considered a higher cognitive skill than understanding. These overlaps in the definitions and their relationship to BRT is shown in Figure 5.10.

Both Michael [2007] and Slominski et al. [2019] found that instructors of anatomy & physiology believed that students found the subject to be difficult because

students believe that memorizing is the same as learning. However, the qualitative data from our sample indicate that this is not the case. In fact, students use very different definitions for these terms which often employ the higher order skills from BRT of understanding and application.

Overall, the lack of consistent definitions for these commonly used terms from student participants should cause us to reconsider our use of these terms without providing additional information or context. Different working definitions of these terms in a research setting is a threat to communicative and interpretive validity and may lead to lack of transferability or generalizability of findings. In the teacher-student relationship, this incongruity may lead to misunderstandings, frustration, or other intended negative outcomes on the part of the student.

5.5.1 Limitations:

The participant pool in this work (n=11) is sufficient for a qualitative study and not considered a limitation of this work. In addition, limitations related to taking a "snaphot" of student definitions is reduced by the second interview and the lack of movement in participant definitions. However, this work is limited by the fact that this data was a portion of the overall interview, and opportunities to probe for additional depth on this topic could have been missed. These interviews were conducted with a specific audience and similar work with a different population may identify different definitions. However, this limitation does not impact the relevance of these findings in anatomy and physiology education.

5.5.2 Future Work:

Student and instructor definitions should be studied further, asking open ended questions and utilizing similar coding methods to determine if these definitions are broadly held by both life science undergraduate students and across STEM disciplines. These participants should be recruited from a range of institution types and sizes. In addition, validity studies should be conducted for key instruments used in discipline based education research that rely on the four terms discussed here.

Chapter 6

VALIDITY OF THE R-SPQ-2F

Johnson, Staci N., Gallagher, E. D. (2019). Issues with the Revised Study Process Questionnaire (R-SPQ-2F) in Undergraduate Anatomy & Physiology Students. Anatomical Sciences Education (under review).

This chapter is a nearly verbatim version of a manuscript draft submitted for review to Anatomical Science Education. As such, it contains a repetition of some of the background and methods appearing in earlier chapters of the dissertation.

6.1 Abstract

The 20-question Revised Study Process Questionnaire (R-SPQ-2F), which categorizes students as either deep approach (DA) or surface approach (SA), was administered to three sections of Anatomy & Physiology (A&P) courses at a highest research university in the southeastern United States as part of a larger research project. 230 respondents completed the full survey and 11 participants were recruited to a comparative case study. Initial review of interview transcripts raised concerns about the validity of the R-SPQ-2F instrument for the current population. Interview transcripts

were coded using a priori codes corresponding to the R-SPQ-2F items. Qualitative and quantitative results were then triangulated. Findings suggest that the R-SPQ-2F was not able to group students by DA or SA in the context of an undergraduate A&P course and requires additional refinement and testing to be a valid instrument for this population. Further, six interviews (3 DA, 3 SA) demonstrated a new theme of "Surface Leading to Deep" with participants indicating that memorization was necessary for the purpose of gaining a full understanding of the course material. This finding has significant implications for instruction, as memorizing and other surface strategies are often minimized and discouraged, yet they are an important step in student learning.

Key Words deep learning, surface learning, achieving learning, mixed methods, survey validation

6.2 Introduction

Student learning continues to be topic of interest for educators across many contexts and educational levels. Within this body of literature, student approaches to learning (SAL) research has examined both the affective and contextual aspects of learning to elucidate student cognitive responses to the task of learning [Barattuci, 2017, Biggs et al., 2001, Entwistle et al., 2000] The SAL concepts of "Deep and Surface Approaches to Learning [Marton and Saljo, 1976] have been consistently utilized in educational research over the past 40 years and has more recently been used to understand how the biological subdisciplines of anatomy and physiology are learned, specifically in medical education [Fyrenius et al., 2007, Pandey and Zimitat, 2007]. Biggs et al. [2001] first developed the Study Process Questionnaire and Learn-

ing Process Questionnaire instruments to quantify a student's approach to learning. The Revised Study Process Questionnaire (R-SPQ-2F), the most recently developed instrument which categorizes student responses as either Surface or Deep, has been used in educational research studies and in physiology education [Biggs et al., 2001, Pandey and Zimitat, 2007, Sabourin, 2016].

6.2.1 Development of SAL Theory

Present research on student learning has built on findings from the 1970s and 1980s on student learning approaches and whether these approaches are fixed or context-dependent [Beattie et al., 1997]. The SAL body of literature was built from findings by four main research groups. Since these groups were addressing the same questions during the same period of time, findings from one group influenced the views and responses of the others.

The Lancaster group, led by Entwistle, mainly utilized quantitative methods of study and separated learners based on a student's personality, motivation, and study methods. Originally, this group held that a student's approach to learning was a fixed characteristic, which remained stable over time and across contexts. This view was later amended in light of findings from the other three SAL research groups [Entwistle and Entwistle, 1991]. The Swedish group, led by Marton, mainly utilized the qualitative approach of phenomenography in describing deep and surface learning. The main contributions from this group were that a student's intention when learning was critical and SAL was flexible and context-dependent [Marton and Saljo, 1976]. The Richmond group, led by Pask, also adopted a qualitative approach to studying SAL and introduced the terms of serialistic and holistic to describe different approaches between students [Beattie et al., 1997]. A serialistic strategy involves

the mastery of procedural details, while a holistic strategy is characterized by the construction of knowledge and development of comprehension [Beattie et al., 1997]. These terms were parallel to Marton's surface and deep learning groups, with serialist and surface being similar and holist and deep also complementary. The Australia group was led by John Biggs and mainly utilized quantitative methods to understand student approaches to learning. Biggs developed various iterations of the 3P (Presage-Process- Product) learning model which recognized the inter-relationships of student characteristics, teaching context, student learning processes, and learning outcomes [Barattuci, 2017, Biggs et al., 2001]. He also developed multiple iterations of the Study Process Questionnaire (SPQ and R-SPQ-2F) to distinguish between deep and surface learning approaches of students. This instrument categorizes students based on their motive for learning and the strategies they use. In contrast to the early view of Entwistle, Biggs held that learning and its approach were context dependent and flexible [Biggs et al., 2001].

Beattie et al. [1997] summarize the findings from these groups in this manner:

> Thus this literature, viewed as a whole, demonstrates that a student's approach to learning is only partly a function of his or her general characteristics, since it can be modified by specific learning situations. Such situational influences include the students' perception of the relevance of the learning task, the attitudes and enthusiasm of the lecturer and the expected forms of assessment. The extent to which a student's predilection for a particular approach can be modified is determined by their meta-learning capability. [Beattie et al., 1997, pg. 10]

Following in the European and Australian traditions, SAL can be viewed as a bottom-up process which combines both affective traits of the student and the

specific learning context. This interaction leads to a specific cognitive response to the task. Overall, the idea of deep and surface learning was widely adopted in the study of learning in higher education and beyond [Clinton, 2014, Mirghani et al., 2014, Monroy and Pina, 2014, Pandey and Zimitat, 2007, Ramburuth and Mladenovic, 2004, Sabourin, 2016]. As research programs moved forward, they began to focus on how to promote deep learning, as well as how to assess deep learning in students [Beattie et al., 1997].

6.2.2 Development of Surface and Deep Approaches to Learning

The terms of deep approach and surface approach to learning have been widely used in education research over the past 40 years. Table 1 presents specific details of how these terms are defined. A deep approach to learning has been previously defined as "an approach that connects new information to previous relevant knowledge" [Beattie et al., 1997] and is aligned with a focus to gain understanding of meaning and an intention to comprehend [Marton and Saljo, 1976]. Biggs also connected this approach to the process of "internalizing" which is an interest in personal growth and an intrinsic motivation to learn. A surface approach to learning has been previously defined as "an approach that focuses on bare essentials and reproduces through rote learning or memorization" [Beattie et al., 1997]. Other characteristics may also include memorization to succeed on a test, retention of literal aspects with no critical analysis or personal contribution, or simply storage of information [Marton and Saljo, 1976]. Biggs also connected this approach to the process of "utilizing" which is viewing study as a task to accomplish and overcome to pursue a career.

Deep Approach	· Is interested in the academic task and derives enjoyment from carrying it out. · Searches for the meaning inherent in the task. · Personalizes the task, making it meaningful to own experience and to the real world. · Integrates aspects or parts of task into a while, see relationships between this whole and previous knowledge. · Tries to theorize about the task, forms hypotheses.
Surface Approach	· Sees the task as a demand to be met, a necessary imposition if some other goal is to be reached. · Sees the aspects or parts of the task as discrete and unrelated either to each other or to other tasks. · Is worried about the time the task is taking. · Avoids personal and other meanings the task may have. · Relies on memorization, attempting to reproduce the surface aspects of the task.

Table 6.1: Description of deep and surface learning approaches [Beattie et al., 1997, Kember, 1996, Marton and Saljo, 1976]

Multiple quantitative measures were developed which used the terminology of surface and deep approach to learning. Of note are the Approaches to Studying Inventory (ASI; [Entwistle and Entwistle, 2003]), Student Cognitions about Learning (SCALI; [Ferla, 2008]) and the Inventory of Learning Styles (ILS, [Vermunt, 1994]). The Australian group developed a 43-question quantitative instrument, the SPQ, to categorize students as surface or deep learners. This instrument was later revised and shortened to a 20-question instrument with the same intention (the Revised Study Process Questionnaire or R-SPQ-2F), but also categorized students on two factors, motive and strategy [Biggs et al., 2001].

As deep and surface learning approaches were studied in additional cultures and contexts, new questions arose. The simple categorization of deep or surface approach and the associated motives and strategies failed to capture the approaches taken by all students. A "new" approach of learning that combined understanding

and memorization was described and coined as an "achieving" learning approach by Kember [1996]. In addition, this work further expanded the 3P Model and focused on how a student's preferred learning approach interacted with the teaching environment to produce learning activities.

Biggs et al. [2001] developed quantitative instruments and identified two distinct groupings that interacted with the surface and deep approaches: a student's motive and their strategy. "Motive" is defined as the student's intention toward the work, which may include a fear of failure, intrinsic interest, or achievement. "Strategy" is defined as the particular actions taken by a student and their outcomes, which may include a repetition or rote learning. This can also include work to maximize meaning and develop understanding, or an effective use of space and time. These characteristics form the basis of items on the Study Process Questionnaire.

6.2.3 R-SPQ-2F Survey Instrument

The R-SPQ-2F instrument provides information about the preferred learning approaches of students [Biggs et al., 2001]. The R-SPQ-2F consists of 20 items that are categorized on one of two approach scales or factors (surface and deep) and one of two characteristic groups or subscales (motive and strategy). For instance, item 1 (*I find that at times studying gives me a feeling of deep personal satisfaction*) is categorized as Deep factor and Motive subscale. Overall, five items fall on each of the four factors and subscales, as indicated on Figure 6.1. The 20 items are scored using a 5-point Likert-type scale (A- this item is never or only rarely true of me to E- this item is always or almost always true of me) which are then converted to numerals (A=1 to E=5). Main factors (surface, deep) and subscales (deep motive, deep strategy, surface

motive, surface strategy) are calculated by summing the responses to the specified questions.

The full survey and complete scoring instructions are available in previous publications [Biggs et al., 2001]. Previous psychometric analysis completed with undergraduate students in the late 1990s has found the instrument to have acceptable scale reliability (Cronbach's alpha = 0.73 for deep approach and 0.64 for surface approach) and a good fit to the 2-factor structure for the general undergraduate population at that time.

Entwistle and Entwistle [1991] found that a qualitative analysis of student interviews and written responses paralleled a surface and deep approach to learning. Pandey and Zimitat [2007] sought to better understand medical student perceptions of learning anatomy and how that correlated to the quality of learning and course grades. Student approach to learning was quantified by the R-SPQ-2F. Successful learning was described by the students in open-ended writing prompts as involving hard work, and a combination of memorization, understanding, and visualization. Mean scores on the R-SPQ-2F found balanced scores for surface ($\bar{x} = 30 \pm 3.4$) and deep ($\bar{x} = 31 \pm 4.2$) approaches to learning. They noted a significant negative correlation between surface approach scores and final grades (r = -0.30, P<0.01). Justicia et al. [2009] examined the underlying structure of the

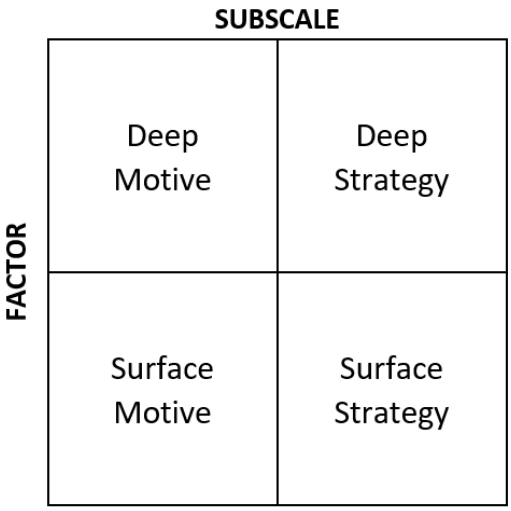

Figure 6.1: Graphical representation of the four subscales measured by the R-SPQ-2F.

R-SPQ-2F using exploratory and confirmatory factor analysis with survey responses from university students in Spain. Their results indicate that the structure of the R-SPQ-2F is best utilized with the two-factor structure of deep and surface learning as measured by the ten items corresponding noted in the original survey administration instructions.

Research Question The R-SPQ-2F was developed and validated with undergraduates from a variety of majors in Hong Kong in the late 1990s. Our research question is "Is the R-SPQ-2F a valid instrument for classifying STEM undergraduates enrolled in Anatomy & Physiology courses at an R1 institution in the southeastern United States?"

6.3 Methods

Methodology & Methods This study was conducted as one step in a comparative case study which investigated the cognitive processes and pathways of Anatomy & Physiology students. The research was reviewed and approved as exempt by the Institutional Review Board at Clemson University (2018-310).

In keeping with case study methodology, we collected data from multiple sources and integrated the data to yield a single case description. The quality frameworks of Q3 Quality in Qualitative Research [Walther et al., 2013] and Legitimation [Collins et al., 2012, Onwuegbuzie et al., 2011] were used to guide the design of this protocol. The Q3 framework provides six areas of validation to consider in all stages of qualitative research, while the Legitimation criterion was utilized to strengthen the conduct and reporting of mixed methods research [Walther et al., 2013, Collins et al., 2012].

Sample Selection During a particular fall semester, a total of 824 students were enrolled in three sections of two Anatomy & Physiology courses at a large institution in the southeastern United States classified as "highest research" (R1) by the Carnegie classifications [Indiana University Center for Postsecondary Research, 2015]. During the second week of classes, course instructors were emailed text for a class announcement and a separate email to students. This invitation included a link to our "Anatomy and Physiology Questions" Survey in Qualtrics, which was comprised of the 20 items that form the R-SPQ-2F followed by prompts for major, current section enrollment, and intent to enroll in the subsequent course in the next semester. The non-R-SPQ-2F items were used as part of the selection process for the full study. Instructors were not provided any information about which students completed the survey or were invited to participate in the full study. Two hundred thirty-one (231) students completed the survey for an overall 27.9% response rate. For Course 1, 154 of 526 students (29.3%) responded. For Course 2, 76 out of 298 (25.5%) responded. A pool of potential participants for the full study was created of all respondents who provided informed consent, completed the R-SPQ-2F items, planned to take the second course of the sequence, and self-identified as a STEM or health science major based on two-digit Classification of Instructional Program (CIP) codes [Paige et al., 2000]. Majors within the bounds of the study were Engineering (code 14), Engineering Technologies and Engineering Related Fields (code 15), Biological/Biomedical Sciences (code 26), Physical Sciences (code 40), or Health Professionals and Related Professions (code 51), although code 15 did not appear in the sample. The remaining pool consisted of 117 students (51.6% of those completing the survey, 14.2% of the course population).

Based on previous literature indicating a lack of inclusion of surface learners in education research [Entwistle and Entwistle, 2003], our intent was to recruit par-

ticipants who showed a strong preference for either surface or deep learning. Since it is possible to receive a high score for both surface and deep learning approaches on the R-SPQ-2F, we used the difference in deep and surface learning scale scores as our selection criterion from in the winnowed sample. Figure 6.2 provides a histogram of deep-surface differential scores ranging from -33 (extreme surface differential) to +29 (extreme deep differential) for the winnowed pool. The winnowed pool was then di-

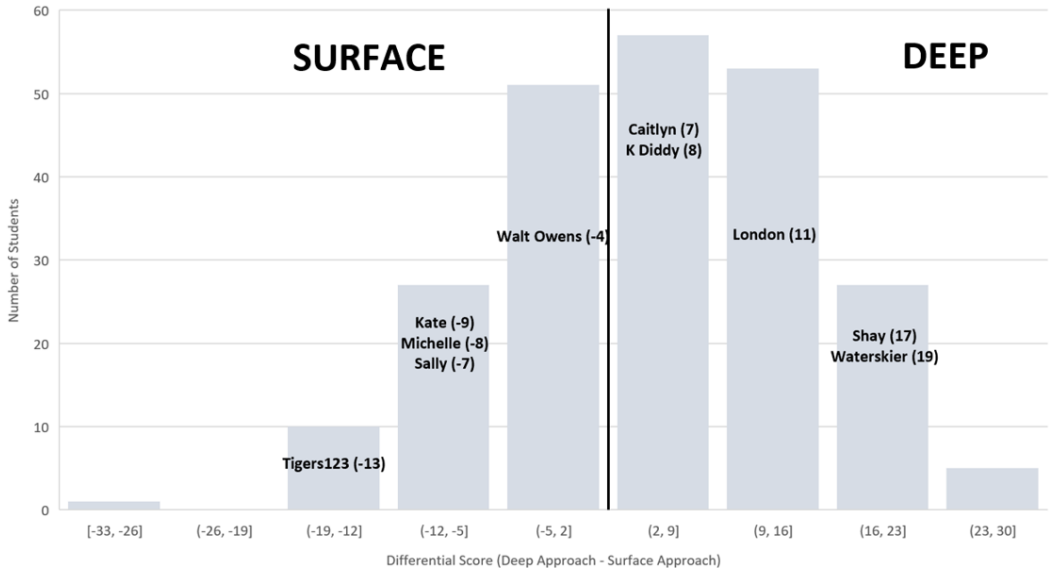

Figure 6.2: Distribution of student differential scores and differential scores for each participant enrolled in three anatomy and physiology sections in Fall 2018 (n=231).

vided by course and rank-ordered based on differential scores. The participants with the four most extreme differential scores at each end of the scale in each class were invited to the full study. If no response was received in 2 days, we sent a reminder email. After an additional three-day window, we removed the student from the list and invited the next rank-ordered candidate from that course. Our final participant pool for the full study included 11 students, five with a deep approach preference and six with a surface approach preference based on their R-SPQ-2F differential scores. These participants, together with their differential score and self-selected pseudonym,

are shown with their relative location in the histogram of differential scores in Figure 6.2.

Data Collection: An interview was conducted with each participant within 3 weeks of the completion of the R-SPQ-2F. The interview protocol consisted of open-ended questions in a semi-structured protocol to allow participants the freedom to expand or elaborate on their responses. Process reliability, which provides conditions to make the research process as independent from random influences as possible, was addressed by maintaining the same core prompts for each interview [Walther et al., 2013]. All interviews were conducted in person, in a neutral location to allow for privacy and quality recording. Interviews were recorded with a digital recorder and transcribed verbatim for analysis, to support communicative validity and process reliability. Theoretical validation focuses on the fit between the phenomenon under investigation and the theory produced [Walther et al., 2013]. The interview prompts were designed to expose the reality of the unique learning processes and pathways taken by members of each bounded case. The semi-structured nature of the interview allowed for clarification of student use of words such as memorization, understanding, and learning. The legitimation framework from Onwuegbuzie et al. [2011] was utilized to ensure quality during the mixing of the data, particularly in the area of weakness minimization.

Initial Concerns About R-SPQ-2F: As interview transcripts were created and verified, concerns arose in the research team about the validity of the R-SPQ-2F with the current population. Weakness minimization occurred as the qualitative data allowed for a greater breadth of response from participants than the quantitative survey alone. Triangulation of individual item responses to their interview excerpts

Table 6.2: Full semi-structured interview protocol, allowing follow-up questions for clarification of responses to each prompt.

1. Describe your A&P class. What do you think about the assignments? Grading procedure? Teaching style?
2. How is this different from your previous biology physiology courses?
3. How do you define learning? memorizing? studying? understanding?
4. How would you rank these (learning, studying, memorizing, understanding) in terms of your personal preference?
5. How would you rank these (learning, studying, memorizing, understanding) for what is needed for success in your anatomy & physiology course?
6. What do you think is the best approach to learning in this A&P class? (Variable based on response to Q5. Use terms ranked 1 and 2.)
7. What do you hope to gain from this course?
8. How do you think the course learning objectives will help you meet your personal goals? (Provide copy of course learning objectives taken from the course syllabus provided by the instructor.)

revealed a lack of agreement between the quantitative and qualitative data. This finding led to detailed analysis comparing quantitative (R-SPQ-2F responses and scores) and qualitative data (interview responses). In the remainder of this paper, we will describe qualitative data collection and analysis related to the validity of the R-SPQ-2F with undergraduate students in anatomy & physiology courses.

Interview Protocol: Interviews with the 11 participants were scheduled within 3 weeks of initial completion of the R-SPQ-2F and completed between September 18 and October 3 of the study semester. The interview protocol consisted of open-ended questions in a semi-structured protocol to allow participants the freedom to expand or elaborate on their responses. The protocol is provided in Table 6.2. Prompts were designed to probe for information about teaching context, student characteristics and preferences, and learning process and approach, aligned with the theoretical framework for the full study. It was not our specific intent during this interview to probe for validity of the R-SPQ-2F with this population, so there is not direct alignment between the interview and survey. Interviews ranged in length from 22 minutes to 33 minutes, with a mean time of 27 minutes.

Analysis: Questions about the validity of the R-SPQ-2F arose during transcript review, as several interview responses did not appear to align with the differential category of the participant. This led us to add a qualitative analysis stage to specifically address the Research Question: "Is the R-SPQ-2F a valid instrument for classifying STEM undergraduates enrolled in Anatomy & Physiology courses at an R1 institution in the southeastern United States?" Analysis proceeded in three main steps:

1. Qualitative and quantitative item comparisons: *A priori* codes for surface, deep, surface-to-deep, and each of the 20 R-SPQ-2F items were used to identify passages that provided qualitative information relevant to each of the 20 R-SPQ-2F items. *A priori* coding proceeded in iterative stages, with one team member identifying all excerpts that she considered met the criteria for a specific *a priori* code and the second team member blind-coding a subset of the data for the same *a priori* code. These iterative cycles continued until the team reached agreement on the boundaries of each code and on coding of specific passages in the data. The complete code book for this analysis is presented on Table J4 in Appendix J.

2. Quantitative and qualitative scale comparisons: After *a priori* coding was complete, the data were grouped by participant and SPQ item. Each member of the research team independently determined whether the available data, considered holistically, indicated agreement or disagreement with the SPQ item. Since the R-SPQ-2F is scored on a 5-point, Likert-type scale, a response of 1 and 2 on the survey was considered a "disagreement" with a positively worded item, while a response of 4 or 5 was considered an "agreement" during the comparison of quantitative and qualitative data. For the surface or deep scale scores, SPQ results of each participant

were compared to the relevant excerpts in the same manner as was conducted for the item analysis.

3. Item Review: Finally, each item of the SPQ was reviewed by the research team to determine the expected scale measured, as well as additional areas of concern for each question.

Reliability and Validity: During analysis, qualitative responses were compared to the responses on the quantitative survey. The process of comparing student interview responses to responses to each survey item provided an opportunity for inside-outside legitimation, which is concerned with the extent to which the participant's view is accurately presented and used for purposes of explanation and description [Onwuegbuzie et al., 2011]. The steps for process reliability helped to ensure accurate presentation of participant words. In addition, the research team took care to take participant words at face value when determining alignment between the qualitative and quantitative data. Weaknesses minimization occurred as the qualitative data allowed for a greater breadth of response from participants than the quantitative survey alone [Onwuegbuzie et al., 2011].

6.4 Results

Findings from the three steps of analysis are presented sequentially.

1. Qualitative and quantitative item comparisons: As previously mentioned, the process of comparing qualitative and quantitative data was undertaken in a systematic fashion. Table 6.3 provides information about the number of participants who provided a coded excerpt for each R-SPQ-2F item and the total number of ex-

Table 6.3: Number of participants and number of coded excerpts of qualitative information provided for each of the SPQ items. Detailed descriptions of the analysis process are provided for shaded items 4 and 13 below.

SPQ Item	Number of Participants Providing Related Quotes	Number of Excerpts Provided
1	1	1
2	1	9
3	10	14
4	10	26
5	1	1
6	4	5
7	8	38
8	4	22
9	3	3
10	6	11
11	6	6
12	8	14
13	9	30
14	0	5
15	5	8
16	0	0
17	1	1
18	7	10
19	5	7
20	4	5

cerpts coded for that item. An in-depth description of the analysis process for two prompts which are representative for prompts with more than one participant quote is presented in the following section.

Examples of Analysis: For item 13 (*I work hard at my studies because I find the material interesting*), nine participants provided information about this survey item with 30 total coded excerpts. This is not surprising since the intention of the interview was to better understand student approach to learning in their anatomy and physiology course and this prompt asks for similar information. This item is compound and gives two different statements: *13a. I work hard at my studies and 13b. I find the material interesting.* The coded excerpts were identified by two coding passes completed for this item to capture qualitative information about effort level given by participants

in the course (corresponding with 13a above) and the participant's interest level in the material of the course (corresponding with 13b above). For compound items, a diagram was constructed to represent what agreement or disagreement in qualitative terms should translate to on the R-SPQ-2F. As an example, Figure 6.3 represents this diagram for item 13. We came to consensus that if the relevant qualitative excerpts indicated that the participant did believe that they worked hard at their studies and that the participant did find the material interesting, we would expect that participant to have responded to item 13 on the R-SPQ-2F with a "4" or "5," while any other combination would lead us to expect a "1" or "2" in response to item 13. All coded excerpts for each participant were grouped together and then read as a unit by the research team. The qualitative excerpt(s) were then used to predict an R-SPQ-2F response for each participant. For example, Kate provided the following quotes coded to 13a:

> For Anatomy, **I definitely put a lot more effort into it...** And I kind of will compare the two and so I'll look at my big pictures and look at the outline and start looking at those smaller aspects- like maybe the molecules or

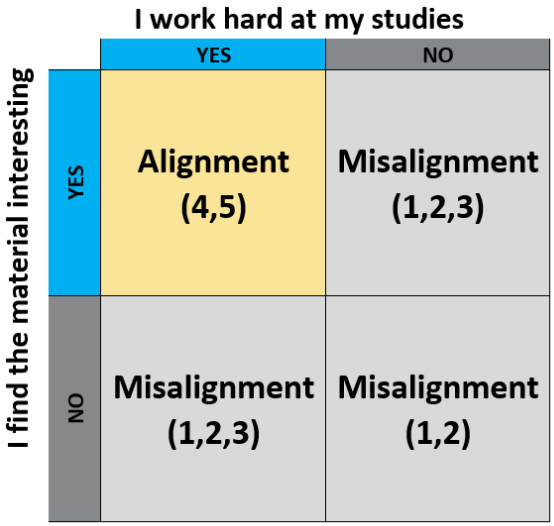

Figure 6.3: Description of how responses to SPQ responses to item 13 were determined to be in alignment or not with their relevant qualitative excerpts.

> the compounds and things that are like making up the different materials and all- just try to put things together. (emphasis added)

The research team agreed that in these quotes, Kate is expressing that they are working hard in their Anatomy course. For the second part of this item, Kate provided the following excerpts coded to 13b:

> **I'm really interested in Anatomy** and know it's going to apply to my career... [I want to] **understand everything about the human body. I think it's really interesting** and I want to be a physical therapist. So, it's important to know how everything works together and how different people's injuries could affect their anatomy and how that could be treated, so.... (emphasis added)

The research team agreed that these quotes showed that Kate has a strong interest in the course material of their Anatomy course. Because of these quotes, we predicted the Kate would respond to item 13 on the SPQ with a 4 or 5 to signify their agreement with this item. We then located Kate's actual response to item 13 on the SPQ instrument which was "2." Therefore, the research team classified Kate's qualitative and quantitative responses on item 13 to be misaligned.

For item 4 (*I only study seriously what's given out in class or in the course outlines*), ten participants provided information about this survey item with 26 total coded excerpts. As noted for the discussion on item 13, this prompt also asks for information related to the participant's approach to studying for the course. The 26 coded excerpts were identified with a single coding pass of the interview transcripts to capture any qualitative information about what the participants choose to study for their anatomy or physiology course. All relevant excerpts for each participant were grouped and read as a whole by the research team to determine whether the partic-

ipant agreed (indicated by an R-SPQ-2F response of 4 or 5) or disagreed (indicated by an R-SPQ-2F response of 1, 2, or 3) with item 4. For example, Angie provides the following excerpts which clearly indicate that they use information provided in lecture almost exclusively in their study:

> But what I also really like about [Instructor 1] is that [they]'ll be like very upfront is to say that- I think the first day [they] said, "I would never put something on the exam that wasn't on this lecture, wasn't on the PowerPoint," which I really appreciate... go to lecture... I write down everything that [they don't] read off the slide, so things that... Like [they]'ll read off the slide and then [they]'ll go and say like another comment about, so I'll always write that down. I make Quizlets for every lecture and....Go through those... I would start going through the lec... **Because, like [they] said- the exams are based off the lecture. So definitely going through the lecture first. Then going through the pages in the book that [they] advised you to go through- like the diagrams are just like a page, specific page.** [They have their] own YouTube channel of, when [they] explains concepts. So going through... Some of those videos. **She has recorded lectures for people that miss lecture and although it's the same thing... Maybe you like just want to hear [them] say it again.** (emphasis added)

The research team predicted the Angie would have a response of 4 or 5 to item 4 on the R-SPQ-2F. When checking participant responses, it was found that Angie had selected a "5" in response to item 4. The research team determined that the relevant qualitative excerpts and the response to item 4 on the SPQ were aligned. All 20 items for the SPQ were analyzed in a manner described for either item 4 or 13 above.

Table 6.4: Table presenting full results of alignment between the qualitative interview data and the quantitative SPQ responses for all participants.

SPQ Item	Alignment	Mild Misalignment	Misalignment
1	1	0	0
2	1	0	0
3	7	0	3
4	4	0	6
5	1	0	0
6	2	2	0
7	7	1	0
8	3	1	0
9	2	0	1
10	5	0	1
11	2	2	2
12	4	2	2
13	6	1	2
14	0	0	0
15	4	1	0
16	0	0	0
17	0	1	0
18	4	1	2
19	2	0	3
20	2	1	1

Item responses on the SPQ that differed by a single unit (research team prediction= 2, participant response = 3) was considered a mild misalignment. Table 6.4 presents the full results of alignment and misalignment for qualitative and quantitative responses.

In summary, we find that items 3, 6, 9, 10, 13, 17, 18, and 20 present mild concern over misalignment, with stronger concerns regarding items 4, 11, 12, and 19. Items 1, 2, 5, 7, 8, and 15 appear well aligned. No evidence was available for items 14 and 16. These determinations are based on the number of aligned responses compared to misaligned responses. Items with equal or greater number of mild misalignment and misalignment noted present strong concerns. Items with majority alignment, but some misalignment present are regarded as those with mild concern.

Table 6.5: Presentation of Surface, Surface to Deep, and Deep code definitions with Participant SPQ Differential score and number of relevant excerpts coded to each.

Participant	**Differential**	**Surface:** Quotes indicate a reliance or desire to memorize or rote learn course information	**Surface to Deep:** Quotes indicate recognition that memorization is necessary with a desire of the participant to understand the material	**Deep:** Quotes indicate a desire to search for meaning in the task and attain understanding of the material
Tigers123	-13	1	1	1
Angie	-12	1	0	3
Kate	-9	1	6	6
Michelle	-8	0	0	3
Sally	-7	2	3	1
Walt Owens	-4	1	0	4
Caitlyn	7	1	0	0
K Diddy	8	2	1	3
Shay	17	3	2	1
Waterskier	19	1	1	3
TOTAL		13	14	25

2. Quantitative and qualitative scale comparisons: Although many of the 20 items had majority alignment, we remained concerned about validity of the SPQ with this population. In the next stage of our analysis we looked at the overall scales of surface approach and deep approach. Participant interviews were coded to surface and deep themes and these were compared to the surface and deep scale scores. The interview transcripts were read again and one of three codes was assigned to relevant passages as described for the item analysis: Surface, Surface leading to Deep, and Deep. Details about number of excerpts and code definitions are provided on Table 6.5. While we are presenting counts, we are not utilizing those counts in our analysis of the SPQ validity.

As indicated on Table 6.5, several participants provided quotes for each of the three codes. Ultimately, most of these groups of quotes have few qualitative differences. For example, Angie was classified as "surface approach" by the SPQ with

a differential score of -12. They provided the following quotes which were coded as Surface:

> I think one of the reasons it works out for me this way is because I know that the final exam isn't cumulative. And so that makes me think about the fact that, whenever we end an exam, when we start something new it's going to be the same process. Like I don't have to continue studying what... I mean I should, but when it's like new material and I need to just like create more brain space with all these new things...

However, they also provided the following quote which was coded as Deep:

> I really hope I learn, and like... I guess- is the word sustain? No - with-withhold the information? Right? I don't want to forget it next semester because... I'm on a pre-med track. And so I think this is the... One of the most more interesting classes I'm going to take- that like, really interests me. Some things that I like, I'm going to see in my future career someday. And so these are concepts that I want to remember and like continue to grow and stuff.

In contrast, K Diddy was classified as "deep approach" by the SPQ with a differential of +8. They provided the following quotes which were coded as Surface:

> I feel like right now I'm not like remembering it because it's like "okay, I gotta remember this for the test" and then it's like "okay on to the next thing."

She also provided the following quote which was coded as Deep:

> Like I would prefer to understand it before I start to study the information... So I really just wanted to understand... Basically how the how the

> body works... And like not a basic understanding because this is not a basic class, but like just enough to help me in my future career.

There is little to no qualitative difference in the description provided by these students in their stated approach to learning despite a 20-point difference in their deep to surface difference scores. In addition, six participants indicated the need for these approaches to be combined for success in the undergraduate anatomy & physiology classroom. The theme of "Surface to Deep" is demonstrated by the following interview excerpts from Shay which connects the need for memorization in this course context to the understanding of relationships between various parts and systems:

> Yeah, for memorizing like you have to know certain terms to be able to build on things. Like if you don't know what like "epithelial" means like- if you don't know that or like the two types of it... Then you're not able to apply it... So I guess that's uh- like the basis of it... And I want to know those terms you're able to know like you're able to like learn them and figure out how they connect together like so... "Oh like these two different things are related." So, you know the definition of them and then you know that they were like related then and kind of how they tie together.

Overall, this information provides additional evidence that the SPQ did not discriminate between the surface and deep learning approaches of current students in an undergraduate anatomy & physiology course.

3. Item Review: The research team reviewed each item to determine our agreement with the category assigned by Biggs et al. [2001] as well as to identify other areas of concern with those items in the current context. A summary of this analysis

is presented on Table 6.6. Overall, the areas of concern identified with the SPQ items can be summarized into four groups:

1. Word interpretation issues
2. Course context/ alignment
3. Compound items
4. Factor/ subscale assignment.

Word interpretation was an area of concern identified in eight items (1, 2, 3, 4, 8, 9, 10, 11). For several of these, the use of the words "studying," "memorizing," and "understanding" in the prompt was the cause of concern. As noted in the interview protocol in Table 6.2, participants were asked their definition of this term and provided varying responses. These findings are fully discussed in Johnson and Gallagher (2019a). Additional terms that may vary in their interpretation due to the nature of the audience include "enough work" (item 2), "pass the course" (item 3), and "learn some things by rote" (item 8). As an example, the term "pass the course" may be defined very differently by students depending on their future goals and aspiration. Consider the following quote from Shay discussing their reasons for taking the course:

> I'm thinking of going to Pharmacy school. And so, this is a prerequisite, like for a lot of Pharmacy schools. Mainly- most of them require both, but some of them just want physiology. But like I mean so I'm gonna be taking both anyway, but it's also on the PCAT too. So like that type of thing, like I need to be prepared for it for that.

For students planning to attend medical school or nursing programs, an A or B in the course may be required when the class is a considered a prerequisite. Therefore,

Table 6.6: Results from item review by the research team

SPQ Item	Biggs Classification	Item Area(s) of Concern
1. I find that at times studying gives me a feeling of deep personal satisfaction.	Deep Motive	Word Interpretation
2. I find that I have to do enough work on a topic so that I can form my own conclusions before I am satisfied.	Deep Strategy	Word Interpretation, Compound item, Factor/ subscale assignment
3. My aim is to pass the course while doing as little work as possible.	Surface Motive	Word Interpretation
4. I only study seriously what's given out in class or in the course outlines.	Surface Strategy	Word Interpretation, Course Context/ alignment, Factor/ subscale assignment
5. I feel that virtually any topic can be highly interesting once I get into it.	Deep Motive	Course Context/ alignment, Factor/ subscale assignment
6. I find most new topics interesting and often spend extra time trying to obtain more information about them.	Deep Strategy	Compound Item, Course Context/ alignment, Factor/ subscale assignment
7. I do not find my course very interesting so I keep my work to the minimum.	Surface Motive	Compound Item, Factor/ subscale assignment
8. I learn some things by rote, gong over and over them until I know them by heart even if I do not understand them.	Surface Strategy	Word Interpretation, Factor/ subscale assignment
9. I find that studying academic topics can at times be as exciting as a good novel or movie.	Deep Motive	Course Context/ alignment
10. I test myself on important topics until I understand them completely.	Deep Strategy	Word Interpretation
11. I find I can get by in most assessments by memorizing key sections rather than trying to understand them.	Surface Motive	Word Interpretation, Factor/ subscale assignment
12. I generally restrict my study to what is specifically set as I think it is unnecessary to do anything extra.	Surface Strategy	Compound Item, Factor/ subscale assignment
13. I work hard at my studies because I find the material interesting.	Deep Motive	Compound Item, Factor/ subscale assignment
14. I spend a lot of my free time finding out more about interesting topics which have been discussed in different classes.	Deep Strategy	None
15. I find it is not helpful to study topics in depth. It confuses and wastes time, when all you need is a passing acquaintance with topics.	Surface Motive	Compound Item, Factor/ subscale assignment
16. I believe that instructors shouldn't expect students to spend significant amounts of time studying material everyone knows won't be examined.	Surface Strategy	Factor/ subscale assignment
17. I come to most classes with questions in mind that I want answering.	Deep Motive	Factor/ subscale assignment
18. I make a point of looking at most of the suggested readings that go with the lectures.	Deep Strategy	None
19. I see no point in learning material which is not likely to be in the examinations.	Surface Motive	None
20. I find the best way to pass examinations is to try to remember answers to likely questions.	Surface Strategy	Factor/ subscale assignment

we are unsure how participants may interpret this phrase and it likely varies due to these factors.

The phrase "learn some things by rote" is not a common description in the context of this course or population, and this term was never used by participants during their interviews. However, it should be noted that the nature of the course content in anatomy and physiology requires memorization or rote learning of many terms or anatomical parts for course success.

Four items (4, 5, 6, 9) present concerns related to the specific course context and by not being tied specifically to the course in question. For example, item 4 (*I only study seriously what's given out in class or in the course outlines*) is classified as measuring Surface Strategy, but we believe this would be dependent on the course expectations for the course in which the survey is completed. For the participants in this study, there is evidence from both the interviews and the course syllabi that deep learning or understanding is required for success in the course and on individual assessments. Shay provided this description:

> gives us the lecture objectives. And [they] says like if you can fill these out without notes, like and you understand it, like you're able to thoroughly like, write about it, then you'll do well on the tests, I guess. (Instructor 2)

Therefore, a static assignment of this factor and subscale may not be appropriate and may skew SPQ results. Items 5, 6, 9 are not clearly tied to the course, which seems to violate Biggs' own assertion that student results from the SPQ are course- and context-dependent.

Compound items are present for items 2, 6, 7, 12, and 13. In all cases, the items present both two statements that are linked and these comprise both a strategy

and a motive. For example, item 2 can be separated as follows: a. I have to do enough work so that I can form my own conclusions (strategy) and b. I have to do enough work before I am satisfied (motive). This pattern is repeated for the other items that are noted and is discussed more fully above in the analysis example of item 13.

The most common area of concern with the SPQ items was related to factor/ subscale assignment which was noted in 12 of the 20 items (2, 4, 5, 6, 7, 8, 11, 12, 13, 15, 16, 17, 20). Some of these issues were connected to one or more of the other themes we have previously discussed. When looking at factor or subscale assignment issues, consider the following examples. Item 11 (*I find I can get by in most assessments by memorizing key sections rather than trying to understand them*) is classified as measuring Surface Motive. However, the terms and actions used in this prompt align with a student's Strategy toward the course and its material. In addition, items 15 and 16 do not ask for a strategy or a motive, but probe for student or instructor expectation about a course. Item 20 is classified as Surface Strategy. However, the determination of whether this is a deep or surface strategy is dependent on the type of questions used by a student, which could be application or deep approach in nature.

6.5 Discussion

Qualitative data in the form of participant interviews calls into question the validity for the R-SPQ-2F for undergraduate students enrolled in anatomy & physiology courses in the southeastern United States. The R-SPQ-2F continues to be used in educational research [Clinton, 2014, Fryer and Ginns, 2017, Lee and Chan, 2018, Mirghani et al., 2014, Sabourin, 2016], but our data indicates a need for revision of survey items and additional testing in new contexts for valid categorization of students into deep and surface approaches to learning. Tested contexts should include

the specific course or student population in which the survey will be administered. Otherwise, interventions based on results relying on the R-SPQ-2F may not have the desired effect.

One possible explanation for the issues observed with the R-SPQ-2F in this study is the lack of recognition of the Achieving approach to learning which has been previously noted in the literature. Kember [1996] defined an achieving approach as an approach that believes memorization is necessary to maintain a high grade, but desires to connect new information to previous knowledge. As previously mentioned, many of the participants of this study expressed aspirations to attend professional or graduate school. This fact motivated them to both achieve high grades while they desired to make additional connections to their existing knowledge. Biggs et al. [2001] briefly acknowledge this orientation in relation to the original SPQ, stating "higher order factor analyses [of the original SPQ] usually associate the achieving motive and strategy with the deep approach." However, the data presented in this paper would question whether this association is true for the updated instrument and for this population.

Another factor to consider related to the validity of this instrument with undergraduate anatomy & physiology students is the nature of the discipline itself. The participants in this study noted multiple times the need to memorize certain aspects of the course material (often classified as a surface approach within the literature) to be able to fully understand it. We categorized these responses as "Surface to Deep" approaches in the qualitative data. Michael et al. [2017] note that physiology is difficult for students to learn, partly because of the need for an adequate knowledge base or other prerequisite knowledge. Much of this knowledge, like names and locations of anatomical parts or various terms, can only be learned through processes or strategies that are often categorized by instructors and researchers as surface approaches. Given

this information, it may also be helpful to consider the surface, achieving, and deep approaches to learning not only as context dependent characteristics, but perhaps as traits on a continuum rather than as discrete categories or groupings.

Finally, it is also possible that an additional factor has impacted the validity of the SPQ. This instrument was developed nearly 20 years ago, which puts the original validation as occurring with students of Generation X or Y. Participants in this study are representatives of Generation Z. It is not clear how the generational difference between these groups impacts their approach to learning, but this is a possibility that should not be overlooked and may require additional study.

Limitations: This work did not begin with the intent to analyze the validity and reliability of the SPQ. The interview protocol did not probe directly for answers to the survey prompts, so important ideas and themes from the instrument may not have been detected. However, we were careful to take participant words at face value and only declared a misalignment when the interview data presented a clear disagreement with that student's response to a survey prompt.

Future Work: As previously mentioned, researchers or practitioners who wish to utilize the R-SPQ-2F should consider testing the validity of the instrument in their population prior to use. These analyses should include exploratory and confirmatory factor analysis. We are in process of completing these steps with the population noted in this paper. Alternatively, an updated instrument which measures or categorizes students as surface or deep approach to learning could be developed for populations for which the R-SPQ-2F is not valid.

6.6 Conclusion

The data presented in this chapter provide evidence that the R-SPQ-2F is unable to differentiate between surface and deep learners. Therefore, I am unable to answer Research Question 2: What are the differences and similarities in cognitive processes and pathways for students with surface learning approaches vs. deep learning approaches? In addition, these data suggest that the concepts of deep and surface learning could be thought of as a continuum rather than discrete categories.

Chapter 7

CASE DESCRIPTIONS and COMPARISON

Cases 1a and 1b were constructed to examine the impact of curricular differences on student learning approach in anatomy & physiology courses (Anatomy to Physiology (A→P) or Anatomy & Physiology I to II (A&P1→2)). The case descriptions and comparison will describe each component of Biggs' 3P Model (See Figure 7.1) along with interaction factors that were identified during data collection and analysis.

7.1 Case 1a - Anatomy then Physiology

7.1.1 Teaching Context

The sequence of Anatomy and then Physiology (A→P) was taught by Instructor 1. Both courses in this sequence were 4-credit courses with three 50-minute lecture periods each week with a 3-hour lab period. The lectures consisted of a single

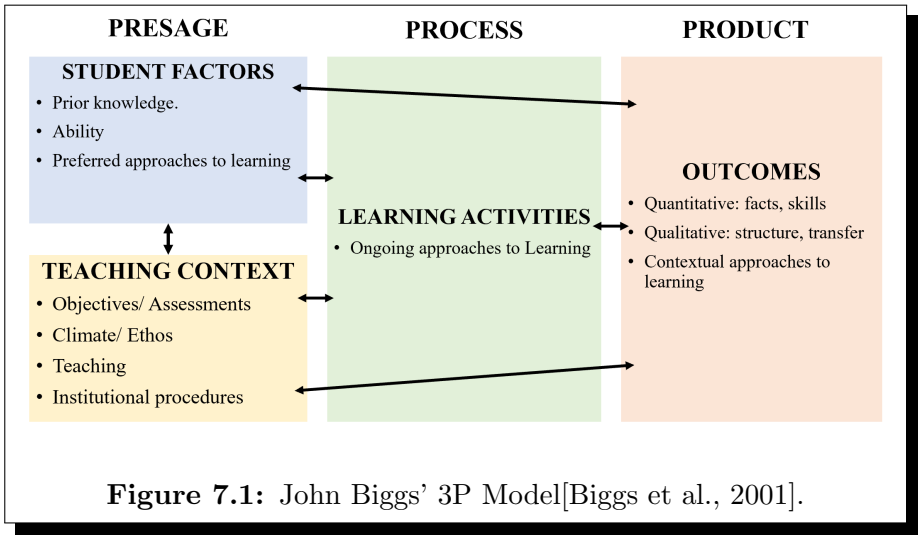

Figure 7.1: John Biggs' 3P Model[Biggs et al., 2001].

Table 7.1: Graded assessments for Case 1a.

Lecture Assessments	**Laboratory Assessments**
ANATOMY	
Exams	Lab practicals
Pre-exam quizzes	Pre-lab assignments
"Notecard" homework	Weekly pre-lab quizzes (in class)
Group project	Lab exercises
	Post-lab assignments
PHYSIOLOGY	
Exams	Lab practicals
Pre-exam quizzes	Pre-lab quizzes (on LMS)
Reading assignment quizzes	Laboratory reports

section with more than 300 students. Thirteen lab sections of 22 or fewer students were offered each semester and were taught by graduate students.

When comparing assessments of each course (A→P), some differences are noted. These are summarized on Table 7.1. Anatomy assessments for lecture included exams, pre-exam quizzes completed through the Canvas learning management system (LMS), and a group project. Exams consisted of mainly multiple choice and fill-in-the-blank questions, with pre-exam quiz questions following the same format. Questions addressed multiple areas of Bloom's Taxonomy [Anderson et al., 2001] and ranged from Remember to Analyze, as reported by participants and observed from

sample questions provided by Instructor 1. In addition, the syllabus required students to have 3x5 notecards to complete "notecard homework" assignments responding to 2 to 4 questions on a given topic.

The lab component of the Anatomy course included the additional assessments of lab practicals, pre-lab assignments, pre-lab quizzes taken at the beginning of most lab periods, lab exercises, and post-lab assignments with identification tasks or content questions. The lab grade counted as 35% of the overall course grade. The content for the Anatomy lab consisted of identification of both macroscopic and microscopic anatomy (gross and histological).

In contrast, the Physiology lecture assessments continued to include exams and pre-exam content quizzes, but Reading Assignment quizzes were added. These quizzes were completed on the LMS and conself-identified shortcomingsted of reading a physiology journal article and responding to a varying number of questions. Both the pre-exam quizzes and the reading assignment quizzes were timed and allowed for multiple attempts by the students, with three attempts for each pre-exam content quiz and two attempts for each reading assignment quiz. Use of 3x5 notecards was not noted on the Physiology syllabus, but participants indicated a continuation in the second semester.

Physiology lab assignments differed more significantly. Students were still required to complete weekly lab exercises and lab practicals. However, pre-lab quizzes were completed through the LMS with two attempts to attain a score of 80% or greater. Students who failed to meet this requirement were not permitted to attend and complete the lab exercise for the week, resulting in a grade of 0 for the weekly lab exercises. No participants reported experiencing the consequences of failing to achieve this standard. Students were also required to complete two laboratory reports for specific lab activities.

For both semesters, Instructor 1 recorded the lectures and posted them on the course LMS page. Course announcements given at the beginning of a class period were not included in these shared recordings. The Anatomy and Physiology courses required different textbooks but did not have a separate lab textbook. Instructor 1 also provided a YouTube channel where models and specimens were reviewed and highlighted for the Anatomy lab. Course grading used a points based system and had identical scales for the assignment of letter grades. This system assigned a given number of points which could be earned by a student for each assignment with a total of 1113 points available in Anatomy (695 in lecture, 418 in lab) and 840 points available in Physiology (560 points in lecture, 280 points in lab). The points earned were then converted to a percentage of total points possible to determine the grade assigned.

The climate/ ethos of the lecture portion of the course was described in mainly positive terms during Interview 1. For example, K Diddy described it this way.

> **K Diddy:** I love [their] teaching style. [Instructor 1]'s very organized. [They] not only lecture well, but [they] also record those lectures. I mean I still go to class, but like if you don't go to class or miss a class, it's very convenient. [Instructor 1]'s so knowledgeable, it makes it easy to like... [They] make it look easy.
>
> **SNJ:** Okay, (silence) so what kinds of things that does [Instructor 1] do- just give off that aura of...
>
> **K Diddy:** [Instructor 1] just stands confidently. (laughing) [They're] also hilarious and that makes it more interesting for students, I think. I know I love to just like laugh in a lecture and when [they] like have a joke. It just makes it way more easier to pay attention. [Instructor 1] also has lots

> of great visual aids... [they] spend a lot of time on [their] notes and it's very, very evident... (K Diddy, Interview 1)

Anatomy and Physiology courses in the sequence list pre-requisite courses. Anatomy required completion of a General Biology I lecture and lab course and required junior standing. The separate laboratory course was listed a a required co-requisite. For Physiology, completion of a General Biology II lecture and lab course, General Chemistry II, and junior standing were required. The Biological Sciences Bachelor of Science (emphasis in Pre-Pharmacy) required both the Anatomy and Physiology courses in the curriculum. The Biological Sciences Bachelor of Arts (emphasis in Pre-Rehabilitation) degree required both courses, but listed a specific exception for completing Anatomy & Physiology I and II in place of this course. The Bioengineering Bachelor of Science curriculum required completion of the Anatomy course only. Students who aspired to medical, physical therapy, and physician assistant professional programs were advised to complete both courses. Biological Sciences and Microbiology majors could complete these courses to fulfill additional biology elective credits, and students in other majors could complete them for general elective credit. A summary of the pre-requisites and the majors required to complete Anatomy and Physiology at University X is available in Table 7.2.

7.1.2 Student Factors

The participants of Case 1a consisted of seven female students (Angie, Caitlyn, K Diddy, Kate, London, Michelle, Sally), all with intentions of attending nursing or professional school upon completion of their bachelor's degree, and then entering a career in health care. One student (Sally) left the study following the first interview, another student (London) departed at the conclusion of the Anatomy course, and a

Table 7.2: Summary of pre-requisites and majors that require Anatomy or Physiology courses at University X. [e] indicates the course may be completed to fulfill an elective requirement within the major.

COURSE	PRE-REQUISITE	MAJOR REQUIREMENT
Anatomy	General Biology I	· B.S. Biological Sciences (Pre-Pharmacy) · B.S. Biological Sciences (Pre-Rehabilitation) · B.S. Bioengineering · B.S. Biological Sciences[e] · B.S. Microbiology[e]
Physiology	General Biology II General Chemistry II Junior standing	· B.S. Biological Sciences (Pre-Rehabilitation) · B.S. Biological Sciences (Pre-Rehabilitation) · B.S. Biological Sciences[e] · B.S. Microbiology[e]

Table 7.3: Summary of Case 1a participants study participation and initial HCI scores.

Pseudonym	Initial HCI Score	Status
Angie	11	Completed study
Caitlyn	9	Completed study but fewer diary responses
K Diddy	7	Completed study
Kate	12	Completed study
London	6	Left study after Anatomy
Michelle	13	Completed study
Sally	16	Left study after Interview 1 due to health concerns

third student (Caitlyn) persisted through the entire study but provided fewer weekly diary responses than other participants. Caitlyn and London had the highest and lowest HCI scores, respectively. Angie and Kate were lab partners for Physiology lab, which was discovered through Kate's weekly diary entries, in which they mentioned Angie by their real name. However, there was no indication they were aware of each other's participation in this study or that they interacted with each other beyond their time in lab and preparation for a single lab practical. Scores on the initial administration of the HCI ranged from 6 to 16 out of 20, indicating a range of incoming knowledge about the subjects of anatomy and physiology.

Preferred approaches to learning for this study was intended to be captured by the R-SPQ-2F during the initial administration. Chapter 6 describes why this information is not being used to describe the participant group. However, participant definition of the term "learning" can provide some insight to this area. All participants defined learning as the acquisition of information but differed in their expected outcome for learning. The outcomes for this group ranged from remembering to applying information. More detail about these definitions is available in Chapter 5. Participants commonly mentioned a desire to hand write information or notes. Most described taking notes during class by typing on their computer and then copying that information by hand at a time following class meetings, sometimes indicating a belief that handwriting led to increased learning or retention of information. This sentiment was described by Angie.

> Writing my notes by hand has helped me a lot in understanding concepts, especially when trying to distinguish key words or phrases, for which I try to write down with a different colored pen or highlight. (Angie, Semester 2 Diary)

Interaction Between Teaching Context and Student Factors Participants indicated two main differences between the Anatomy and Physiology courses. First, most students indicated that the Physiology course was more difficult than Anatomy during their final interview, describing how the content and the assessments were more challenging in the second semester.

> I think that it's... The content might be harder. The lecture tests were definitely easier in Anatomy. (Michelle, Interview 3)

Second, students indicated more integration between the content of Physiology lecture and Physiology lab when compared to Anatomy lecture and lab.

> Because Anatomy was just totally separate information that you had to know for lab. And this is like... it was like relating to the same body system you were talking about in lecture. But like, you wouldn't find any lab information on lecture tests or lecture information on lab tests. And you could see a little bit of overlap in between in Physiology. (Michelle, Interview 3)

Some negative aspects of the courses were reported as the study progressed, usually related to participant affect in relation to Instructor 1. Participants frequently noted the speed at which the material was presented, often discussing Instructor 1's speech in this manner. These excerpts were always associated with either frustration or stress, along with the desire that the speed of the course would slow down.

> It's honestly kind of frustrating sometimes, because it's the same scenario in class. Where [they] talks at 90,000 miles an hour... (Kate, Interview 3)

Two of the participants were advised by Instructor 1 and other participants also indicated significant interactions with them outside of the course setting. However, this familiarity sometimes led to feelings of *stress*.

> Notecard homeworks- I feel like they're...I hate them, but I feel like they're important because [they] test on them, but they're usually about stuff that we're supposed to find out for ourselves. And I feel like I'm just shooting in the dark, writing out some random paper and [they] knows exactly who I am. So [their] going to read and be like "[Kate], what are you thinking right now?" (laughing) I feel like turning it in. I don't know like... I just

> feel like because of [their] personality... I mean, I love [them], like I'm so glad that [they're] my teacher for this. I enjoy [them] as Professor, but I mean... Sometimes like people will ask questions, and [they] just laugh. Like in a joking manner or will stay just like "oh wait," like "I already explained that" or "We'll get to that." Or something. So I'm like, I bet [they're] reading that note card thinking [their] judgmental thoughts, like... (laughing) the girl doesn't know anything. So, yeah, I don't know about those but I feel like I have to appreciate them because they're on the test. (Kate, Interview 3)

It is important to note that all participants liked and appreciated Instructor 1 throughout the study. However, examples of negative affect became more frequent as the courses progressed. Participants spoke less about the laboratory portion of the course, but in some cases expressed frustration about the structure of the lab. K Diddy described this practice during lab practicals in Anatomy.

> That'll be like, what is the... I'm trying to think...What is the tissue of this slide? And then it'll be like, name what's at the pointer. And then you'll be kind of like... We... Like I know that's like a cell but like do you want what's inside the cell? Because like that's what the thing is. And like we'll talk to the TA. And my TA's like "I don't know, you tell me." Like I can't tell you. Like that's why I'm asking you. Like do you want like the certain cell types? Like when you get like a slide of blood, there's like four different cell types in there. There's probably a lot more than four, obviously. I don't know what I'm talking about. But if, you know,... So like if it's pointing to a... What are those... Macrophages are like really big, right? So its pointing to like a macrophage, do you want...

> Do you want to know the type or does it want to know like the inner layer of the macro... I don't know if that's really true or what not. But like we have talked about this, right? (K Diddy, Interview 2)

Since 13 sections of the lab were offered, participants had different instructors for this portion, but this quote indicates some lack of communication between students and graduate TAs which were associated with increased negative affect.

7.1.3 Learning Activities and Outcomes

Identifying cognitive processes and pathways of undergraduates while learning anatomy & physiology was the focus of this project. Within Biggs et al. [2001] 3P Model, these are situated in learning activities. Three main code groups emerged from the data as defined previously in Chapter 4: Tasks or Actions, Self-Identified Shortcomings, and Affect. Participants articulated several themes in each of these categories and many of them were associated with specific Outcomes or to each other. Figure 7.2 provides an overview of the relationships between these groups.

Task/ Action Participants indicated various tasks or actions over the two semester span. When interacting with course material, participants described the processes of absorbing information or engaging with material. Absorbing information was evident in re-reading notes, utilizing repetition to remember specific material, or by copying the words from

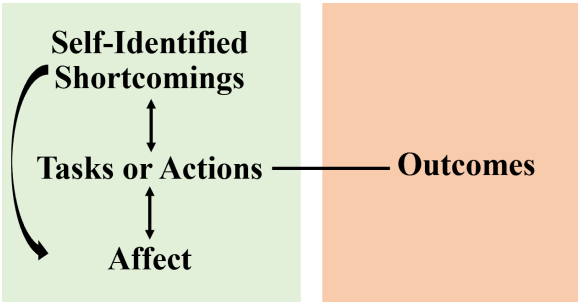

Figure 7.2: A summary of the overarching themes in Learning Activities and their relationships to one another.

instructor provided resources, like PowerPoint slides. In contrast, engaging with material provided evidence of additional mental engagement and manipulation of course content. This could be evidenced by summarizing or expanding instructor provided resources, thinking about connections of course material, or applying course material to a new context. All participants in Case 1a displayed the practice of both absorbing information and engaging with course material.

Participants also indicated the use of hands on activities and instructor provided resources during their time interacting with course material. Several participants described their use of lab exercises throughout both semester as a hands on activity.

> In lab we tend to do experiments from what we discuss in class. The lab lags about a week or so behind from lecture. We basically just use our own bodies to see how physiology works. For example, we did several experiments on reflexes a couple weeks ago after discussing them in class, then compared the results to other groups. (K Diddy, Interview 3)

The main instructor resources described by Case 1a participants were the recorded lectures and Instructor 1's YouTube channel. Both of these were used extensively by participants. The recorded lectures were reported to be uploaded at the conclusion of each week, and almost all of the participants indicated their regular use of this tool. In fact, more than one participant indicated that they basically typed a transcript of each class meeting, as they made sure to capture every word spoken by Instructor 1 in their notes. The use of the YouTube channel was confined to the Anatomy lab, as it was used extensively to prepare for the Anatomy lab practicals. These short videos showed Instructor 1 manipulating and describing various anatomical features on the models that were used in both the lab meetings and on lab practicals.

In other cases, participants described *opting out* as intentionally choosing to avoid or not use a particular resource. The most frequent item described in this way was the practice of departing from a session of the laboratory section prior to the posted end of class. Angie described this occurrence in this way:

> Lab is scheduled to be three hours, but I kid you not- my labs lasted like 30- 45 minutes and everyone was out. (Angie, Interview 2)

The majority of participant excerpts linked tasks or actions to specific outcomes. The interactions between tasks or actions and outcomes were not always presented as one leading to the other, but were connections or associations, in most cases. This is graphically represented by the line (rather than an arrow) between *tasks or actions* and *outcomes* in Figures 4.4 and 7.2. It is important to note that most of these connections were provided in response to interview prompts seeking to elicit information about learning processes used by students, rather than in response to weekly diary prompts which specifically asked about outcomes. This fact seems to indicate a strong outcome orientation of the participants, as they linked their actions in a course to intended outcomes.

Outcomes described by participants as related to mastery of course content fell into the categories of remembering, remembering/understanding, understanding, and applying. These outcomes correspond to Bloom's Taxonomy levels 1 to 3 [Anderson et al., 2001] and were sometimes categorized in these areas due to the definitions provided in Interviews 1 and 3. In addition, all Case 1a participants described a range of these outcomes rather than a single, static outcome for this course and material. The outcome of understanding was only found connected to specific tasks or actions, while each of the others was identified both connected to a task or activity, as well as alone. Excerpts which described an outcome without an associated task

or action were commonly provided in responses to diary prompts asking about the course content for a given time period.

Conflict Between Teaching Context, Learning Activities, and Outcomes

For Case 1a, the most common outcomes described related specifically to course performance. Completing assessments, successful class performance, and less than hoped class performance were frequently connected to tasks or actions undertaken in relation to the course. In some cases, participants describe learning activities used in preparation for a lab practical or exam. At other times, participants provided detailed insight into how they used their course resources, such as notes and textbooks, to complete an outside of class assessment. As discussed in Chapter 4, these discussions present an example of how the teaching context and learning activities are producing specific outcomes for the participants. The participants of Case 1a experienced a tension between these different areas. Completed assessments were mentioned multiple times by participants along with an intrinsic desire to attain a thorough understanding of the course material. However, they noted that they did not have time to accomplish these tasks. The common response of participants was to acquire adequate information to make an acceptable grade, usually by absorbing information through repetition, but this led to negative affect in the form of frustration and stress when thinking about both their interest in the subject matter and the knowledge that the course content would be needed in the future. Kate provided these quotes in describing this tension.

> In all honesty I did not have as much time to prepare for exam 2 as I would have liked... It was not a fun time and I have pretty much already forgotten everything that was on the test because I didn't have time to commit any of it to my long term memory. I feel like that's one of the unfortunate things about college because as much as I really want to learn

> and understand anatomy, I just think it's impossible to find the time to devote to really learning and understanding it. (Kate, Semester 1 Diary)

> That's the big thing with this class is that I have so much other stuff going on in it. There's so much information. I just feel like I'm never going to be able to commit it to long-term memory, which really stinks because I want to. Like I really care about this class and I would love to learn all the parts of human body, but it's just hard. (Kate, Interview 2)

This tension represents a conflict between student factors and teaching context, as represented by the awareness of knowledge needed for present and future success, along with the realization of the amount of time available to prepare for the present assessment. However, these quotes also highlight the impact of outside influences, such as student course schedule and extra-curricular activities like clubs or jobs, on the learning activities and outcomes of undergraduates. In addition, these excerpts provide evidence that participants are viewing *completing assessments* as an outcome, as already discussed in Chapter 4. As participants attempt to resolve this conflict between the assessment and their own learning activities, they experience various negative affect and struggle with their perception of their performance in the course, as described in self-identified shortcomings.

Additional outcomes described by participants were less connected to the learning objectives for the courses. Awareness of the discipline and fascination with content were both identified by some participants, but rarely connected to specific tasks or actions in the course.

Self-Identified Shortcomings Participants described the tasks or actions of altering study habits, getting outside help, and managing time, but also described each of

these as specific areas in which they were deficient or needed additional help, leading to coding these as self-identified shortcomings. Additional shortcomings were identified by participants as lacking focus and following along. The issues with following along seemed to be related to the teaching context of the course and what the participants believed was needed to be successful in the course. In some cases, participants indicated difficulty in following the thought process of the instructor. However, in many other cases, students indicated an inability to keep up with typing or writing the words spoken by the instructor. In both instances, participants indicated significant use of the recorded lectures posted on the LMS page to overcome these issues. Angie summarizes both of these areas of concern in this quote, where they notes their inability to follow the instructor's train of thought or the connection of specific examples, as well as their struggle to maintain focus on the important content of the course.

> I think [they are] just used to kind of like having a slide up and then kind of just rambling on about like random things every once in a while. Some of the examples [they give] in class like aren't relatable and I really don't understand how it applied to whatever we were learning. So that kind of distracts me from what we're supposed to be learning. [They talk] really fast sometimes and I don't think anyone is wanting... Will ever, like, call [them] out and say like, "can you like repeat that." Because [they want] to get through, like, lecture. (Angie, Interview 3)

Participants described the self-identified shortcomings of mastering course content related to each of the four Bloom's-type outcome groups described in the preceding section (remembering, remembering/ understanding, understanding, applying). The outcome of less than hoped performance was also identified specifically as an

self-identified shortcoming by several participants. Given the career aspirations of this group, it is not surprising that high grades are a desired course result. Another self-identified shortcoming described issues experienced by participants to *understand test or quiz questions.* This shortcoming presents an interaction between the teaching context and outcomes. Several participants described issues with understanding questions on exams and quizzes, but the most frequent comment was related to question structure, as described by Michelle.

> The hardest questions to me are ones that have answers such as A) answer B) answer C) answer D) A and B E) none of the above. Those type questions make me second guess my answer choices because there could be a possibility of something else. (Michelle, Semester 1 Diary)

Another self-identified shortcoming of *failing to recognize important content* was generally related to the volume of the content contained on each assessment, both for lecture and lab. Few concerns were mentioned concerning lab practicals and quizzes, which involved anatomy identification in the first semester and application questions in the second semester. The majority of these excerpts related specifically to lecture exams. Several participants described the need to retain all information spoken by Instructor 1 to have a satisfactory performance on exams.

> I think more of I wasn't expecting to.... need to know everything that [they] talked about but you do. So.... Really just knowing everything because you know, you can emphasize some things more than others. But I think that for like the first exam I was like, "oh, well, this probably isn't important." But you just needed to know everything that [they] talked about, that sort of thing. (Michelle, Interview 2)

Affect While describing their learning activities, participants expressed predominantly negative affect. Most commonly, the emotions of discouragement, frustration, and being overwhelmed were described as connected to outcomes. However, some instances described affect as solely connected to learning activities, as participants talked about being discouraged or overwhelmed by the process of working with the course content. However, as mentioned earlier, these feelings were also present as participants described some of the practices of Instructor 1. A common area of this frustration involved an inability to capture notes effectively during a lecture meeting.

> And then also if I miss something, sometimes I get frustrated because I'll be typing so fast and [they're] still going. (Kate, Interview 2)

However, the majority of affect experienced by participants was reported in connection with the outcomes of completing assessments or attempting to remember, understand, or apply the course material. Angie describes their experience of being overwhelmed studying for a lecture exam which actually causes additional distraction in the process.

> I mean now like if you're... I guess if you're talking about like when I start prepping to study for something. No, I mean I just always know like starting with notes, I like have to mentally prepare myself like "you're about to do a lot of material." Like I get off any... Like I turn my phone off because I need no distractions. I really need to focus on that. But then I started getting like being overwhelmed like "I should really go through the lecture and make sure I didn't miss like a detail. I should really go through my PowerPoint and make sure I wrote every single note." Yeah, I like I get like super tedious, but... (Angie,)

K Diddy also describes their thoughts about the weekly lab quizzes in this way:

> It's the same format as our quizzes where we're supposed to like... I feel like if I really tried on the quizzes, it would be easier to study for practical but then that would require me to rem... Remember like three chapters a week. I feel like yes, in the long run, yes, that would help. That's what everybody keeps telling me. But I'm like, do you have a biochem test this week? No. No, you don't. So don't tell me what to do. (K Diddy, Interview 2)

Both of these quotes highlight how preparing for assessments is connected to a feeling of being overwhelmed for the participants. However, the ultimate source of this affect is not completely clear. Given the professional school and career aspirations of these participants, this experience may have been linked to some internal or external pressure related to achieving those goals. In a similar vein, some participants also describe feelings of discouragement and frustration connected specifically to the completion of course assessments. Overall, the excerpts that express discouragement, frustration, and being overwhelmed in relation to outcomes do not follow a single theme, but range across aspects of teaching context and course material.

Other areas of both positive and negative affect were identified by the participants. Additional negative affect included confusion, worry and not having fun. While these themes were mentioned less frequently, their appearance is usually in the form of very strong emotions. K Diddy describes preparation for an exam and the worry that ensues.

> So just like studying on a day-to-day basis and then studying before the exam. I would say studying for the exam is like chaos. Like everything is unleashed... And panic arises. Because then I realize that I don't know this stuff. It's like "oh crap, I really can't remember this." Like that's

> when I'm like... So when I was studying, I like... that's when I like to annotate my note cards. So I like, read the question and then flip it over and read it and be like, Oh that's important, highlight that, just like read it a couple times. Okay- got this, next one. But when I try to quiz myself, I'm like, I don't know. (Laughing) And then I'm like starting to panic because its like more things you don't know than you do know. (K Diddy, Interview 2)

While these excerpts for negative affect often describe difficulty in the course, they are sometimes associated with the themes of opting out. However, this is not always the case. K Diddy displays a continuation of their task in the midst of their panic. Surprisingly, the negative affect themes are not frequently associated with the action of opting out or abandoning their efforts related to the course, despite the fact that one participant received a failing grade in anatomy and did not continue in the study. I believe it is possible that this participant to did not freely express their thoughts about the course, as I noted concerns about this following both interviews conducted with this participant. During interviews and written responses, this participant seemed very concerned about making a good impression on me as an interviewer and seemed guarded in many of their responses. Negative affect was expressed at times, but I remain concerned that the full description of their experience is not captured in the data.

Despite the frequent appearance of negative affect expressed by students, particularly in connection with assessments, positive affect was also present. Specific areas identified included determination, enjoyment, being encouraged, and finding the material interesting. Of these, enjoyment and interest were most frequently displayed by participants. This was often connected to the individual's future career

goals, but that was not always the case. Caitlyn describes their interest, as well as enjoyment, in the course material in this way.

> I do because I like... I do love, like I love like everything biology. I really do. Like I really love learning about the body. Like I think it's so interesting, like especially, like, this class and Cell Biology like... Sometimes when I'm studying I'll just sit back and be like, "this is literally all happening inside my body right now." And I just like don't... Like, like it's just happening! Like, and you don't know it, but it's like... You wouldn't be surviving if it weren't- type of thing. So I think it's like so interesting. I just don't know if it's what I want to be in [for my career]. So it's like, it's really hard for me, because like, that's [a career in health care] what I've always thought I wanted to do. Like, I always thought I wanted to be in the medical field and now I don't know. So like, it's kind of hard but I feel like regardless of how everything turns out... Like, if I am like, put back on the medical track or whatever, like I still, like, enjoy learning about it. (Caitlyn, Interview 3)

Quantative Data Results Data were collected to assess the specific outcomes related to content mastery. These data included responses to weekly diary prompts, construction of a concept map during interviews 2 and 3, and completion of the HCI at the start of the study and the conclusion of both fall and spring semesters. The focus of this study was to identify the cognitive processes used in anatomy and physiology courses, but the quantitative data collected has not yet been analyzed. However, HCI scores are available for report. At the conclusion of the study, the HCI scores ranged from 9 to 18. Few participants made steady improvements over the course of the academic year, with some participants making no improvement or attaining

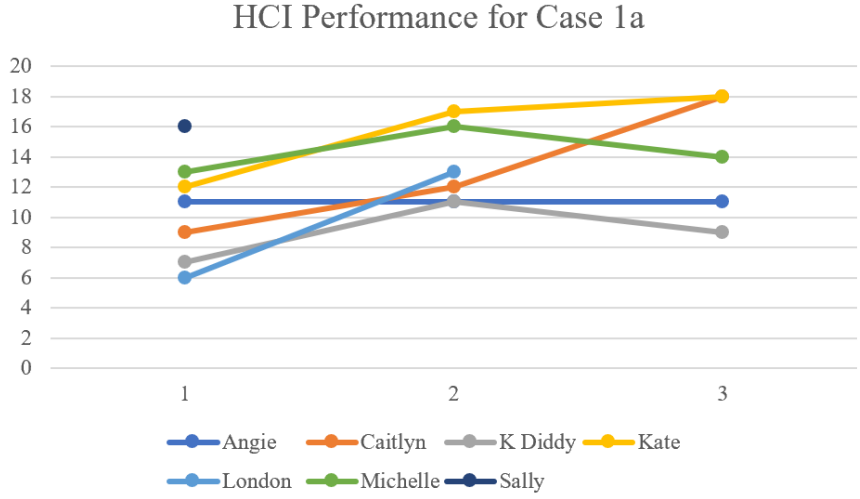

Figure 7.3: Scores on the Homeostasis Concept Inventory (HCI) for participants in Case 1a for each administration. The HCI was administered in September/ October 2018 (1), December 2018 (2), and April 2019 (3).

their highest grade at the conclusion of the fall semester. For the five participants who completed the study, two showed an increase in their score at each time point, one had the same score at each time point, one scored highest at the second administration, and one scored highest at the first administration. This course sequence received the bulk of instruction about homeostasis during semester 2, so the greatest increase would have been expected at the last administration. It is not clear why this result was not seen. Greater clarity about this result may be evident in a future analysis of the homeostasis concept maps produced by participants at Interviews 2 and 3 which gave more information related to the Product theme of the 3P Model. A graph showing each participant's scores is presented in Figure 7.3.

In summary, students describe a range of tasks or actions utilized to move toward desired outcomes in the class. These tasks are often linked to specific outcomes, but this is not always described by participants as tasks *leading to* actions. Tasks and

actions include both absorbing and engaging course material, as well as outwardly visible actions like hands on activities and getting outside help. Both actions and outcomes are entwined with self-identified shortcomings and affect experienced by participants. In particular, some specific tasks are recognized by students to be deficient or in need of modification. Both positive and negative affect are experienced, but negative affect appears to be increasing across the course of the study, particularly in relation to course assessments.

7.2 Case 1b - Anatomy & Physiology I then II

7.2.1 Teaching Context

The sequence of Anatomy & Physiology I (A&P1) and Anatomy & Physiology II (A&P2) was taught by Instructor 2. Both courses in this sequence were 4-credit courses with two 75-minute lecture periods each week with a 2-hour lab period. The lectures consisted of two different sections, one section in early morning and one section in afternoon, with more than 250 students in each section. There were 22 laboratory sections offered in each of the two semesters of the sequence. Participants reported that Instructor 2 provided "vague" PowerPoint slides which formed the basis of each lecture and a list of "Lecture Objectives" for each class meeting.

Assessments between A&P1 and A&P2 had no discernible differences, but were divided by lecture and lab. A summary of course assessments is presented in Table 7.4. Lecture assessments included multiple choice question exams and daily homework activities assigned via *Mastering A&P*, which had been modified by the instructor. Mastering A&P is a commercially available product from Pearson that provides questions aligned with each chapter of selected textbooks. Participants re-

Table 7.4: Graded assessments for Case 1b. Lab assessments in italics indicate items that were assigned less regularly and did not have due dates on the course syllabus.

Lecture Assessments	**Laboratory Assessments**
Exams (Multiple choice questions)	Lab practicals
Mastering A&P homework	Pre-lab assignments
	Weekly lab quizzes
	Post-lab worksheets
	Exit quizzes

ported that these questions focused on recall of course material. The multiple choice exams were reported to require higher levels of Bloom's Revised Taxonomy.

> I would say, after taking... Seven of [Instructor 2]'s exams, if you don't understand but you just memorize it, you... You're not going to do well. You're not going to do well. (Waterskier, Interview 3)

Lab assessments were more numerous and included pre-class assignments, lab quizzes, exit quizzes, post-lab assignments, and lab practicals. Participants reported no difference between the structure or assessment types in A&P1 and A&P2. However, Instructor 2 indicated that A&P1 was taught with an emphasis on the concept of homeostasis and A&P2 was taught with an emphasis toward body systems.

Course grades were calculated as 70% based on lecture assignments (65% exams, 5% Mastering A&P), and 30% based on laboratory grades. The laboratory syllabus indicated that each laboratory meeting would include a variety of assessment tasks. This could include quizzes, worksheets, practical exams or laboratory reports. Each of these assessments had a given number of points, and the final lab grade was determined by dividing the total number of points amassed by the total number of points available at the end of the semester. However, no information was provided on the syllabus about available points on each type of assessment or the total points available to be earned.

The Academic Success Center and Instructor 2 collaborated to provide Peer Assisted Learning (PAL) sessions for this course sequence. Two different groups of PAL leaders facilitated two sessions per week, providing worksheets to all students in the class and additional active learning tasks and verbal explanations during the twice-weekly meetings.

In terms of course climate and ethos, participants indicated a positive view of both Instructor 2 and their graduate teaching assistants for lab. In fact, there are no quotes that indicate negative affect toward Instructor 2 or graduate TAs. Two participants had regular meetings with Instructor 2 and indicated they had formed a good relationship of the course of both semesters. Walt Owens described their view of Instructor 2 in this way:

> I think [Instructor 2] is, like the professor. [They're] like really good. [They understand] that we're students, and I don't think, like, [they ask] too much of us. And, like, [they're] funny. [They keep] it like loose. [They], like, [relate] to us really like well and interacts with us. (Walt Owens, Interview 2)

The A&P 1 and 2 courses each listed specific pre-requisites. For A&P1, completion of a sequence of General Biology I lecture and lab and General or Introductory Chemistry were required. For A&P2, the only pre-requisite requirement was A&P1. Both courses listed a co-requisite laboratory course. Several majors listed both courses in this sequence as curricular requirements. These included Nursing Bachelor of Science (BS), Pre-Health/ Pre-professional Health Studies BS, Pre-Health/ Health Promotion and Behavior BS, Pre-Health/ Cardiovascular Imaging Leadership BS, and Parks, Recreation and Tourism Management/ Recreational Therapy BS. The university catalog specifically stated that these courses would not satisfy biology elective

Table 7.5: Summary of pre-requisites and majors that require Anatomy and Physiology I or II courses at University X.

COURSE	PRE-REQUISITE	MAJOR REQUIREMENT
A&P I	General Biology I General or Introductory Chemistry	· B.S. Nursing · B.S. Pre-Health/ Pre-Professional Health Studies · B.S. Pre-Health/ Health Promotion and Behavior · B.S. Pre-Health/ Cardiovascular Imaging Leadership · B.S. Parks, Recreation, and Tourism Management
A&P II	A&P I	· B.S. Nursing · B.S. Pre-Health/ Pre-Professional Health Studies · B.S. Pre-Health/ Health Promotion and Behavior · B.S. Pre-Health/ Cardiovascular Imaging Leadership · B.S. Parks, Recreation, and Tourism Management

credits for students with Biological Science or Microbiology majors. A summary of the pre-requisites and the majors required to complete Anatomy & Physiology I and II at University X is available in Table 7.5.

7.2.2 Student Factors

The participants in Case 1b consisted of four individuals- three female and one male (Shay, Tigers123, Walt Owens, and Waterskier). All of these participants intended to pursue careers in the health care field, but only one (Shay) aspired to a doctorate-level professional degree. One participant (Tigers123) left the study when they dropped A&P1 in mid-October. None of the participants indicated that they knew each other or recorded studying or working together during the entire academic year. Participant data for this case is drawn mainly from the interviews, as all of these students provided fewer weekly diary responses than requested. All participants in-

Table 7.6: Summary of Case 1b participants study participation and initial HCI scores.

Pseudonym	Initial HCI Score	Status
Shay	15	Completed study
Tigers123	11	Departed study in mid-October after changing major
Walt Owens	12	Completed study
Waterskier	13	Completed study

dicated an interest in the course material at Interview 1, and several indicated this interest to go beyond the connections to their career aspirations. Scores on the initial administration of the HCI ranged from 11 to 15 out of 20, indicating a range of incoming knowledge about the subjects of anatomy and physiology. *Preferred approaches to learning* were intended to be measured by the R-SPQ-2F, but Chapter 6 describes why this data is not utilized for this purpose. Participants were asked for their definition of the term "learning" which provides some information about their preferences in this area. Tigers123 described learning as a simple acquisition of information, but Shay described learning as an outcome of remembering, understanding, or applying information. Waterskier and Walt Owens thought about learning as a combination of these definitions, describing both a process of acquisition leading to remembering or understanding. More details about these definition groups is available in Chapter 5, but this data indicate variety in approach for these participants.

Interaction of Teaching Context and Student Factors With the exception of the course content, participants indicated no discernible difference between A&P1 and A&P2 courses. Assessments, lab exercises, and lecture structure were all confirmed to remain the same. There were 22 sections of lab offered, but none of the participants indicated issues with their graduate TAs for the course.

Two of the participants indicated regular meetings with Instructor 2. Waterskier described regular meetings to get additional help on course content. Beyond

descriptions of meetings about course content, participants indicated positive perceptions of Instructor 2, but did not report discussions or interactions outside of class time or meetings.

7.2.3 Learning Activities

The same three categories for learning activities emerged from the data as in Case 1a (see Figure 7.2). Similar to Case 1a, the tasks or actions identified were sometimes associated with self-identified shortcomings or affect.

Tasks/ Actions and Outcomes When interacting with the course material, participants noted both absorbing course information and engaging with course material. Most excerpts noted as absorbing information described listening during lecture or writing the spoken words of an instructor. In contrast, Waterskier described their process of constructing a study guide from information provided by the instructor by adding and reorganizing the information. This process indicated manipulation of the material and gives an example of engaging with course material.

> It was just the one thing that wasn't on there was... The cascade or like process for an erection. That wasn't on the lecture objectives. So like when we were talking about the anatomy of it, like in the lecture objectives, I kind of was just like... We're just going to add this right here, because it fits. So I always make sure that everything that I have in my notes in that study guide, whether it's a lecture objective or not. But I definitely try to organize under the lecture objective, if it's there. (Waterskier, Interview 3)

The use of instructor-provided resources was frequently mentioned by all participants. However, the resources available to Case 1b participants included lecture objectives, additional tools included in the Mastering A&P package, and attending PAL sessions. PAL sessions were noted by all participants, although Tigers123 noted their inability to attend and described how this was connected to their poor performance in the course and eventual departure. The other participants indicated attendance at sessions, although the frequency of this attendance varied based on other commitments. Walt Owens described a PAL session in this manner.

> But for the [PAL sessions] that I usually go to, we check in and then they have like a worksheet and they'll break the worksheet up. It's like, worksheet like, that's related to what we just learned about in class. And so, we... You'll sit at a table and like, your table is like assigned to do part of the worksheet. And then what... They give us some time to go through it and then, like, we can ask questions and stuff. And so each table kind of goes around and like fills in the blanks that they got and you like copy down, like, with the answers and you can... Like we talk about some stuff and the PALs [session leaders]... This is where the PALs might ask like questions about how it might relate to other topics- and things like that. And so sometimes there's like a little... another like, a separate worksheet that's kind of like a quiz. It's not graded or anything. It's just like extra practice and stuff like that. That just depends on like time wise and I guess what we're studying... Things like that. (Walt Owens, Interview 1)

Participants also noted hands on activities as helpful in mastering course content. While some of these activities were noted to occur in PAL sessions, the majority were specifically connected to lab exercises or open lab times facilitated by under-

graduate TAs. In these cases, dissection of cats or the use of physical models were most frequently described.

Participants noted some instances of opting out, choosing not to use available resources, the most common of these being the course textbook. Cost of the textbook and advice of previous course enrollees were the reasons most often mentioned by participants about why they chose to not purchase the textbook. Some participants described getting outside help as part of how they mastered course content. This was most commonly associated with study groups or getting help from friends who had taken anatomy and physiology previously at their own or another university. For some participants, they noted these practices as the some of the most important to their learning and performance in the course.

Participants identified three different outcomes associated with course content in the Anatomy & Physiology courses: *remembering, remembering/understanding, and applying*. While some participants described remembering the course material, a more common theme was the description of remember/understand. Participants described not only their content knowledge gained, but also talked about explaining their knowledge to someone else. Participants also described the outcome of application. In fact, Walt Owens described how they continued to engage the course material about blood and circulation, moving to application, and also connected this to positive affect.

> I guess like when I like... I, I understood like how like blood worked and like... The different processes to it and how it all kind of connected, that I found that I knew it a lot better. It was a little more satisfactory, rather than like I just memorized something. So I think that was like a big

bolstering to like why I feel like I understanding's the most important. (Walt Owens, Interview 3)

Participants in Case 1b describe completed assessments as an outcome, as well as less than hoped performance and successful performance. As explained in Chapter 4, these outcomes are directly related to specific grades or assessments themselves. The appearance of these areas of outcome seem to indicate an outcome-orientation of the participants.

Participants described their practices of *getting outside help*, and the most frequent type of help noted in the data was the use of PAL. All participants who remained in the study reported attendance at PAL sessions and use of PAL worksheets and tools. Waterskier described their attendance in this way.

PAL is Sunday/ Wednesday. So that's the big one for me, because sometimes I'm like, okay, I don't have time to type my lecture notes. And then I just go to [PAL] and that's good review. (Waterskier, Interview 2)

In contrast to themes that focus on course performance, the theme of awareness of discipline is expressed by participants but is not associated with any specific task or action. Walt Owens describes how they has met their goal for the course of gaining a better understanding of the body, while also becoming aware of the limits of the course requirements.

I think its been just like really good. I know, like a few times, like [Instructor 2] mentioned in lecture like... Like [they're] not going as deep as [they] could. And I think that's just because like [they know] like a lot of it is, like this is just a bi... Large overview... And so, it's been really good as far as like getting a better understanding of like, the different

> processes in the body, why the body reacts this way to certain things. Like a general... Like a very... Like it's deep but it's all... Because it's a lot of information and it's really interesting, but it's also like I understand to general overview. (Walt Owens, Interview 3)

Related to this code is *fascination with discipline* which was only expressed by Waterskier. While not directly connected to affect, these outcomes suggest an enjoyment and fascination with the material independent of course expectations, but the significance of this observation is not clear.

Participants in Case 1b also describe interactions between the 3P Model areas. Some individuals describe issues with being able to *recognize important content*. However, this theme was not persistent across participants and time, as participants all noted their use of the instructor provided Lecture Objectives. Based on participant descriptions, these objectives consisted of a list of general topics that formed the basis of each lecture presentation. Class members were encouraged to expand on each topic to ensure they were prepared for course exams and all participants indicated this suggested practice to be helpful.

Self-Identified Shortcomings The tasks of altering study habits, managing time, and struggling to master course material were described by students to also be areas in which they struggled. Each of the participants who completed the full study indicated that their time to invest in the course was decreased due to outside influences. Shay and Waterskier described the time required by their jobs as deterrents to increasing study time, but all three also described involvement in various organizations or sports teams. All excerpts describing the need to alter study habits were provided by Tigers123, who dropped the course and departed from the study. The struggles

they described in their interviews indicated unsuccessful attempts to improve their course performance.

> I like... Was never like on top of things, which just isn't me. So... And so then started thinking like how could I like fix things? And so I tried different study habits and like still would just feel really behind. (Tigers123, Interview 2)

Despite the fact that other participants described a desire to improve course performance, they did not call their own study habits into question when considering how to realize this goal. The struggle to master course content was also frequently associated with engaging with course material, as well as seeking the outcomes of remembering or understanding. Overall, each of self-identified shortcomings codes were connected to both tasks or actions of participants or the outcomes they experienced in the course.

Feelings/ Affect Both positive and negative feelings were described by participants, but positive affect was the major theme. Most examples of affect were connected to tasks or actions rather than outcomes. In particular, the ideas of enjoyment and being interested were most frequently mentioned. As an example, Walt Owens describes their thoughts of the course in this way.

> I like... Enjoy going to this class I think a lot more than I thought I would, as well... But for the most part like I enjoy going to lecture, like lab. Like anatomy lab, even if we have like a quiz or something like I still enjoy going to it. I don't really find myself stressing too much, even if I like stress about studying. But like at the end of the day, it's like, "okay." This is still like an enjoyable class and lab, so. (Walt Owens, Interview 2)

In a similar manner, participants also expressed interest in the course topics and a determination to successfully complete the class. However, negative affect was not identified for all participants, but most commonly appeared in relation to the tasks connected to outcomes. While some excerpts describe feelings of discouragement, being worried, or feeling overwhelmed, positive feelings or motivation are also apparent.

> But I just kind of... I've started to get discouraged but it's also kind of motivated me. Like I just need to work harder. I need to find a better way to study, because I thought I knew how to study and I'm struggling. It's kind of... Its kind of showed me that I need to... Because now I've figured out how I learn best, I need to make it work when that opportunity is not provided to me. (Waterskier, Interview 2)

Quantitative Data Results As before, data were collected to assess content mastery. However, qualitative data such as concept maps and responses to diary prompts related to course content have not been analyzed. A quantitative measure of student mastery of homeostasis as an outcome is represented by the scores on the HCI completed at the end of the study. All participants increased their score from first administration with a range of 15-16. These patterns are shown on Figure 7.4.

In summary, participants in Case 1b worked to absorb or engage with course material, but also participated in hands on activities, used instructor resources, and sought the assistance of others. These tasks or actions were often connected to specific outcomes, like completing course assessments or mastering course material. However, the participants recognized various shortcomings in both their approach to the course material and their performance. In some cases, participants experienced negative affect related to these events, but more commonly experienced positive affect as the expressed enjoyment and interest in the course content. It is important to note

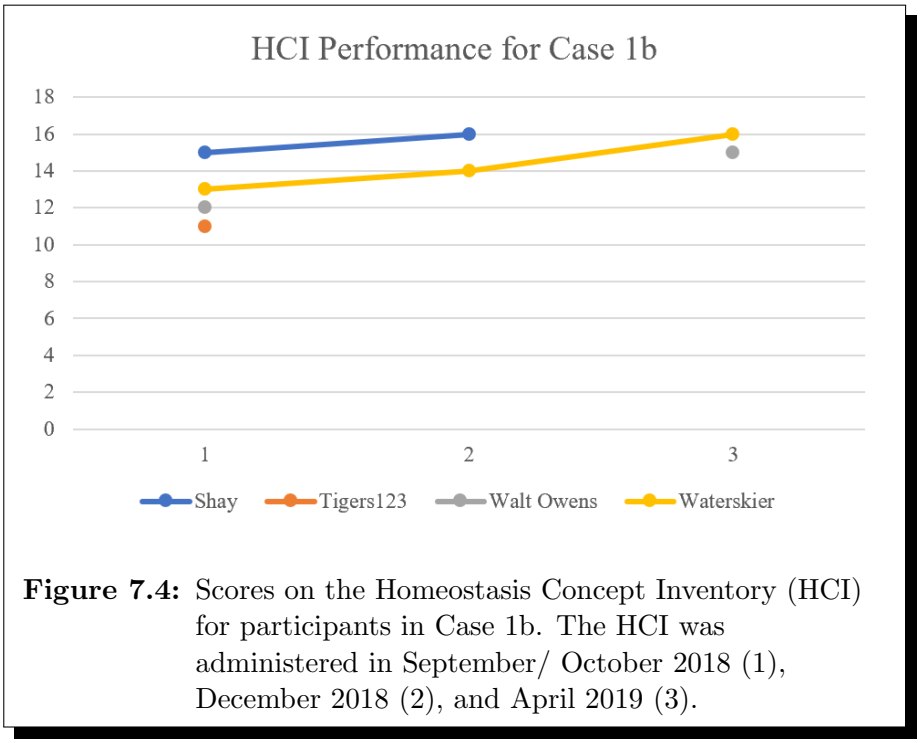

Figure 7.4: Scores on the Homeostasis Concept Inventory (HCI) for participants in Case 1b. The HCI was administered in September/ October 2018 (1), December 2018 (2), and April 2019 (3).

that the majority of data used in this case were participant interviews, as Case 1b participants provided fewer weekly diary responses than the participants of Case 1a. However, there were no themes that emerged from the weekly diary data that were not also articulated in the interviews, so the impact of this difference between the cases seems to be minimal.

7.3 Case Comparison

Cases 1a and 1b demonstrated both similarities and differences in Teaching Context, Student Factors, Learning Activities, and Outcomes, which are described below.

7.3.1 Comparison of Teaching Context

The courses for Case 1a and 1b were both 4-credit courses, with lectures taught in large lecture halls with more than 200 students. The laboratory sections for Case 1a were 3-hours long each week, while those for Case 1b were 2-hours long. Participants describe both instructors as organized and providing course information in a timely manner on the course LMS website. All lecture sections consisted of instructor presentation of material, mainly via PowerPoint. However, Instructor 2 was noted to not list the bulk of information on slides, while Instructor 1 omitted fewer items from the slides. Instructor 1 recorded all lectures and posted them on the course LMS website, while Instructor 2 helped coordinate PAL sessions aligned with their courses. The number of assessments differed between courses, but the majority of assessments were completed for the laboratory portion of the course. Case 1a had content quizzes in the time leading to an exam, while Case 1b had a type of content quiz, Mastering A&P homework, due prior to every class meeting, except for days of exams and the start of a new unit. Exams in Case 1a had a variety of question types, while Case 1b exams were solely multiple choice questions. For Case 1a, the change between first and second semester courses in content and assessments was more dramatic, while Case 1b was described this way by Waterskier.

> And I would say that for the whole class, I would say this is a year-long semester with a month-long break in the middle. (Waterskier, Interview 3)

While there are differences between the details of the courses, the main differences seem to lie in the types of resources provided to students by the instructors. Instructor 1 provides recorded lectures, while Instructor 2 provides lecture objectives and helps to coordinate PAL sessions.

7.3.2 Comparison of Student Factors

There was a difference in the number of participants for Case 1a and 1b (7 vs. 4), and Case 1a participants were all females while one male participant was part of Case 1b. The difference in participant numbers resulted in a greater amount of data collected for Case 1a, but the same themes were evident for both cases. The career aspirations of all participants centered on the health care field, but participants in Case 1a were predominantly interested in doctoral-level professional degrees of medicine and physical therapy. In considering their approach to learning, Case 1a participants all viewed learning as a process of acquisition with various levels of content mastery. However, Case 1b participants indicated greater variability in their view of learning, as definitions ranged from a process of acquisition only, an outcome of remembering or applying, or a combination of these actions or outcomes. The HCI data indicated a higher starting knowledge of the concept of homeostasis for Case 1b who had a range of scores from 11 to 15 out of 20 in contrast to the performance of Case 1a participants whose scores ranged from 6 to 13. This difference could be due to the fact that A&P1 content centered on the topic of homeostasis in the early weeks of the semester, giving Case 1b student instruction on this topic prior to HCI completion.

7.3.3 Comparison of the Teaching Context/ Student Factors Interaction

More significant differences were noted between Case 1a and 1b in this area. Participants in Case 1a reported negative affect in relation to the course pacing, the structure of laboratory sections, and personal interactions with Instructor 1. However, none of these sentiments were evidenced by the participants of Case 1b. When

considering the types of affect expressed in relation to other aspects of the course, it is possible that the affect experienced in relation to each instructor carried over into other areas. The negative affect experienced in relation to Instructor 1 could be connected to the stress, frustration, and discouragement in relation to other course components. However, the current analyses do not provide evidence for assignment of direct connection or causation of this observation.

7.3.4 Comparison of Learning Activities

There were few qualitative differences between the Learning Activities used by participants in Case 1a and 1b. *Absorbing information* and *engaging with course material* were themes present for both cases, and the remaining tasks or actions identified in the data were the same. Participants used different instructor provided resources when comparing the cases. Case 1a participants accessed recorded lectures and Instructor 1's YouTube channel, but Case 1b participants used Instructor 2's lecture objectives and attended PAL sessions. Self-identified shortcomings in relation to learning activities identified between the cases were also the same. There were differences between the types of affect reported by participants in the cases. Case 1a demonstrated predominantly negative affect, while Case 1b expressed mostly positive affect. The affect theme of amused was only expressed by Case 1a participants and was absent for Case 1b.

The themes identified for learning activities represent the cognitive processes and pathways used by the participants in Case 1a and 1b and provides an answer to Research Question 1. The data indicate no differences in the types of cognitive processes and pathways used by students in Anatomy→Physiology or Anatomy & Physiology I→II.

7.3.5 Comparison of Outcomes and Related Interactions

There were few qualitative differences between the outcomes realized by participants in Case 1a (A→P) and 1b (A&P1→2). The most significant difference was the infrequent expression of frustration in Case 1b, while it was expressed more broadly, and in connection with both learning activities and outcomes, for Case 1a. When viewing the interactions between learning activities and outcomes, the same associations between tasks or actions and outcomes were noted between the cases. For both cases, completing assessments was the outcome most frequently associated to a tasks or actions. However, Case 1a showed more connection of this outcome to other tasks or actions. In addition, outcomes specifically related to course performance and content mastery were emphasized by participants over those connected to their own interest in the subject, but participants in Case 1b were more likely to highlight these aspects.

The main difference between Case 1a and 1b was evident in the interaction between student factors, teaching context, and the outcome of completed assessments. Participants in Case 1a describe a tension between how they were able to prepare for an exam, their own goals, and the various requirements to be successful on these assessments. While the outcome of completing assessments is evidenced by both cases, only Case 1a participants provide evidence of tension or internal conflict. This view is highlighted by the dominance of negative affect, such as discouragement, being frustrated, and feeling overwhelmed. In contrast, Case 1b demonstrates mainly positive affect about the factors related to the course, mainly portraying enjoyment and interest. It is not clear if the source of this tension lies with the participants of the cases, the instructors and their approach to the course, or some aspect of the

Table 7.7: Comparison of Case 1a and 1b characteristics, as aligned with Biggs' 3P Model [Biggs et al., 2001].

	Case 1a (A→P)	**Case 1b (A&P1→2)**
Teaching Context	Taught by Instructor 1, Large lecture with lab sections, Recorded lecture available, Changes between fall and spring courses	Taught by Instructor 2, Large lecture with lab sections, PAL sessions available, Fall and spring courses had same structure, but different body systems
Student Factors	7 female participants, Learning defined actions leading to an outcome, Initial HCI scores = 6-16	4 participants (3 female, 1 male), Learning definitions varied, Initial HCI scores = 11-15
Learning Activities	Use of recorded lectures and YouTube channel, Early lab departure	Use of Lecture Objectives and PAL, Did not purchase textbook
Outcomes	Regular frequent connection to *tasks or actions*, Final HCI scores = 9-18	Regular frequent connection to *tasks or actions*, Final HCI scores = 15-16
Interactions Noted	*Stress* and *frustration* from course pacing, lab structure, and personal interactions with Instructor 1. Negative affect associated with *completing assessments*.	Regular meetings reported with Instructor 2 with positive affect.

assessments themselves. However, additional discussion on this topic will be provided in Chapter 8.

7.3.6 Conclusion

The main difference between Case 1a and 1b lies mainly in how the participants responded to completing assessments. While this outcome was important to the participants in both cases, the tasks or actions associated with arriving at this outcome produced many negative feelings and emotions for the participants in Case 1a. Assessments themselves are viewed as part of Teaching Context by Biggs with in the 3P Model, so the tension demonstrated here represents a complex interaction between teaching context, student factors, outcomes, and also learning activities, as well. I explore possible explanations for this phenomenon in Chapter 8.

Chapter 8

DISCUSSION and CONCLUSIONS

8.1 Discussion

8.1.1 Answering the Research Questions

This work began with two specific research questions.

What are the differences and similarities in cognitive processes and pathways for:

RQ1: Students enrolled in a course sequence of Human Anatomy → Human Physiology (A→P) vs. Anatomy & Physiology I → Anatomy & Physiology II (A&P1→2)?

RQ2: Students with surface learning approaches vs. deep learning approaches?

With regards to research question 1, there are many similarities in the cognitive processes and pathways displayed by participants of Case 1a and 1b and a few key

differences. Both Case 1a and 1b describe eight main themes for the tasks or actions taken as Learning Activities. These themes have some overlap with the previous work of Pandey and Zimitat [2007] and Fyrenius et al. [2007] described with the theoretical model in Chapter 2. However, the current work provides a different focus to the learning activities present.

Pandey and Zimitat [2007] described ten "successful approaches" to learning anatomy for medical students, but focused mainly on the presence of memorizing, understanding, and visualizing. Based on their definition of memorizing, the theme of absorbing course information from the current study captures the same student approaches. For understanding and visualizing, the theme of engaging with course material from the current study is most similar. Based on the findings reported in Chapter 5, the terminology used in the current study may provide a clearer idea of what mental processes students use when attempting to master course material. In addition, previous work in the science of learning has indicated that mental engagement in the learning task leads to more efficient memory consolidation. Brown et al. [2014] emphasize findings from various researchers that show active engagement with course material, usually in the form of retrieval practice or interleaving, is superior to simple exposure to the material. The approaches described by the participants in the current study include both absorbing information and engaging with the course material, which aligns more closely with Brown et al. [2014]. Additional approaches noted by Pandey and Zimitat [2007] are attendance/ preparation, constant revision, interest, note-taking/ drawing, using specimens, and discussion. Participants in Cases 1a and 1b reported similar approaches to their undergraduate course.

Participants in the current study frequently noted their attendance in class and use of taking notes or drawing as preferred methods of working with course content. However, these excerpts were categorized to either absorb information or engage

course material depending on the type of mental engagement that was evident in the excerpt, as described above. While Pandey and Zimitat [2007] participants noted the use of Discussion, Case 1a and 1b also indicated participation in discussion activities, which were captured in the getting outside help or engage course material categories. Using specimens was also noted by the participants of the current work, and these excerpts were coded in either hands on activities or using instructor resources. It is important to note that many additional activities and resources were used by the participants of the current study, expanding beyond those noted by Pandey and Zimitat [2007]. These were captured during the first round of open coding. One common example is the use of Quizlet. The appearance of this tool could be due to time. Quizlet and other online quizzing platforms have become more abundant and easy to access over the 12-year span since Pandey and Zimitat [2007]'s work was published.

Pandey and Zimitat [2007]'s participants also highlight the approach of time on task/ hard work most frequently. With the exception of opting out, all themes identified in the current study would represent time on task or hard work. However, the format of data collection by Pandey and Zimitat [2007] asked for written responses to open-ended questions and participants provided data that were grouped into more than one category. If I had adopted a similar approach to analysis, this would have also been a common theme.

Interest was noted as a specific approach by Pandey and Zimitat [2007]. However, this idea was identified as an area of affect in the current work. The presence of interest was shown to interact with the various processes and approaches of participants in Cases 1a and 1b, but it was not identified as an independent strategy. Finally, Pandey and Zimitat [2007] list constant revision as an approach mentioned by 30% of their participants. However, they provide no definition for this action.

While it is possible that this theme may be captured in the current idea of engaging course material, this may not be an accurate assumption.

Fyrenius et al. [2007] described three approaches to achieving understanding in physiology: sifting, holding, and moving. Sifting is described as "acquired from books and teachers" [Fyrenius et al., 2007] and is closely aligned with absorbing information in the current study. Both holding ("structured reorganization of new information") and moving ("application of knowledge used to verify understanding") [Fyrenius et al., 2007] would be captured by engaging with course information. However, these alignments are imperfect due to the focus of Fyrenius et al. [2007] on understanding. In fact, these areas would more closely align with the outcomes of remembering, understanding, and applying, respectively.

A summary of the connections between Pandey and Zimitat [2007], Fyrenius et al. [2007], and the current work is presented in Figure 8.1. In contrast to Pandey and Zimitat [2007], the current work followed the pattern of Bloom's Revised Taxonomy [Anderson et al., 2001] by describing remembering, understanding, and applying as outcomes rather than specific approaches to mastering course material. However, the use of remembering or memorizing as approaches is consistent with the definition and use of these words by participants in this study. For a more detailed discussion of these definitions, see Chapter 5. Overall, the themes identified in previous work are similar to those in the current study.

In another previous study with medical students, Wilhelmsson et al. [2010] described a "deficit in meaningfulness" experienced by participants enrolled in Anatomy in their second-year. This phenomenon referred to a deficit in the connections of current material to other biological concepts or phenomenon. This experience led students to seek connections in other areas of medicine, including Physiology, to fill the gap in their knowledge when a particular structure was "left alone." When this

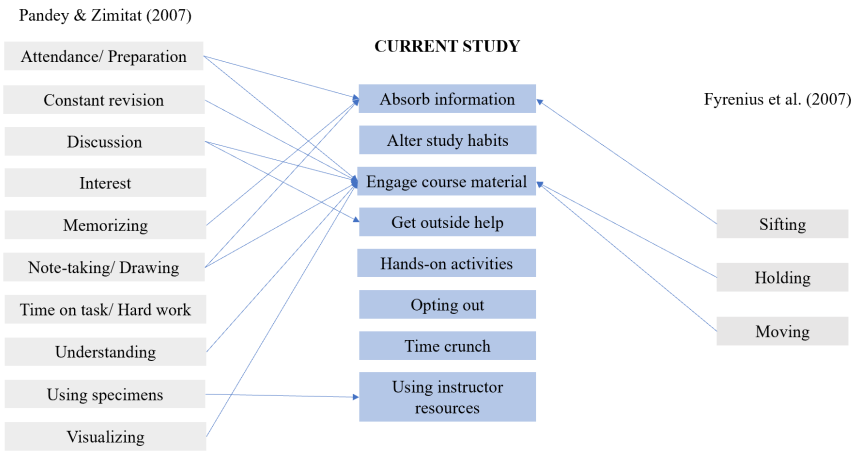

Figure 8.1: A visual representation of approaches identified by Pandey and Zimitat [2007] and Fyrenius et al. [2007] compared to Tasks/ Actions from the current study.

failed, participants experienced a disconnection and "the students were forced into the corner of rote-learning." In this study, participants of Case 1a were enrolled in Functional Human Anatomy, a course with a similar focus on anatomy in the absence of physiology. Participants reported the outcome of remembering (which includes actions of memorizing or rote-learning) to be most closely associated with a lack of time to understand or apply the material, representing a similar approach to the material, despite the differences in course setting and course difficulty (undergraduate vs. medical school). It is possible that a similar "deficit of meaningfulness" was present for these students since they are completing a similar curricular path.

Each of the previously reported studies [Pandey and Zimitat, 2007, Fyrenius et al., 2007, Wilhelmsson et al., 2010], were conducted with medical students rather than undergraduates. While some approaches and themes are consistent, others differ, as described above. However, similar to these previous works, the current study is unable to describe which of these cognitive processes or pathways are most efficient or successful.

As discussed in Chapter 6, research question 2 cannot be answered with the current data. Participants were recruited to the study after completing the R-SPQ-2F based on their Deep to Surface differential score. The goal was to recruit participants on the extremes of the deep and surface scales of the survey. Interview data raised concerns about the validity of the R-SPQ-2F, and additional analysis supported these concerns.

Source of Teaching Context/ Student Factor/ Outcome Conflict As noted previously, the main difference between Case 1a and 1b was found in the negative affect associated with outcome of completed assessments. Figure 8.2 displays the relevant themes and information for Case 1a in this conflict. The course assessments can be thought of in terms of formative and summative assessment. These assessments must be completed by some series of tasks or actions to arrive at the participant-identified outcome of completed assessments. As educators, we expect the process of completing an assessment will also result in the acquisition of new knowledge. However, the excerpts coded as complete assessments provide no evidence of this additional outcome. Participants seem to be experiencing some type of conflict between this area of teaching context and their stated outcomes. There are several possible causes of this phenomenon that we will explore here.

For student factors, the participants of Case 1a differed little from Case 1b in terms of course expectations or approach to learning. The majority of Case 1a participants intended to pursue a doctoral-level professional degree, while only one member of Case 1b held this aspiration. There is little evidence that this difference is alone responsible for the discrepancy in affect related to assessments.

Some aspects of the teaching context for Case 1a may also play a role. While not evident through the course learning objectives, there is a difference in the depth of

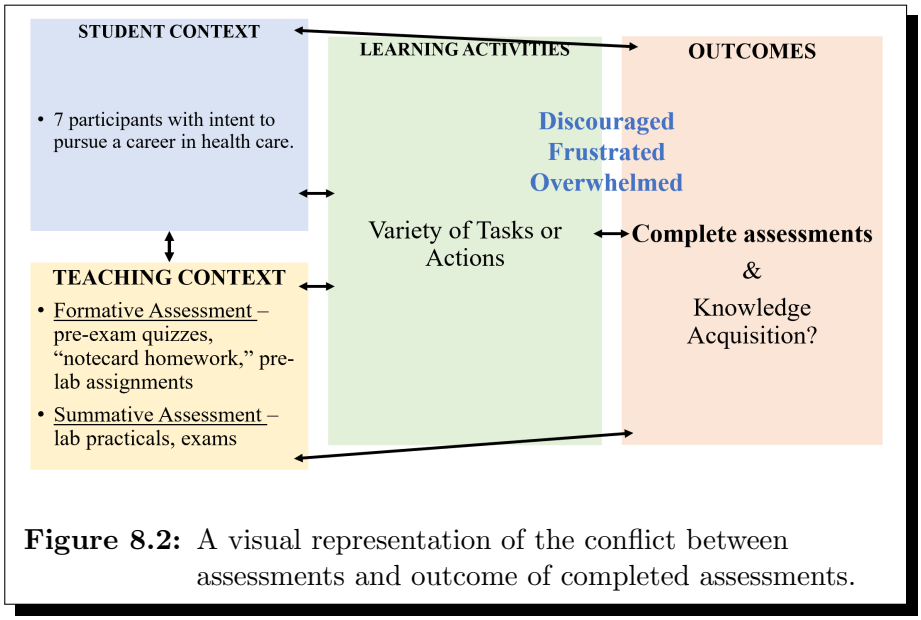

Figure 8.2: A visual representation of the conflict between assessments and outcome of completed assessments.

knowledge required for successful completion of the courses in Case 1a when compared to those of Case 1b. However, the content itself is rarely mentioned by the participants in conjunction with negative affect. Another option could be the question or assessment type. Participant reports of details for assessments provide few differences between the types of questions. Case 1b lecture assessments were solely multiple choice questions, while Case 1a pre-exam quizzes and exams contained mainly multiple choice questions with some additional fill-in-the-blank questions or true/ false questions. For both cases, participants indicated some difficulty with understanding questions on assessments. While these comments were associated with negative affect, they do not seem to fully explain the difference in negative and positive affect experienced by the participants. It is also possible that the increased negative affect for Case 1a is caused by Instructor 1. Despite the fact that Instructor 1 was at times associated with *stress* by the participants, there was continued positive affect from the participants with regards to the instructor. This fact makes it seem less likely that Instructor 1's presence was the cause of this phenomenon.

However, a key difference between Case 1a and 1b is the presence or utilization of formative assessment. The assessments of pre-exam quizzes and "notecard homework" could be considered formative assessments. Formative assessment has been described in this way:

> Rather than focusing on the indication of what has been learned, formative assessment helps students and teachers to identify learning gaps and anticipate future teaching steps. ([Pastore and Pentassuglia, 2015, pg. 409])

However, there is evidence that participants did not use these tasks in a way for them to be formative in nature, even though they may have realized this as the instructor's intent. For example, Kate says this about the way Instructor 1 wanted pre-exam quizzes to be used.

> **Kate**: I actually really like the lecture quizzes. I don't use them, I don't think in the way that [they]... in... intended for them to be used...
> **SNJ**: Okay. So what do you think [Instructor 1] wants you to do?
> **Kate**: Umm... I think [they want] us to use it as a way to like, help ourselves study. Like maybe test it, like do it once before, and then study, and then do it again. Because we have three attempts on each one. So I'm... Yeah, I don't know, I guess. I just always kind of thought, anything that I do last minute, I'm like, oh [they're] gonna hate this. (laughing) But some people don't even do them. So I mean, I guess its probably better than nothing. So...
> (Kate, Interview 2)

For the "notecard homework," participants did indicate during the second semester that the topics from this assignment had appeared on exams, but overall found the questions somewhat disconnected from course material.

> So far for the lecture, [they've] asked us to turn in a note card- just for the question that [they] didn't necessarily cover in detail in class, just to see- what we, like, could assume about the question. But [they've] only asked for two of those. And then obviously it's like the readings that go along with it. But that's on your own. (Sally, Interview 1)

Participants sometimes described the pre-exams quizzes not as opportunities for learning but as one way to boost your course grade, as expressed in this quote

> But we've kind of been trying a little bit harder to get something out of them [pre-exam quizzes]... But we still aren't really getting anything out of them... Like we do them because it helps our grade so much. (K Diddy, Interview 2)

The formative assessment of Mastering A&P homework differed in due date, as these were due prior to most classes through a unit of study. The pre-exam quizzes were opened and then allowed for up to three tries on the assignment, with a due date just before the exam itself. All participants in Case 1a described taking the quizzes in the day or two prior to the exam. Therefore, the pre-exam quiz did not function as formative assessment, rather as a pre-test or review tool for the exam itself.

However, Kate clearly expresses a desire and appreciation for formative assessment, by describing this in-class activity.

> did this one thing at the... Recently in the class where [they] kind of put a question on [the] last PowerPoint slide and we all talked about it in class.

> And then like [they] went over it. That was WAY better. If [they] just did that and basically put the questions or put the topic on the board and be like "so you guys talk about this." And then we like talked to our neighbor for a few minutes and then we go over it together- that'd be great... And then like I mentioned earlier, those slides that we have with the questions, where we kind of talk about it was just... Was great. The one that [they] asked us was... Which type of muscle contraction puts more strain on the heart? Isometric or isotonic? And it was like a really good question. And we all came up with different answers. And so... And then [they] went over it and I felt like I really learned a lot from that. And so I think like interacting with the class and interacting with [them] was really useful and that's something that we don't really do that much. So, as compared to the note cards, I feel like that would be a good replacement for that.Instructor 1 (Kate, Interview 3)

When considering the role of formative assessment in a course, prior work has provided information about its impact on the student experience of a course. Brazeal et al. [2016] conducted a mixed methods study and sought to understand both the role of formative assessment in learning, as well as describe student perceptions of these tasks. They presented five objectives of formative assessment.

1. Clarify learning expectations and clarify criteria for success
2. Reveal evidence of student understanding to the instructor
3. Provide feedback that moves learners forward for instructional adjustments and student self-assessment
4. Activate students as instructional resources for one another

5. Activate students as the owners of their own learning

Participants in this study reported that pre-exam quizzes and "notecard homework" did achieve these objectives of a formative assessment. In Case 1a, the pre-exam quizzes certainly met objectives 1 and 3. Participants described quiz questions as being useful in preparing for the exam. In addition, having three attempts to complete the quiz resulted in students searching their textbooks and notes for information when they missed a question. "Notecard homework" was described by participants as providing hints for exam topics, aligning with objective 1. However, feedback was not provided in a regular manner for these assignments. Completion of both of these assessments did at times cause participants to work with classmates, fulfilling objective 4. However, there is no evidence that objectives 2 or 5 were met by these assessments. In addition, due to the late time completion of the pre-exam quizzes, the full benefits of fulfilling these objectives may have been lost.

Haroldson [2012] described student perceptions of formative assessment in a chemistry classroom. These students expressed "feeling good during the learning process" and "knowing what was wrong" as benefits of formative feedback. As before, the use of "notecard homework" and pre-exam quizzes as described by Case 1a participants may have prevented the full realization of similar benefits and positive affect.

If participants were unaware of the learning expectations during the unit of study and were unable to self-assess their knowledge until the days just prior to an exam, a response of *frustration*, *feeling overwhelmed*, and *discouragement* seems possible. While there is not conclusive evidence that a lack of formative assessment was the cause of the increase in negative affect for Case 1a participants in relation to

Table 8.1: Demonstration of counts of Alignment (A) and Misalignment(M) with R-SPQ-2F responses in each "studying" definition category from Interview 1.

Definition Category	A	M (Mild)	M
1. Process	2		
2. Use of time	1		
3. Extrinsic outcome	1		2
4a. Intrinsic outcome (Memorization)		1	1
4b. Intrinsic outcome (Understanding)			1
4c. Intrinsic outcome (Memorizing & Understanding)		1	

completing assessments, the above excerpts support this idea as worthy of additional study.

8.2 Theoretical Implications

As noted in Chapter 5, students use a variety of definitions for common terms in educational research. This seems to have an impact on their interpretation of previously validated survey items, as demonstrated in Chapter 6 with the R-SPQ-2F. As an example, item 4 asks for level of agreement with this statement: *I only study seriously what's given out in class or in the course outlines.* A pattern emerged in the alignment or misalignment of participant responses on the R-SPQ-2F and information provided in the first interview. Participants who defined "studying" as solely an action (definition groups 1 and 2) always aligned their survey response with their qualitative response. In contrast, participants that defined "studying" as a combination of an action and an outcome (definition groups 3 and 4) almost always displayed a misalignment with their survey response. A summary of this is provided in Table 8.1.

The use of SAL and the concepts of surface and deep learning are prevalent in current educational research (see Clinton [2014], Mirghani et al. [2014], Monroy

and Pina [2014], Pandey and Zimitat [2007], **?**], Sabourin [2016]). However, the data presented in Chapters 6, 4, and 7 provide evidence that the concepts of deep and surface learning may best be thought of as a continuum rather than discrete categories. Participants in this study frequently used a great variety of approaches to the material in their anatomy & physiology courses with success. In addition, more work is needed to understand if the categorization of *study strategies* as surface or deep is useful or appropriate, as well as how the themes of absorbing information or engagement with course material are connected to these ideas.

8.3 Implications for Practice

As described earlier, participants in this study use common words in education research very differently (see Chapter 5). This has been shown to impact reliability and validity of survey instruments (see Chapter 6), but can also have impacts on instruction. In my own work as a practitioner, students frequently ask for advice about approaches to learning or studying. However, the same misalignment of definitions observed between surveys and study participants can occur between instructors and their students. It is especially important to clarify your own definitions of terms related to presence of an action and/or outcome and to gather this information from students before providing the requested advice. A mismatch in instructor and student use of words can cause unneeded frustration on the part of both student and instructor. Therefore, it is important to reconcile and clarify definitions when providing advice and instruction to students.

8.4 Recommendations for Further Research

The data collected for this project have many possible additional analyses, with the next steps listed here. First, a confirmatory factor analysis (CFA) will be completed for the R-SPQ-2F. In addition to the 263 responses collected in Fall 2018, 140 additional responses have been collected in Fall 2019. The Concept Maps constructed by participants at Interviews 2 and 3 will be analyzed to better understand student thinking about homeostasis. This analysis will focus on the *outcomes* described in these maps, which made analysis during this study, which focused on learning activities, more appropriate for future work. Finally, longitudinal coding [Saldaña, 2016] and analysis will be completed to see how cognitive processes and pathways are changing over the course of the two semester sequence.

For future work, additional study should be completed to gain insight into how students in both biological sciences, more broadly, and STEM fields, in general, define important terms like "learning," "memorizing," "studying," and "understanding." Findings from the upcoming CFA of the R-SPQ-2F should help inform development of a new instrument to better categorize students on the surface or deep learning continuum. Finally, the Process and Pathways model should be tested in other contexts, such as different university types and class configurations.

Appendices

Appendix A Pilot Study Code Book and Example Quotes

A.1 "Successful Approaches to Learning Physiology": Pandey and Zimitat [2007] Categories

These groups were used as *a priori* codes in the unitized pilot study data.

Memorization is defined by Pandey and Zimitat as "a surface approach to learning... with the intention to memorize facts and information, and recite them back in response to questions." [Pandey and Zimitat, 2007]

> "What I found most helpful in order to memorize all of this information was just repetitiveness." Participant 2

Understanding is not defined by Pandey and Zimitat. My definition, which is consistent with other literature [Fyrenius et al., 2007], is "possessing a relevant knowledge object that can be applied to a problem."

> "The reason I did not think action potentials were very difficult this week either I think was because we had already talked about action potentials in muscle cells and this was mainly a review for the nerve cells." Participant 1

Visualization is not defined by Pandey and Zimitat [2007]. Excerpts that were coded with this theme all refer to "looking", "seeing", or a reference to being visual or visualizing.

> "It became more difficult when you had to switch between different equations like [P]ascal's law and then on to [L]a[P]lace's law. I'm a very visual person so i don't know if instead of thinking about it in equations if i would have visually processed and thought about what was happening to the blood pressure if that would have helped me understand what was happening." Participant 2

Time on Task/ Hard Work have been separated in my coding.

Time on Task was used for any excerpt referencing a tool or resource used by the student for study which was not captured by another code. In particular, Quizlet was referenced several times. This code was also used when the quote referenced a significant amount of time spent on the task.

> "With the action, insertion, and origins I had them on Quizlet and went over them again and again specifically using the write and learn programs. I used the learn program a couple times first before moving on to write but after studying them for a couple hours over three nights I felt very confident on them." Participant 2

Hard Work was used for excerpts that indicated a general difficulty.

> "In the moment it isn't difficult, but trying to retain it has proven not easy." Participant 1

Attendance/ Preparation was used for excerpts that reference activities during a class period or attendance at class time. It might also apply to excerpts that reference completion of homework or other pre-class assignments, but no references of this nature are present in this data set.

"I didn't use any strategy outside of the lecture" Participant 1

Constant Revision was applied to excerpts that reference changing and updating either physical or mental representations.

> "When talking about ECGs I drew a lot of ECGs and then talked through what was wrong with them and why, i found that the repetitiveness of this approach helped me really understand what was going on in the ECG." Participant 2

Interest was applied to excerpts that explicitly or implicitly reference "interesting" or "interest".

> "I have always thought this is one of the more interesting things while studying anatomy and physiology of a human. There is a human body in front of us then there are all these little checks and balances going on underneath the skin that most people genuinely don't know about. These chemicals and hormones that regulate the blood pressure of a human start in one area of the body, typically the brain or a specific gland and then will travel around the body to the specific spot they need to go to. These spots can either be the heart or a specific blood vessel in a specific part of the body. I just think its crazy how many processes are going on throughout the body to make the what we see on the outside possible." Participant 2

Note-taking/ Drawing have been separated in my coding.

Note-taking was applied to excerpts that reference "notes" taken by the student, both inside or outside of class, or study guides or other notes or documents provided by the instructor to fill-out, complete, or review.

"For the most recent test I rewrote my notes and used guided notes made by the professor." Participant 1

Drawing was applied to excerpts that reference implicitly or explicitly reference "drawing".

"Going into the weekend i had a lot of things that i wanted to keep straight. In order to achieve this i found it the most helpful to write and draw everything out on one page that i was mixing up. That way i could visually see the different concepts that i was confusing with each other all at once." Participant 2

Specimens was applied to excerpts that reference models, diagrams, or dissection specimens.

"I grouped all the muscles by their region, head, trunk, legs, and arms. Then when I went up to the lab to look at the models of the arms and legs I thought I was fairly prepared however I struggled finding the muscles in the models at first." Participant 2

Discussion was applied to excerpts the reference working, studying, or discussing with other students or peers.

"I also studied with peers, we made up questions involving the material and tested each other." Participant 1

A.2 Fyrenius et al. [2007] Parallel Frameworks

All of these categories were used in coding this pilot study data.

Sifting is defined as "receiving and condensing information for understanding." [Fyrenius et al., 2007] Students using this approach believe that knowledge is hidden in a book or within the instructor and is something to "take in". Application of the information does not occur. This code was applied to excerpts that reflect these ideas and may mention copying or transcribing information from another source, as well as an explicit mention of memorization.

> "As i went through the lab book when I looked at the muscles I would write the name down five times. I think this helps me because I write each different muscle group on a different color of paper." Participant 2

Building is defined as "relating previous knowledge and making the understanding your own." [Fyrenius et al., 2007] Students using this approach participate in active construction of knowledge and relate new information to prior knowledge and experiences. The framework does sub-divide *Building* into *Holding* and *Moving* based on intention. The *Building* code is applied to excerpts that reflect application or active construction of knowledge with no indication of intention.

> "During class [I] also noticed that the processes that occur in the body generally are similar to some degree." Participant 2

Holding is defined as "structuring and reorganizing information to reach a final goal." This form of understanding is tenuous and may be disturbed by a new explanation or way of describing the information. *Holding* is also characterized by high structure and control or the idea of "holding on to" information. This code was applied to excerpts that reference these ideas.

> "I tried to read through the chapter and write down the review at the end of the chapter but that did not really help me, I do not know if this

> was *because it was explained in a way that was different than what was discussed in class* (emphasis mine) or why it did not aid my studying process." Participant 2

Moving is defined as "continuously striving for a change in perspectives" [Fyrenius et al., 2007]. In this relativistic approach to learning and understanding, application is stressed. Four specific subgroups were identified by Fyrenius *et. al*: inquiry, repetition with variation, visualization, and active admission of not understanding. Excerpts that reference these particular actions or intentions were assigned this code.

> "I have also realized that talking 'around' the concept, by this i mean coming up with as much information i can on the topic and talking about how different concepts connect to them." Participant 2

Linear conceptions of knowledge occur when relating parts to wholes is defined as an unproblematic relationship between details and wholes. In these instances, more understanding is gained by learning more details. Fyrenius and colleagues add, "the depth depends on when you stop asking the question 'why?"' [Fyrenius et al., 2007].

> "I found looking at dermatome maps to locate pain and sensations based on the different nerve tracts the most interesting. It is so mind blowing that you can trace the largest sensations through their pathways and pinpoint what the cause is." Participant 1

Competing conceptions of knowledge are present when learning new details threaten understanding of the whole. This may be described as "getting lost in the details" or studying related parts and wholes at different times.

"One main question that i am still looking into is the direction of blood flow in and around the heart and how the blood travels through the body and then back to the heart. This is something I am getting a better understanding of but it will still take more looking into." Participant 2

Collaborating conceptions of knowledge is described as the state where learning details promotes and sustains the understanding of the whole. This can include alternating between studying parts/ details and wholes while studying.

"When thinking about the body and all the processes that occur it blows my mind how many "little" things have to happen in order to see the "bigger" things occur. (to me the little things would be the neurons firing to create the action potential and the bigger things would be a muscle moving or an organ performing the proper function)" Participant 1

Appendix B Alignment of Frameworks

When comparing the codes assigned from each framework, there was not a clear-cut overlap. A Sankey diagram was prepared to visualize this information (see Figure 2.4). The quotes included are presented as typed by the participants.

Quotes for Matched Codes

Sifting and Note-taking

"I also find it helpful when the study guides have a more generalized topic on then and then i can fill it out with more detail." Participant 2

Sifting and Specimens

"I used models and diagrams provided by the professor to learn specific parts of the brain and where they are located" Participant 1

Sifting and Memorizing

"What i found most helpful in order to memorize all of this information was just repetitiveness" Participant 2

Sifting and Discussion

"When i learned the muscles and the bones i found that it was easier to have someone with you and hear them say the different parts to you. I am going to try and go in with a partner tomorrow (friday) and this weekend to see if that will make it easier comprehend the information." Participant 2

Sifting and Time on Task

"This week in order to study the information learned in class i looked up videos that specifically helped to explain how blood flows through the heart." Participant 2

Sifting and Attendance

"I didn't use any strategy outside of the lecture" Participant 1

Sifting and Hard Work

"In the moment it isn't difficult, but trying to retain it has proven not easy." Participant 1

Building and Discussion

"However after going over them a few times with a partner I felt much better" Participant 2

Building and Time on Task

"The next major question i am looking into is when an antigen enters the body, looking at how the lymphocytes work together to form antibodies and use memory T cells to fight against the antigen as a whole. I am good at the individual portions but putting it all together is something i am still working on. " Participant 2

Building and Visualizing

"It became more difficult when you had to switch between different equations like pascal's law and then on to laplace's law. I'm a very visual person so i don't know if instead of thinking about it in equations if i would have visually processed and thought about what was happening to the blood pressure if that would have helped me understand what was happening." Participant 2

Building and Understanding

"During class i also noticed that the processes that occur in the body generally are similar to some degree." Participant 2

Holding and Note-taking

"Since the test is next week tuesday i started reviewing by filling in the study notes that were provided by Dr. Sinnamon." Participant 2

Holding and Time on Task

"With the action, insertion, and origins I had them on quizlet and went over them again and again specifically using the write and learn programs. I used the learn program a couple times first before moving on to write but after studying them for a couple hours over three nights I felt very confident on them." Participant 2

Holding and Memorizing

"I find that when im learning new things i like to have bright colors to help me learn it. When im writing flash cards or writing on a whiteboard i like to use bright pens and markers so when i am taking the test i try and think back to the color that i wrote it down with." Participant 2

Holding and Drawing

"To help me prepare for the first test in Anatomy I tried to draw out as much of the processes I could." Participant 2

Holding and Time on Task

"I also looked at the diagrams that show how the blood is moving through the body and tried to recreate them as well." Participant 2

Holding and Visualizing

"With the content we learned in class on tuesday, neurotransmitters and the synaptic cleft, I would tell them to find diagrams and drawing of these things and recreate them. Drawing the different diagrams and pictures

really helps me understand things better. This way I can trace the specific pathway the protein or molecule follows and not just read what is going on." Participant 2

Holding and Discussion

"I also find it helpful to review with someone else when we communicate back and forth and have more of a dialogue about the topics i feel like I hold in the information better than when i study by myself." Participant 2

Holding and Specimen

"Specifically i looked back on the different diagrams of the different white blood cells and then recreated them on my own in order to fully understand the difference for them. Participant 2

Holding and Constant Revision

"I have found in the last couple months that studying and color coding things have really helped me. I have started going to the library and writing on the whiteboard in there with different colored dry erase markers. I like being able to see most of the topics in front of me at once and I feel like the color coding of the information helps separate the information so its in 'smaller' groups to memorize." Participant 2

Moving and Drawing

"When talking about ECGs I drew a lot of ECGs and then talked through what was wrong with them and why, i found that the repetitiveness of this

approach helped me really understand what was going on in the ECG." Participant 2

Moving and Time on Task

"I also studied with peers, we made up questions involving the material and tested each other" Participant 1

Moving and Visualizing

"Going into the weekend i had a lot of things that i wanted to keep straight. In order to achieve this i found it the most helpful to write and draw everything out on one page that i was mixing up. That way i could visually see the different concepts that i was confusing with each other all at once." Participant 2

Moving and Discussion

"I also discuss the notes with my peers and made up questions to ask each other." Participant 1

Moving and Understanding

"The reason I did not think action potentials were very difficult this week either I think was because we had already talked about action potentials in muscle cells and this was mainly a review for the nerve cells." Participant 1

Moving and Specimen

"I grouped all the muscles by their region, head, trunk, legs, and arms. Then when I went up to the lab to look at the models of the arms and legs I thought I was fairly prepared however I struggled finding the muscles in the models at first." Participant 2

Moving and Memorizing

"After a lot of repetition and drawing and writing out on a whiteboard many different times in different colors i feel more confident in these areas and are not confusing them as easily." Participant 2

Moving and Note-taking

"As i went through the lab book when I looked at the muscles I would write the name down five times. I think this helps me because I write each different muscle group on a different color of paper." Participant 2

Moving and Interest

"I have always thought this is one of the more interesting things while studying anatomy and physiology of a human. There is a human body in front of us then there are all these little checks and balances going on underneath the skin that most people genuinely don't know about. These chemicals and hormones that regulate the blood pressure of a human start in one area of the body, typically the brain or a specific gland and then will travel around the body to the specific spot they need to go to. These spots can either be the heart or a specific blood vessel in a specific part of the body. I just think its crazy how many processes are going on throughout the body to make the what we see on the outside possible." Participant 2

Appendix C Anatomy & Physiology Student Questions Survey including R-SPQ-2F

INSTRUCTIONS: This questionnaire has a number of questions about your attitudes towards your studies and your usual way of studying.

There is not a *right* way of studying. It depends on what suits you own style and the course you are studying. It is accordingly important that you answer each questions as honestly as you can. If you think you answers to a question would depnd on the subject being stuied, give the answer that would apply to your current anatomy & physiology course (Biol 2220 or Biol 3150).

Please choose the *one* most appropriate response to each question. Do not spend a long time on each item: your first reaction is probably the best one. Please answer each item.

Do not worry about projecting a good image. Your answers are CONFIDENTIAL. Thank you for your cooperation.

1. I find that at times studying gives me a feeling of deep personal satisfaction.
2. I find that I have to do enough work on a topic so that I can form my own conclusions before I am satisfied.
3. My aim is to pass the course while doing as little work as possible.
4. I only study seriously what's given out in class or in the course outlines.
5. I feel that virtually any topic can be highly interesting once I get into it.

6. I find most new topics interesting and often spend extra time trying to obtain more information about them.

7. I do not find my course very interesting so I keep my work to the minimum.

8. I learn some things by rote, going over and over them until I know them by heart even if I do not understand them.

9. I find that studying academic topics can at times be as exciting as a good novel or movie.

10. I test myself on important topics until I understand them completely.

11. I find I can get by in most assessments by memorizing key sections rather than trying to understand them.

12. I generally restrict my study to what is specifically set as I think it is unnecessary to do anything extra.

13. I work hard at my studies because I find the material interesting.

14. I spend a lot of my free time finding out more about interesting topics which have been discussed in different classes.

15. I find it is not helpful to study topics in depth. It confuses and wastes time, when all you need is a passing acquaintance with topics.

16. I believe that instructors shouldn't expect students to spend significant amounts of time studying material everyone knows won't be examined.

17. I come to most classes with questions in mind that I want answered.

18. I make a point of looking at most of the suggested readings that go with the lectures.

19. I see no point in learning material which not likely to be in the examination.

20. I find the best way to pass examinations is to try to remember answers to likely questions.

Responses are on a Likert-type scale, as follows:

A this item is never or only rarely true of me

B this item is sometimes true of me

C this item is only true of my about half the time

D this item is frequently true of me

E this item is always or almost always true of me

Additional Questions

- Your Name:
- Your School Email Address:
- What is your major?
- Which Anatomy & Physiology class are you enrolled in this semester?

  Human Anatomy - Biol 3150 with Dr. McNutt Scott

  Anatomy & Physiology I - Biol 2220 with Prof. Cummings)

- Do you plan to enroll in the second semester of this course (Biol 2230 or Biol 3160) in Spring 2019?

  Yes - the second semester course is required for graduation in my major.

  Yes - the second semester course is a required pre-requisite for the graduate/ professional school I wish to attend.

  Yes - I'm planning to take the second semester course even though I am not required to do so.

  No - I have already taken Biol 2230 or Biol 3160

  No - I do not need to take the second semester course

  Unsure

- Do you have friends in this course that you plan to study with?

  Yes *Open ended question asking to list the names of friends*

  No

- You consent to use of the answers/ responses from "Anatomy & Physiology Student Questions" in the Cognitive Processes and Pathways in Physiology study. You understand that the responses will be analyzed and you may be invited to participate in interviews and weekly sharing of your thoughts about learning. You understand that you may decline to participate in this study at any time and that your answers and identity will be kept confidential by the research team.

  Yes

  No

SCORING INSTRUCTIONS The responses to items are scored as follows: A=1, B=2, C=3, D=4, E=5

To obtain main scale scores add item scores as follows:

- DA = 1 + 2 + 5 + 6 + 9 + 10 + 13 + 14 + 17 + 18
- SA = 3 + 4 + 7 + 8 + 11 + 12 + 15 + 16 + 19 + 20

Appendix D Homeostasis Concept Inventory [McFarland et al., 2017]

Correct answers are presented in bold text in the Appendix but were not visually distinguishable on the version administered to students.

Please select the best answer for each of the following multiple-choice questions.

1. In organisms, like humans, homeostatic negative feedback mechanisms result in:

   a an unfavorable, or damaging effect on the body.

   b a constant decrease in the regulated variable.

   c equilibrium among body cells and fluids.

   d maintenance of an internal variable within a 'normal' range of values.

   A new species of deer is found in North America. Researchers establish that the concentration of X in the blood is maintained at a relatively constant level over time, even when the animal's external or internal environment changes.

2. Some disturbance causes the concentration of X to increase. What change will occur in the activity of the sensor that detects X? The sensory receptor will:

   a increase its firing rate from zero to the maximum possible firing rate.

   b fire at a new rate proportional to the magnitude of X.

   c not change its firing rate.

3. When any disturbance causes the value of X to decrease there will be a physiological response that causes X to:

a **increase back towards its normal value.**

b decrease still further.

c stay constant at its new value.

4. A homeostatic control mechanism functions to maintain the concentration of X at a relatively constant level. This mechanism is functioning:

a when the concentration of X gets too high.

b when the concentration of X gets too low.

c when the concentration of X gets too high or too low.

d at all concentrations of X.

5. The body has a sensor that detects blood pressure, but does not have a sensor that detects heart rate. Which of the following remains relatively constant when the internal or external environment changes?

a heart rate

b blood pressure

c both

d neither

6. Normal body temperature of a healthy adult is about 37 degrees C. A fever occurs when the temperature set-point is elevated. Jasmine feels cold as she develops a feveer because her body temperature at the time is:

a less than 37 degrees C.

b increasing above 37 degrees C.

c less than the new set point temperature.

7. A homeostatic mechanism in the human body has a control center, also called an integrator, that is part of which organ system or systems?

   a the endocrine system

   b the nervous system

   c the endocrine system, the nervous system, or both.

8. Plasma calcium concentration is maintained relatively constant even when calcium intake increases. Based on this information, one can conclude that:

   a plasma calcium must be needed for the normal function of many cells.

   b the plasma calcium concentration must be controlled by the nervous system.

   c there must be a mechanism to detect the concentration of calcium in the plasma.

9. Baroreceptors detect blood pressure. Blood pressure is maintained relatively constant even when the internal or external environment changes. Under what conditions do the baroreceptors send signals to the brain?

   a when blood pressure is not at its normal value

   b when blood pressure is increasing

   c when blood pressure is constant

   d at all levels of blood pressure

10. An animal lives in a habitat where oxygen levels in the environment vary over time as shown below (in Figure 1).

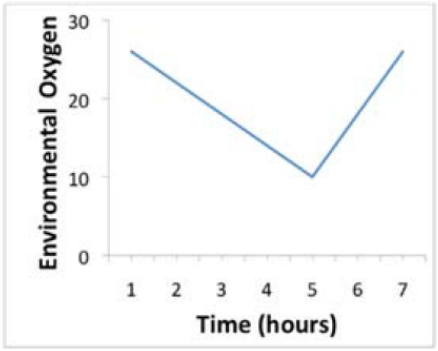

Figure D1: Figure 1 for HCI item 10

If the oxygen level in the blood of the animal is regulated by a homeostatic mechanism, which of the figures correctly shows oxygen levels in the blood of the animal over time? *The correct answer is A.*

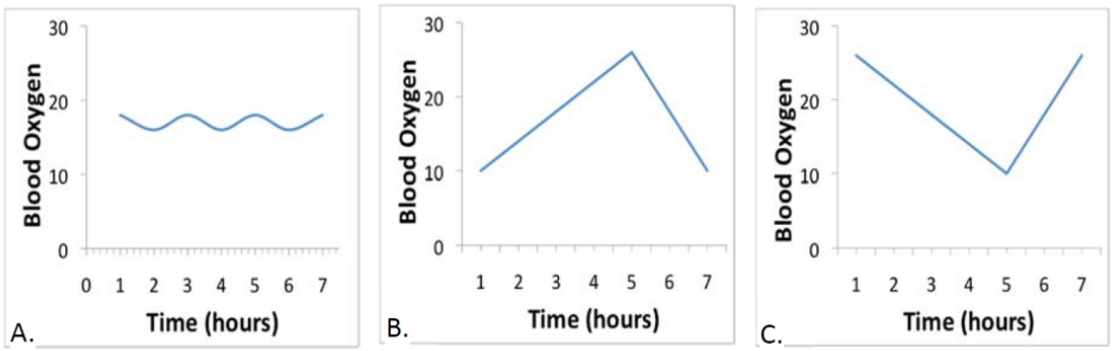

Figure D2: Answer choices for HCI item 10.

11. While watching TV, Sam eats 6 frosted sugar cookies. As glucose is absorbed from Sam's digestive tract, there is a rise in his blood glucose concentration. Blood glucose is homeostatically maintained. Which of the following will occur FIRST? A change in:

a **activity of the sensors that monitor blood glucose.**

b activity of effectors that lower blood glucose.

c release of hormones that change blood glucose.

12. Dora walks home on a freezing winter night and starts to shiver. What determines how much she will shiver?

a her body temperature

b the outside air temperature

c her set point temperature

d the difference between the set point temperature and her body temperature

e the difference between outside air temperature and her body temperature

13. Homeostatic systems require a sensor, a control center, also called an integrator, and an effector. The role of the effector is to directly change the:

a **value of the homeostatically regulated variable.**

b value of the set point.

c magnitude of the signal from the sensor.

d activity of the control center or integrator.

14. In temperature regulation, the sweat gland is an effector that most directly causes a change in:

a **body temperature.**

b the body's temperature set point.

c signals from the sensory receptors in the skin.

d the temperature control center, also called an integrator, in the brain.

15. Blood pressure is maintained relatively constant even when the internal or external environment changes. Effectors are parts of the body that receive signals from a control center. Which of the following is an effector in the system that maintains blood pressure?

a blood volume

b sensory receptors for blood pressure

c cardiac muscle

d the resistance that must be overcome for blood to flow

16. The control center, also called an integrator, receives signals from the sensors that are part of the mechanism and a set-point signal. Which of the following represents how the control center processes these two signals?

a **(set-point signal) −(sensor signal)**

b (set-point signal) + (sensor signal)

c (set-point signal) × (sensor signal)

d (set-point signal) ÷ (sensor signal)

17. Baroreceptors sense blood pressure. The baroreceptor nerves are cut so the signal from the baroreceptors is unable to reach the cardiovascular control center. After cutting the nerves, blood pressure will:

a remain constant.

b decrease.

c increase.

d become equal to the set-point.

18. Information from sensory receptors in homeostatic systems:

    a determines the set point.

    b is sent to effectors.

    c is sent to control centers, also called integrators.

    d stays in the receptor until the regulated variable changes back to normal.

19. In a homeostatic system the control center, also called an integrator, receives sensory information from receptors and:

    a determines what the body wants.

    b determines the set-point.

    c processes the information and controls the behavior of the effector.

    d transmits the sensory information unchanged to the effector.

    e controls the activity of the sensory receptors.

20. Samira is watching a movie and eats 3 chocolate bars. As Samira's digestive tract absorbs the sugar, there is an initial increase in her blood glucose. When are blood glucose sensors signaling?

    a before eating

    b during eating

    c while eating and digesting the chocolate bars

    d all the time

Appendix E Prompts for Instructor Interview 1

Footnotes provide information about each prompt's connection to the theoretical framework.

1. Describe a typical class meeting for lecture. (Probe for details and depth.)[1],[2]
2. Describe a typical class meeting for lab. (Probe for details and depth.)[3],[4]
3. (Have course objectives printed on index cards.) Rank your course objectives in order of importance. (Probe for details in a think-aloud method.)[5]
4. What roles do lecture and lab each play in student learning for this course?[6],[7],[8]
5. Are there aspects of the course that you would like to change?[9],[10]
6. Are there any aspects of the course that are set by university or departmental policies that you wish you could change?[11]
7. Request previous exams, quizzes, or other assessments.

[1]Teaching Context: Climate/ Ethos
[2]Teaching Context: Teaching
[3]Teaching Context: Climate/ Ethos
[4]Teaching Context: Teaching
[5]Teaching Context: Objectives
[6]Teaching Context: Objectives
[7]Teaching Context: Assessments
[8]Teaching Context: Teaching
[9]Teaching Context: Teaching
[10]Teaching Context: Institutional Procedures
[11]Teaching Context: Institutional Procedures

Appendix F Prompts for Student Interviews

Table F1: Complete Interview Protocol for Interview 1.

Prompt	Reasoning for Question with Theoretical Framework Connection
1. Describe your A&P class? What do you think about the assignments? Grading procedure? Teaching style?	Interaction of Student Factors: Preferred approaches to learning and Teaching Context: Climate/ Ethos, Teaching Context: Institutional procedures
2. How is this different from your previous biology physiology courses?	Interaction of Student Factors: Preferred approaches to learning and Teaching Context: Climate/ Ethos, Teaching Context: Institutional procedures, Student Factors: Preferred approaches to learning
3. How do you define "learning?" "memorizing?" "studying?" "understanding?"	Student Factors: Preferred approaches to learning
4. How would you rank these (cards labeled "learning", "studying", "memorizing", "understanding") in terms of your personal preference? For this A&P course?	Student Factors: Preferred approaches to learning, Outcomes: Contextual approaches to learning
5. What do you think is the best approach to learning in this A&P class? (Variable based on response to Q4. Use terms 1 and 2.)	Learning Activities: Ongoing approaches to learning
6. What do you hope to gain from this course?	Outcomes: Qualitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
7. (Provide copy of course learning objectives.) How do you think these learning objectives will help you meet your personal goals?	Student Factors: Prior knowledge, Student Factors: Ability, Interaction of Student Factors: Preferred approaches to learning and Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning

Table F2: Complete Interview Protocol for Interview 2.

Prompt	Reasoning for Question with Theoretical Framework Connection
ANGIE	
1. In the first interview in September, you mentioned that lecture and lab were very different, and then discussed how the timing doesn't align well in your diaries. Can you me more about that/ can you give me an example? What has happened that you didn't expect? What hasn't happened that you did expect?	Interview 1: lines 8-12, Diary response 10/29; Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. You said in interview 1 that you didn't want to just memorize but also talked about not having enough time. How have you approached (reconciled the conflict, etc.) the material as the semester has continued? (line 180-190)	Interview 1: line 180-190; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning

3. In your diaries, you mentioned that you don't plan to use Chegg anymore as a study tool. Can you tell me more about this - give a play-by-play about what this looked like for you when you were using it?	Diary response 10/15; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. You also mentioned that you were going to [Instructor 1]'s office hours and talked about preparing for that. Can you tell me more about how you prepare for your visit's with [Instructor 1]? Why do you choose this approach? (Probe for other approaches - hand-written note cards, out loud processing, Quizlet).	Diary responses 9/24, 10/15; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. Do you feel like the above methods have been effective? How do you know this has been effective or that it is working?	Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
6. You have indicated the following positive or negative outcomes "Win" - understanding all parts of the vertebrae while working in lab; "Loss" - didn't do as well on 2nd lecture exam as hoped. Can you tell me more about each of these? (Probe more on "understanding" and what it means - source, timing, evaluation, etc.) How did your preparation for exam 2 compare with your normal practices when preparing for this class and its assignments/ assessments?	Diary responses 10/8, 10/15; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
7. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? Can you tell me about how you have used these activities within the course?	Learning Activities: Pathways to learning
8. Describe your approach on your lecture quizzes. How do you use the 3 attempts on this assignment. Has this changed as the semester progressed?	Interview 1: line 44; Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
9. How has your approach to this course changed over the semester?	Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning, Outcomes: Qualitative: structure, transfer
10. During our first interview, you told me you were really interested in understanding of how the human body worked to help you in your future career (Probe for exact career.). How has this goal impacted your approach to the class? In what ways has this course helped with that goal? Do you feel like this goal has been met? Why? How?	Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning

11a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 11b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 11c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 11d. Are there additional links between the themes, words, or ideas? 11e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more...	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
12. Overall, how do you think this Anatomy course is going?	3P Model
MICHELLE	
1. In the first interview in September you mentioned that lecture and lab were very different and also re-stated this in a recent diary entry. Can you tell me more about that/ can you give me an example? What has happened in lecture that you expected in lab but didn't?	Interview 1: line 15-20, Diary response 10/29; Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. In your diaries, you have mentioned that you review your notes after class. Can you tell me more about this? Give a play-by-play about what this looks like for you? Why do you choose this approach? (Probe for other approaches - re-watching lectures and add to notes, re-write PPTs, attend office hours, Google items were mentioned).	Diary response 9/24, 10/1; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. Do you feel like the above methods have been effective? How do you know this has been effective or that it is working?	Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
4. You have indicated the following positive or negative outcomes. "Win" - A on 2nd exam; "Loss" - previous week "Hard to keep up". Can you tell me more about these? How did your preparation for exam 2 compare with your normal practices when preparing for this class and its assignments/ assessments?	Diary response 10/8; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? Can you tell me about how you have used these activities within the course?	Learning Activities: Pathways to learning
6. Describe your approach on your lecture quizzes. How do you use the 3 attempts on this assignment. Has this changed as the semester progressed?	Angie Interview 1: line 44; Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
7. You mentioned in our first interview that you ask yourself practice questions about the material as you try and understand. How do you know what questions to ask yourself? How do you determine if your answers to the questions are correct? You mentioned that you did not have a good source of questions for practice, as well. How have you compensated for this as the semester has progressed?	Interview 1: lines 189-192 & 211-213; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning

8. How has your approach to this course changed over the semester?	Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning, Outcomes: Qualitative: structure, transfer
9. During our first interview, you told me you hoped to build a base of knowledge to help you when you get to medical school. How has this goal impacted your approach to the class? In what ways has this course helped with that goal? Do you feel like this goal has been met? Why? How?	Interview 1: line 239-242, 246; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
10a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 10b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 10c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 10d. Are there additional links between the themes, words, or ideas? 10e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more...	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
11. Overall, how do you think this Anatomy course is going?	3P Model
TIGERS123	
1. When did you start thinking about changing your major? Was there a specific event, etc? (Get play-by-play of going from thoughts to decision to carrying out.) When did you make the change in your major and schedule (date)? What is your new major and how did you come to that new direction?	Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
2. You uploaded several documents into our shared folder. Can you tell me how you used these documents within your work in the class?	Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. You mentioned in our first interview that you planned to type in [Instructor 2]'s PowerPoint. How did that change work for you?	Interview 1: line 25-26; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? Can you tell me about how you have used these activities within the course?	Learning Activities: Pathways to learning
5. You mentioned in the first interview that you were changing your study methods following the first exam. Can you describe what methods or activities you used during for the 1st test? What changes did you make as you moved into preparing for second round of test/ practical?	Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning, Outcomes: Qualitative: structure, transfer

6. In the first interview in September you mentioned that you don't like computers but that the homework for the class is online. How did you address this as the semester as progressed?	Interview 1: line 302 & 75; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning, Outcomes: Qualitative: structure, transfer
7. In the first interview, you ranked these terms as (use order) for success in this class. Based on class experience, would you change the order of these in terms of importance for success in the class? (Probe to understand how this may have impacted her decision to leave the class/ major. Make sure she is ranking in order of importance for success in the class, not as a process).	Student Factors: Preferred approaches to learning, Outcomes: Contextual approaches to learning
8. If you could re-start this semester, what changes would you make to your study plan or approach for this class? Do you think this new plan would have made a difference of whether you would still be in the class/ major?	Teaching Context: Assessments, Teaching Context: Climate/ Ethos, Teaching Context: Teaching interacting with Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
9. Is there anything else you think we should know about your experiences in this class?	3P Model
10. Is there anything else you think we should know about your reasons for changing major?	3P Model
CAITLYN	
1. In your diaries, you have mentioned that you "use repetition" to study for exams. Can you tell me more about this - give a play-by-play about what this looks like for you? Why do you choose this approach? (Probe for other approaches - re-write notes, looking at textbook, discussing as a group and drawing).	Diary response 10/1; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. Can you tell me more about how you used your lab material to prepare for the second lecture exam? How did your preparation for exam 2 compare with your normal practices when preparing for this class and its assignments/ assessment?	Diary response 10/1, 10/22; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. Do you feel like the above methods have been effective? How do you know this has been effective or that it is working?	Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
4. What would you describe as your biggest "Win" of the semester? What has been your biggest "Loss" of the semester? Can you tell me more about this?	Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? Can you tell me about how you have used these activities within the course?	Learning Activities: Pathways to learning
6. Describe your approach on your lecture quizzes. How do you use the 3 attempts on this assignment. Has this changed as the semester progressed?	Angie Interview 1: line 44; Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer

7. How has your approach to this course changed over the semester?	Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning, Outcomes: Qualitative: structure, transfer
8. During our first interview, you told me that you felt like Anatomy was crucial since you intended to enter the medical field as a PA. How has this goal impacted your approach to the class? In what ways has this course helped with that goal? Do you feel like this goal has been met? Why? How?	Interview 1: line 307, 309; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
9a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 9b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 9c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 9d. Are there additional links between the themes, words, or ideas? 9e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more...	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
10. Overall, how do you think this Anatomy course is going?	3P Model
K DIDDY	
1. In the first interview in September you mentioned that lecture and lab were very different and also re-stated this in a recent diary entry. Can you tell me more about that/ can you give me an example? What has happened in lecture that you expected in lab but didn't?	Interview 1: line 83-85; Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. In our first interview, you mentioned that all of the assignments at that point were good for "reinforcing the information. And none of it's... busywork." How do you currently view the assignments in the class? (Probe for any new types of assignments, etc.) What is your approach to "busywork" assignments? How is this different than the approach you take to the assignments in this class?	Interview 1: line 29-30; Teaching Context: Assessments interacting with Learning Activities: Ongoing approaches to learning
3. In your diaries, you have mentioned that you have been taking notes in class and spending more time analyzing the visual aids in the PowerPoints. Can you tell me more about this - give a play-by-play about what this looks like for you? Why do you choose this approach? (Probe for other approaches - focusing more in class, flashcards, Quizlet made by a classmate).	Diary response 10/8; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. Do you feel like the above methods have been effective? How do you know this has been effective or that it is working?	Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning

5. You have indicated the following positive or negative outcomes. "Win" - felt better about 2nd lab practical; "Loss" - grade on exam 2 Can you tell me more about these? You mentioned that you made a PowerPoint to quiz yourself for the lab practical. Can you describe how you made this? (Probe for source of questions, how she used it to prepare). You also mentioned that you "2nd guessed yourself" on the 2nd lecture exam - can you tell me more about this/ give an example? How did your preparation for exam 2 compare with your normal practices when preparing for this class and its assignments/ assessments?	Diary response 10/8, 10/15; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
6. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? Can you tell me about how you have used these activities within the course?	Learning Activities: Pathways to learning
7. You described your approach on your lecture quizzes during your first interview. What is your current approach to the quizzes?	Interview 1: line 50-65; Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
8. How has your approach to this course changed over the semester?	Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning, Outcomes: Qualitative: structure, transfer
9. During our first interview, you told me you were really interested in gaining an understanding of how the human body worked to help you in your future career of nursing. How has this goal impacted your approach to the class? In what ways has this course helped with that goal? Do you feel like this goal has been met? Why? How?	Interview 1: line 304-310; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
10a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 10b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 10c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 10d. Are there additional links between the themes, words, or ideas? 10e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more...	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
11. Overall, how do you think this Anatomy course is going?	3P Model
KATE	

1. In the first interview in September you mentioned that lecture and lab were very different and also re-stated this in a recent diary entry. Can you tell me more about that/ can you give me an example? What has happened in lecture that you expected in lab but didn't?	Interview 1: line 29-31; Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. The first time we talked, you mentioned that there were 'stories from lecture on the test that you were not aware of.' Can you give me an example of this from exam 1, if you remember? Have these types of questions appeared on the tests you have taken since then? How have you adjusted your approach to the class to account for these questions?	Interview 1: line 15-16; Teaching Context: Assessments interacting with Learning Activities: Ongoing approaches to learning
3. In your diaries, you have mentioned that you have used Quizlet and YouTube. Can you tell me more about this - give a play-by-play about what this looks like for you? Why do you choose this approach? (Probe for other approaches - making outlines (process described in interview 1), making note cards).	Diary response 9/24; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. Do you feel like the above methods have been effective? How do you know this has been effective or that it is working?	Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
5. You have indicated the following positive or negative outcomes. "Win" - 90 on 2nd exam; "Loss" - struggle with muscle attachments. Can you tell me more about these? How did your preparation for exam 2 compare with your normal practices when preparing for this class and its assignments/ assessments?	Diary response 10/8, 10/15; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
6. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? Can you tell me about how you have used these activities within the course?	Learning Activities: Pathways to learning
7. You mentioned in your diary that you usually complete the quizzes the night before an exam. Describe your approach on your lecture quizzes. How do you use the 3 attempts on this assignment? Has this changed as the semester progressed?	Angie Interview 1: line 44, Diary response 10/29; Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
8. How has your approach to this course changed over the semester?	Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning, Outcomes: Qualitative: structure, transfer
9. During our first interview, you told me you wanted to understand everything about the human body to help you as a physical therapist. How has this goal impacted your approach to the class? In what ways has this course helped with that goal? Do you feel like this goal has been met? Why? How?	Interview 1: line 270-273; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning

10a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 10b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 10c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 10d. Are there additional links between the themes, words, or ideas? 10e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more...	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
11. Overall, how do you think this Anatomy course is going?	3P Model
LONDON	
1. You've mentioned in your interview and in diary entries that you have struggled with the "all of the above" or "none of the above" questions on the lecture exam. How has your approach to exams changed to compensate for this challenge?	Interview 1; Teaching Context: Assessments interacting with Learning Activities: Ongoing approaches to learning
2. In your diaries, you have mentioned that using Quizlet has been a better strategy that re-writing your notes after class but then for exam 3, you seemed to use a more similar approach to the start of the semester. Can you tell me more about this - give a play-by-play about what this looks like for you? Why do you choose this approach? (Probe for other approaches - re-watching lectures + add to notes, re-write PPTs, attend office hours, using textbook).	Diary responses 9/24, 10/1, 10/8, 10/22; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. Do you feel like the above methods have been effective? How do you know this has been effective or that it is working?	Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
4. What would you describe as your biggest "Win" of the semester? "Loss" or disappointment in Exam 2? Can you tell me more about these?	Diary response 10/15; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? Can you tell me about how you have used these activities within the course?	Learning Activities: Pathways to learning
6. Describe your approach on your lecture quizzes. How do you use the 3 attempts on this assignment? Has this changed as the semester progressed?	Angie Interview 1: line 44; Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
7. How has your approach to this course changed over the semester?	Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning, Outcomes: Qualitative: structure, transfer

8. During our first interview, you told me you hoped to build a base of knowledge and that you were taking this class because you were interested in the topic. How has this goal impacted your approach to the class? In what ways has this course helped with that goal? Do you feel like this goal has been met? Why? How?	Interview 1; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
9a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 9b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 9c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 9d. Are there additional links between the themes, words, or ideas? 9e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more...	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
10. Overall, how do you think this Anatomy course is going?	3P Model
SHAY	
1. In your diaries, you have mentioned that you have been using Quizlet to study. Can you tell me more about this - give a play-by-play about what this looks like for you? Why do you choose this approach? (Probe for other approaches - write steps of processes, attend PAL, fill in lecture objectives - probe to understand this).	Interview 1: line 108, Diary responses 10/1, 10/8, 10/22, 11/5; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. Do you feel like the above methods have been effective? How do you know this has been effective or that it is working?	Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
3. "Win" - A on 2nd exam; "Loss" - difficulty with processes. Can you tell me more about this (ask each separately)?	Diary response 10/8; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? Can you tell me about how you have used these activities within the course?	Learning Activities: Pathways to learning
5. Explain the structure of Mastering homework assignments. Can you update answers? How frequently are these assigned? How do you approach this assignment?	Teaching Context: Assessments, Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
6. How has your approach to this course changed over the semester?	Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning, Outcomes: Qualitative: structure, transfer

7. During our first interview, you told me you hoped to prepare for the PCAT and learn what you needed for Pharmacy School. How has this goal impacted your approach to the class? In what ways has this course helped with that goal? Do you feel like this goal has been met? Why? How?	Interview 1: line 362, 364-367; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
8a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 8b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 8c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 8d. Are there additional links between the themes, words, or ideas? 8e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more...	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
11. Overall, how do you think this A&P course is going?	3P Model
WALT OWENS	
1. In our first interview, you mentioned that your study habits could be attributed to laziness. Can you tell me more about why you describe your approach this way?	Interview 1: line 174; Student Factors: Ability, Student Factors: Preferred approaches to learning, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. In your diaries, you have mentioned that you have been using reviewing your notes to study. Can you tell me more about this - give a play-by-play about what this looks like for you? Why do you choose this approach? (Probe for other approaches - attend PAL, PAL worksheets, lecture objectives).	Interview 1: line 108, Diary responses 10/8, 10/15; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. Do you feel like the above methods have been effective? How do you know this has been effective or that it is working?	Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
4. "Win" - 88 on 2nd exam; "Loss"- difficulty with processes of bone formation. Can you tell me more about this (ask each separately)?	Diary response 10/8, 10/15; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? Can you tell me about how you have used these activities within the course?	Learning Activities: Pathways to learning

6. Explain the structure of Mastering homework assignments. Can you update answers? How frequently are these assigned? How do you approach this assignment?	Teaching Context: Assessments, Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
7. How has your approach to this course changed over the semester?	Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning, Outcomes: Qualitative: structure, transfer
8. During our first interview, you told me you hoped to get a good grade and understand better how the human body worked. How has this goal impacted your approach to the class? In what ways has this course helped with that goal? Do you feel like this goal has been met? Why? How?	Interview 1: line 268-279; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
9a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 9b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 9c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 9d. Are there additional links between the themes, words, or ideas? 9e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more...	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
11. Overall, how do you think this A&P course is going?	3P Model
WATERSKIER	
1. In interview 1, you mentioned you were considering buying the textbook. Have you done that? (If yes) How has having the textbook changed your approach to the class? (If no) What have you done to compensate for not having the textbook?	Interview 1: line 93-96; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. In your diaries, you have mentioned that you have been using reviewing your notes to study. Can you tell me more about this - give a play-by-play about what this looks like for you? Why do you choose this approach? (Probe for other approaches - attend PAL, PAL worksheets (Sets of sheets mentioned. Are there multiple ones - how does this work?), lecture objectives, notecards, go through assignments, annotate notes on lecture objectives, coloring workbook)	Diary responses 10/1, 10/8, 11/5; Teaching Context: Institutional procedures, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. Do you feel like the above methods have been effective? How do you know this has been effective or that it is working?	Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
4. What would you describe as your biggest "Win" of the semester? What has been your biggest "Loss" of the semester? Can you tell me more about this? Additional Follow-Ups... ; "Loss" - not enough time to prepare for exam 2. Can you tell me more about this (ask each separately)?	Diary response 10/15; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning

5. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? Can you tell me about how you have used these activities within the course?	Learning Activities: Pathways to learning
6. Explain the structure of Mastering homework assignments. Can you update answers? How frequently are these assigned? How do you approach this assignment?	e, Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
7. How has your approach to this course changed over the semester?	Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning, Outcomes: Qualitative: structure, transfer
8. During our first interview, you told me you planned to declare Nutrition as a major and hoped to gain a better understanding of how the human body worked. How has this goal impacted your approach to the class? In what ways has this course helped with that goal? Do you feel like this goal has been met? Why? How?	Interview 1: line 253, 255-258; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
9a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 9b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 9c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 9d. Are there additional links between the themes, words, or ideas? 9e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more...	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
11. Overall, how do you think this A&P course is going?	3P Model

Table F3: Complete Interview Protocols for Interview 3.

Prompt	**Reasoning for Question with Theoretical Framework Connection**
ANGIE	
1. In your diaries this semester, I've noticed that you use re-writing your notes by hand and drawing a lot during your study time . Why do you choose that approach? Can you describe a time this has worked well this semester?	Semester 2 Diary responses, line 90-91, 110-112, 132-135; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning

2. How have your habits changed since semester 1? Are you using the same pattern and tools?	line 116-121, Interview 2; line 8, 88-90, 108-112; Semester 2 Diary, Teaching Context: Institutional procedures, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. In our last interview you mentioned that you spend a lot of time on this class, Could you explain more about that? How does this compare to your other classes? (Follow ups - how is this distributed (days, times)? Get to quantification eventually.)	Interview 2, line 102-105; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. You have indicated a change in how you see lecture and lab fitting together. Can you tell me more about this?	line 10-20, Interview 1; line 39-52, Semester 2 Diary; Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. Last time we talked, you expressed frustration about lack of structure to the course. (Researcher Note: Her only example is changing topics quickly (ie - finishing 1 system and starting a different system in the same period)). How has this changed in the spring semester? How does this impact how you are approaching the class? Interacting with the material?	line 55-74, Interview 2; Teaching Context: Teaching interacting with Learning Activities: Ongoing approaches to learning
6. Do you still have quizzes with 3 attempts? If there is a difference - How has your approach changed from last semester?	Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
7. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? How have you used those activities and would they replace your most or least important?	Learning Activities: Pathways to learning
8. You've mentioned in previous interviews that your goal was to understand how the human body worked to help you in your future career as a pediatrician. Have your goals changed since that time? How well is this course helping you to meet your goals?	Interview 2, line 476-483; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
9. How do you define "learning?" "memorizing?" "studying?" "understanding?"	Student Factors: Preferred approaches to learning, Outcomes: Contextual approaches to learning
10. How would you rank these terms (previous question) in terms of your personal preference? For this class? Compare ranking for class to beginning - Explain the differences between your rankings from September to now.	Learning Activities: Ongoing approaches to learning

11a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 11b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 11c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 11d. Are there additional links between the themes, words, or ideas? 11e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more... 11f. Here is the concept map you created at our last interview. I see some differences - can you talk me through how your thoughts have changed? (Guide student through map differences, asking for clarification and depth.)	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
12. Is there anything else that I haven't asked you about that you think is important for me to know about how you have been learning in these 2 courses?	3P Model
CAITLYN	
1. In your diaries this semester, I've noticed that you use re-watching [Instructor 1]'s lectures during your study time. Is this new for this semester? If Yes - What led to you adding this? If No - Cool, you never mentioned this last semester. Has there been a difference in how you are using them, how frequently you watch, etc? Why do you choose that approach? Can you describe a time this has worked well this semester?	Semester 2 Diary; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. How have your habits changed since semester 1? Are you using the same pattern and tools?	line 397-401, Interview 2; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. In one of your diary entries, you mentioned that you planned to spend more time on this class. Could you explain more about that? How does this compare to your other classes? (Follow ups - how is this distributed (days, times)? Get to quantification eventually.)	line 5-6, Semester 2 Diary; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. You mentioned earlier that you are a very visual person, how does that impact this course? The lecture portion? The lab portion? Your interactions with other students?	line 295-296, Interview 2; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. You have said in your diary that lab and lecture are connected to each other. Can you tell me more about how these connect to each other? Do you see any differences from this semester to last?	line 109-111, Semester 2 Diary; Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
6. Do you still have quizzes with 3 attempts? If there is a difference - How has your approach changed from last semester?	Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer

7. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? How have you used those activities and would they replace your most or least important?	Learning Activities: Pathways to learning
8. In our first interview, you mentioned that your goal was to gain a better understanding of how the human body worked to move you toward your goal of becoming a PA. Have your goals changed since that time? How well is this course helping you to meet your goals?	line 307, Interview 1; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
9. How do you define "learning?" "memorizing?" "studying?" "understanding?"	Student Factors: Preferred approaches to learning Outcomes: Contextual approaches to learning
10. How would you rank these terms (previous question) in terms of your personal preference? For this class? Compare ranking for class to beginning - Explain the differences between your rankings from September to now.	Learning Activities: Ongoing approaches to learning
11a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 11b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 11c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 11d. Are there additional links between the themes, words, or ideas? 11e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more... 11f. Here is the concept map you created at our last interview (page 2-3 of Map Notebook). I see some differences - can you talk me through how your thoughts have changed? (Guide student through map differences, asking for clarification and depth.)	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
12. Is there anything else that I haven't asked you about that you think is important for me to know about how you have been learning in these 2 courses?	3P Model
K DIDDY	
1. In your diaries this semester, I've noticed that you are making study guides and taking notes while you re-watch the lecture videos during your study time. Why do you choose that approach? Can you describe a time this has worked well this semester?	line 41, 83-85, Semester 2 Diary; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. You have mentioned that you are working with a tutor this semester. What strategies do you use with your tutor? How have your habits changed since semester 1? Are you using the same pattern and tools? Which of these strategies were suggested by your tutor? Which ones do you do WITH your tutor?	Interview 2; line 41, 56, 83-85, Semester 2 Diary; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning

3. In one of your diaries you mentioned that you spend a lot of time on the assignments and studying for this class. Could you explain more about that? How does this compare to your other classes?	line 98-99, Semester 2 Diary; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. You have indicated a change in how you see lecture and lab fitting together during this semester. Can you tell me more about this?	line 121-125, Semester 2 Diary; Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. In our last interview you mentioned that you "go to the Quizlets". Whose Quizlets are you using? How do you decide which ones to use? Have you continued to use this approach this semester?	line 195-198, Interview 2; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
6. You described "busywork" and your approach to it in our last interview. Looking back, are there any parts of this class or assignments that you would now consider "busywork"? If yes - Interesting, in our first interview you said that "none of its (the work of the class) is busywork". Can you tell me what is different or what has changed that now makes you feel this way?	line 94-96, Interview 2; Teaching Context: Assessments interacting with Learning Activities: Ongoing approaches to learning
7. Do you still have quizzes with 3 attempts? If there is a difference - How has your approach changed from last semester?	Teaching Context: Assessments, Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
8. How do you view the role of lecture quizzes in your learning? Are there changes that could be made to make them more effective for your learning?	Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
9. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? How have you used those activities and would they replace your most or least important?	Learning Activities: Pathways to learning
10. In our first interview, you mentioned that your goal was gaining an understanding of how the human body worked to help you in your future career of nursing. Have your goals changed since that time? How well is this course helping you to meet your goals?	line 304-310, Interview 1; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
11. How do you define "learning?" "memorizing?" "studying?" "understanding?"	Student Factors: Preferred approaches to learning, Outcomes: Contextual approaches to learning
12. How would you rank these terms (previous question) in terms of your personal preference? For this class? Compare ranking for class to beginning - Explain the differences between your rankings from September to now.	Learning Activities: Ongoing approaches to learning

13a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 13b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 13c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 13d. Are there additional links between the themes, words, or ideas? 13e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more... 13f. Here is the concept map you created at our last interview (page 10-11 in map notebook). I see some differences - can you talk me through how your thoughts have changed? (Guide student through map differences, asking for clarification and depth.)	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
14. Is there anything else that I haven't asked you about that you think is important for me to know about how you have been learning in these 2 courses?	3P Model
KATE	
1. How have your habits changed since semester 1? Are you using the same pattern and tools?	lines 86-87, 195, 238-246, 249; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. In your diaries this semester, I've noticed that you have used various study tactics during your study time. Why do you choose that approach? Can you describe a time this has worked well this semester? Do you use a different approach for lecture and lab studying? (probe for differences)	line 52-54, 74-79, 94, 135, Semester 2 Diary; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. You described the process of re-watching lectures and creating the outlines as "not efficient and boring" Why do you think its boring? Why do you think it is "not efficient"? What criterion are you using to make that decision? What would need to change so it would not be boring? How are you gauging if a study process is efficient? What criterion are you using to judge the method you will use?	line 177-179, Semester 2 Diary; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. In one of your diaries you mentioned that you spend a lot of time on the assignments and studying for this class. Could you explain more about that? How does this compare to your other classes? (Follow ups - how is this distributed (days, times)? Get to quantification eventually.)	line 26, 75, 95, Semester 2 Diary; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. Now that we are at the end of the semester, how do you see lecture and lab fitting together? Can you tell me more about this?	Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
6. Do you still have quizzes with 3 attempts? If there is a difference - How has your approach changed from last semester?	Teaching Context: Assessments, Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer

7. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? How have you used those activities and would they replace your most or least important?	Learning Activities: Pathways to learning
8. In our first interview, you mentioned that your goal was to understand everything about the human body to help you as a physical therapist. Have your goals changed since that time? How well is this course helping you to meet your goals?	line 270-273, Interview 1; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
9. How do you define "learning?" "memorizing?" "studying?" "understanding?"	Student Factors: Preferred approaches to learning, Outcomes: Contextual approaches to learning
10. How would you rank these terms (previous question) in terms of your personal preference? For this class? Compare ranking for class to beginning - Explain the differences between your rankings from September to now.	Learning Activities: Ongoing approaches to learning
11a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 11b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 11c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 11d. Are there additional links between the themes, words, or ideas? 11e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more... 11f. Here is the concept map you created at our last interview (page 10-11 in map notebook). I see some differences - can you talk me through how your thoughts have changed? (Guide student through map differences, asking for clarification and depth.)	Learning Activities: Pathways to learning, Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer
12. Is there anything else that I haven't asked you about that you think is important for me to know about how you have been learning in these 2 courses?	3P Model
MICHELLE	
1. In your diaries this semester, I've noticed that you are writing notes by hand while you re-watch the lecture videos during your study time. Why do you choose that approach? Can you describe a time this has worked well this semester?	line 5-8, Semester 2 Diary; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning

2. The last time we talked, you said that you expected Physiology to be easier than Anatomy since you did not have to learn her question type and the way she ran the class. Can you tell me more about how this has worked out this semester?	line 431-435, Interview 2; Teaching Context: Objectives, Teaching Context: Assessments, Teaching Context: Climate/ Ethos interacting with Learning Activities: Ongoing approaches to learning
3. How have your habits changed since semester 1? Are you using the same pattern and tools?	lines 5-8, 41-42, 59, Semester 2 Diary; Teaching Context: Institutional procedures, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. In one of your diaries you mentioned that you spend a lot of time on the assignments and studying for this class, Could you explain more about that? How does this compare to your other classes? (probe for day and time distribution)	line 73-77, Semester 2 Diary; Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. Since we are nearing the end of the semester, can you tell me more about how you see the lecture and lab portions of the class fitting together?	Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
6. Do you still have quizzes with 3 attempts? If there is a difference - How has your approach changed from last semester?	Teaching Context: Assessments, Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
7. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? How have you used those activities and would they replace your most or least important?	Learning Activities: Pathways to learning
8. In our first interview, you mentioned that your goal was to build a base of knowledge to help you when you get to medical school. Have your goals changed since that time? How well is this course helping you to meet your goals?	line 239-242, 246, Interview 1; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
9. How do you define "learning?" "memorizing?" "studying?" "understanding?"	Student Factors: Preferred approaches to learning, Outcomes: Contextual approaches to learning
10. How would you rank these terms (previous question) in terms of your personal preference? For this class? Compare ranking for class to beginning - Explain the differences between your rankings from September to now.	Learning Activities: Ongoing approaches to learning

11a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 11b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 11c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 11d. Are there additional links between the themes, words, or ideas? 11e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more... 11f. Here is the concept map you created at our last interview (page 10-11 in map notebook). I see some differences - can you talk me through how your thoughts have changed? (Guide student through map differences, asking for clarification and depth.)	Learning Activities: Pathways to learning
12. Is there anything else that I haven't asked you about that you think is important for me to know about how you have been learning in these 2 courses?	3P Model
SHAY	
1. In your diaries this semester, I've noticed that you are making Quizlets and writing out processes during your study time. Why do you choose that approach? Can you describe a time this has worked well this semester?	line 5-6, 25, Semester 2 Diary; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. How have your habits changed since semester 1? Are you using the same pattern and tools? How are you using the lecture objectives? How have the lecture objectives changed since last semester? Could you explain more about that?	line 5-6, 25-26, Semester 2 Diary, Interview 2; Teaching Context: Institutional procedures, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. In one of your diaries you mentioned how you are spending time on this class. How does this compare to your other classes? (probe for day and time distribution)	Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. Since we are nearing the end of the semester, can you tell me more about how you see the lecture and lab portions of the class fitting together? Have the types of activities changed from fall to spring semester?	Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. Do you still have Mastering homework? Have there been any changes to this assignment since the fall? How has your approach changed from last semester?	Teaching Context: Assessments, Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
6. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? How have you used those activities and would they replace your most or least important?	Learning Activities: Pathways to learning

7. In our first interview, you mentioned that your goal was to prepare for the PCAT and learn what you needed for Pharmacy School. Have your goals changed since that time? How well is this course helping you to meet your goals?	line 362, 364-367, Interview 1; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
8. How do you define "learning?" "memorizing?" "studying?" "understanding?"	Student Factors: Preferred approaches to learning, Outcomes: Contextual approaches to learning
9. How would you rank these terms (previous question) in terms of your personal preference? For this class? Compare ranking for class to beginning - Explain the differences between your rankings from September to now.	Learning Activities: Ongoing approaches to learning
10a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 10b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 10c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 10d. Are there additional links between the themes, words, or ideas? 10e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more... 10f. Here is the concept map you created at our last interview (page 10-11 in map notebook). I see some differences - can you talk me through how your thoughts have changed? (Guide student through map differences, asking for clarification and depth.)	Learning Activities: Pathways to learning
11. Is there anything else that I haven't asked you about that you think is important for me to know about how you have been learning in these 2 courses?	3P Model
WALT OWENS	
1. In your diaries this semester, I've noticed that you are taking notes in class, going to PAL, and filling out the lecture objectives during your study time. Why do you choose that approach? Can you describe a time this has worked well this semester?	line 13, 25, Semester 2 Diary; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. How have your habits changed since semester 1? Are you using the same pattern and tools? How are you using the lecture objectives? How have the lecture objectives changed since last semester?	line 13, Semester 2 Diary, Interview 2; Teaching Context: Institutional procedures, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. Since we are nearing the end of the semester, can you tell me more about how you see the lecture and lab portions of the class fitting together? Have the types of activities changed from fall to spring semester?	Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning

4. The last time we talked you described a "post-lab assignment" as more of an exit assessment. Do you still have assignments to turn in after lab?	line 254-255, 274-276, Interview 2; Teaching Context: Assessments, Learning Activities: Ongoing approaches to learning
5. In one of your diaries, you mentioned that you used the "Lab Notebook" to study for the exam. What is this? Can you tell me more about how you used it to prepare for the exam?	line 88, Semester 2 Diary; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
6. Do you still have Mastering homework? Have there been any changes to this assignment since the fall? How has your approach changed from last semester?	Teaching Context: Assessments, Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
7. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? How have you used those activities and would they replace your most or least important?	Learning Activities: Pathways to learning
8. In our first interview, you mentioned that your goal was to get a good grade and understand better how the human body worked. Have your goals changed since that time? How well is this course helping you to meet your goals?	line 268-279, Interview 1; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
9. How do you define "learning?" "memorizing?" "studying?" "understanding?"	Student Factors: Preferred approaches to learning, Outcomes: Contextual approaches to learning
10. How would you rank these terms (previous question) in terms of your personal preference? For this class? Compare ranking for class to beginning - Explain the differences between your rankings from September to now.	Learning Activities: Ongoing approaches to learning
11a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 11b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 11c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 11d. Are there additional links between the themes, words, or ideas? 11e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more... 11f. Here is the concept map you created at our last interview (page 10-11 in map notebook). I see some differences - can you talk me through how your thoughts have changed? (Guide student through map differences, asking for clarification and depth.)	Learning Activities: Pathways to learning

12. Is there anything else that I haven't asked you about that you think is important for me to know about how you have been learning in these 2 courses?	3P Model
WATERSKIER	
1. In your diaries this semester, I've noticed that you are taking notes in class, going to PAL, and filling out the lecture objectives during your study time. Why do you choose that approach? Can you describe a time this has worked well this semester?	line 13, 25, Semester 2 Diary; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
2. How have your habits changed since semester 1? Are you using the same pattern and tools? How are you using the lecture objectives? How have the lecture objectives changed since last semester?	line 65-67, Interview 2; Teaching Context: Institutional procedures, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
3. In one diary entry, you mentioned that you were "keeping on top" of the material for the class. Can you tell me more about this? What types of things make you feel this way? (probe for specific activities, alignment with the class, etc.)	line 44-45, Semester 2 Diary; Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
4. In one of your diaries you talked about how you are spending time on this class. Could you explain more about that? How does this compare to your other classes? (probe for day and time distribution)	Outcomes: Quantitative: facts, skills, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
5. Since we are nearing the end of the semester, can you tell me more about how you see the lecture and lab portions of the class fitting together? Have the types of activities changed from fall to spring semester?	Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
6. In our last interview, you said "now that I've figured out how I learn best, I need to make it work when that opportunity is not provided to me." How do you learn best and how does this class fit with that?	Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
7. In one of your diaries, you talked about how lecture and lab were not lining up well, in terms of material, and that you were concerned about how this would impact your grade on upcoming exams. Can you tell me more about this? Has the lab 'caught up' to lecture since that time?	line 103-107, Semester 2 Diary; Teaching Context: Climate/ Ethos, Teaching Context: Teaching, Learning Activities: Ongoing approaches to learning, Learning Activities: Pathways to learning
8. Do you still have Mastering homework? Have there been any changes to this assignment since the fall? How has your approach changed from last semester?	Teaching Context: Assessments, Learning Activities: Ongoing approaches to learning, Outcomes: Qualitative: structure, transfer
9. I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? How have you used those activities and would they replace your most or least important?	Learning Activities: Pathways to learning

10. In our first interview, you mentioned that your goal was to gain a better understanding of how the human body worked as Nutrition major. Have your goals changed since that time? How well is this course helping you to meet your goals?	line 253, 255-258, Interview 1; Student Factors: Prior knowledge, Student Factors: Ability, Student Factors: Preferred approaches to learning interacting with Outcomes: Quantitative: facts, skills, Outcomes: Qualitative: structure, transfer, Outcomes: Contextual approaches to learning
11. How do you define "learning?" "memorizing?" "studying?" "understanding?"	Student Factors: Preferred approaches to learning, Outcomes: Contextual approaches to learning
12. How would you rank these terms (previous question) in terms of your personal preference? For this class? Compare ranking for class to beginning - Explain the differences between your rankings from September to now.	Learning Activities: Ongoing approaches to learning
13a. On this paper (using Livescribe pen and paper), can you list themes, words or ideas that come to mind when you think about "Homeostasis"? There are no right or wrong answers. 13b. Can you take the words that you have listed here and organize or group them on this sheet (within Livescribe notebook, with Livescribe pen). As you do this, please explain how and why you are grouping them like you are. 13c. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 13d. Are there additional links between the themes, words, or ideas? 13e. Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis? Explain more... 13f. Here is the concept map you created at our last interview (page 10-11 in map notebook). I see some differences - can you talk me through how your thoughts have changed? (Guide student through map differences, asking for clarification and depth.)	Learning Activities: Pathways to learning
14. Is there anything else that I haven't asked you about that you think is important for me to know about how you have been learning in these 2 courses?	3P Model

Appendix G Weekly Diary Prompts

Table G1: Complete list of weekly diary prompts and dates. S1= Semester 1, S2= Semester 2.

Date	Prompts	Connection to Theoretical Framework
S1, Week 1	Explain the main content from this week's classes in a way that a classmate who was absent could understand. (If there are any connections to homeostasis, be sure to point them out.)	Product; Outcomes: Qualitative: structure, transfer
	How did you go about learning the content you just described? Elaborate on resources used.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S1, Week 2	As you prepare for the second lecture exam, what concepts have you found most confusing so far? What concepts have been most clear?	Product; Outcomes: Qualitative: structure, transfer
	How will you spend your study time in preparing for the upcoming lecture and lab exams? If you are making any changes to your approach since exam one, please describe this.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S1, Week 3	Which content did you find interesting this week? Explain why. If there are any connections to homeostasis, please mention them.	Product; Outcomes: Qualitative: structure, transfer
	What has been difficult in your class [Course 1/ Course 2] this week? Be as detailed as possible.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S1, Week 4	Describe the content that was included on the second exam. Please be as specific as you can. If there are any connections to homeostasis, please mention them.	Product; Outcomes: Qualitative: structure, transfer
	Describe the strategies you used to prepare for Exam 2. Include the amount of time you invested, how you expected to do on this exam, and whether you think your grade reflects you mastery of this material.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S1, Week 5	What content did you encounter this week that is in conflict with your prior understanding? If there are any connections to homeostasis, please be sure to point them out.	Product; Outcomes: Qualitative: structure, transfer
	How did you go about studying the content from your course this week? Elaborate on resources used.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S1, Week 6	Describe the relationship between the lecture and lab portions of this course. Please be as specific as you can.	Process: Teaching Context
	What was the most helpful classroom activity in your [Course 1/ Course 2] class this week? Be as detailed as possible in your description of the activity and why it was helpful to you.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning; Teaching Context: Teaching

S1, Week 7	As you prepare for the next lecture exam, what concepts have you found most confusing so far? What concepts have been most clear? If there are any connections to homeostasis, please be sure to point them out.	Product; Outcomes: Qualitative: structure, transfer
	How will you spend your study time in preparing for the upcoming lecture exam? Please point out similarities and differences from your preparation for exam 1 or 2.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S1, Week 8	What was the hardest question for you on your most recent exam? What made it difficult? Explain why.	Product; Outcomes: Qualitative: structure, transfer, Teaching Context: Assessments
	What tools or resources could you have employed when preparing for the exam that would have made the question easier for you? Please be as specific as possible.	Process; Learning Activities: Pathways to learning
S1, Week 9	How well do you think your current grade reflects you mastery of the course objectives? Be as detailed as possible.	Product; Outcomes: Qualitative: structure, transfer, Teaching Context: Assessments
	In what ways do you think participating in this study has affected your approach or attitude to course tasks? Describe any differences between the impact of interviews, uploading course artifacts, and responding to weekly diary prompts.	
S1, Week 10	Which content did you find interesting during the past 2 weeks? If there are any connections to homeostasis, please mention them.	Product; Outcomes: Qualitative: structure, transfer
	What tools or strategies are you planning to use to prepare for the final exam that you wish you had known about or used at the start of the semester? Be as specific as possible.	Process; Learning Activities: Pathways to learning
S2, Week 1	What changes do you anticipate making in your study habits in the second half of this course sequence? Please give information for both lecture and lab components of this class.	Process; Student Factors: Preferred approaches to learning
	Did anything happen over break that changed how you plan to approach your Anatomy/Physiology course this semester? If so, please provide an elaborate description of what happened and your planned changes. if not, please remind me how you plan to approach the course.	Process; Student Factors: Preferred approaches to learning
S2, Week 2	Thinking about both the lecture and lab, describe similarities and differences between the fall course and the spring course that you have noticed so far. Please include information about assignments, class activities, instructor expectations, and anything else that seems important to you.	Process; Student Factors: Preferred approaches to learning, Teaching Context: Objectives, Assessments, Climate/ Ethos, Teaching
	What study strategies or tools have you used so far in the class? Please describe how you are suing these and if they are a new approach for you. Be as detailed as possible.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S2, Week 3	As you prepare for the first exam, what concepts have you found most confusing so far? What concepts have been most clear? Please give examples and note whether they are from lecture, lab, or both.	Product; Outcomes: Qualitative: structure, transfer

	How will you spend your study time in preparing for the upcoming lecture exam? If you are making any changes to your approach since last semester, please describe this.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S2, Week 4	Explain the main content from this week's classes in a way that a classmate who was absent could understand. (If there are any connections to homeostasis, be sure to point them out.)	Product; Outcomes: Qualitative: structure, transfer
	How did you go about learning the content you just described? Elaborate on resources used.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S2, Week 5	Describe the content that was included on the first exam. Please be as specific as you can. If there are any connections to homeostasis, please mention them.	Product; Outcomes: Qualitative: structure, transfer
	Describe the strategies you used to prepare for Exam 1. Include the amount of time you invested, how you expected to do on this exam, and whether you think your grade reflects your mastery of this material.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S2, Week 6	Which content did you find interesting this week? Explain why. If there are any connections to homeostasis, please mention them.	Product; Outcomes: Qualitative: structure, transfer
	What has been difficult in your class [Course 1/ Course 2] this week? Be as detailed as possible.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S2, Week 7	What content did you encounter this week that is in conflict with your prior understanding? If there are any connections to homeostasis, please be sure to point them out.	Product; Outcomes: Qualitative: structure, transfer
	How did you go about studying the content from you course this week? What assignments or course events have impacted the time and approach you have taken this week?	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S2, Week 8	Describe the relationship between the lecture and lab portions of this course. Please be as specific as you can.	
	What was the most helpful use of class time in your (A&P2/ Physiology) lecture or lab this week? Be as detailed as possible in your description of what happened and why it was helpful to you.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning, Teaching Context: Teaching
S2, Week 9	What was the hardest question for you on your most recent exam? What made it difficult? Explain why.	Product; Outcomes: Qualitative: structure, transfer
	What tools or resources could you have employed when preparing for the exam that would have made the question easier for you? Please be as specific as possible.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S2, Week 10	Explain the main content from this week's classes in a way that a classmate who was absent could understand. (If there are any connections to homeostasis, be sure to point them out.)	Product; Outcomes: Qualitative: structure, transfer
	How did you go about learning the content you just described? Elaborate on resources used.	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning

S2, Week 11	Thinking back over the semester, how have your study practices for this class been impacted by other factors? Please describe the impact of your other classes, club or organization involvement, work responsibilities, and other social commitments. If there are other factors that have impacted your study, either positively or negatively, please list and describe those, as well.	Process; Learning Activities: Ongoing approaches to learning
	How have the factors that you just discussed impacted your mastery of the course material?	Product; Outcomes: Qualitative: structure, transfer
S2, Week 12	Which content did you find interesting this week? Explain why. If there are any connections to homeostasis, please mention them.	Product; Outcomes: Qualitative: structure, transfer
	What has been difficult in your class [Course 1/ Course 2] this week? Be as detailed as possible.	Product; Outcomes: Qualitative: structure, transfer and Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S2, Week 13	Describe the content that was included on the last lecture exam. Please be as specific as you can. If there are any connections to homeostasis, please mention them.	Product; Outcomes: Qualitative: structure, transfer
	Describe the strategies you used to prepare for your last exam. Include the amount of time you invested, how you expected to do on this exam, and whether you think your grade reflects your mastery of this material	Process; Learning Activities: Ongoing approaches to learning and Pathways to learning
S2, Week 14	How well do you think your current grade reflects your mastery of the course objectives? Be as detailed as possible.	Product; Outcomes: Qualitative: structure, transfer
	In what ways do you think participating in this study has affected you approach or attitude to course tasks? Describe any differences between the impact of interviews, uploading course artifacts, and responding to weekly diary prompts.	

Appendix H Participant Recruitment

Table H1 gives information about deep learners in Anatomy, while Table H2 provides the same information for A&P1. Table H3 lists information about surface learners in Anatomy, while Table H4 has this information for A&P1.

Table H1: Recruitment for Case 1a/2a (Deep Approach students in Anatomy). Presented in order that invitations were extended based on Differential Score rank. Study Participants are indicated by bold text.

Inclusion Decision	Surface Approach Score	Deep Approach Score	Differential Score	Major (CIP Code)
1. Invited; no response	14	43	29	Biological Sciences (26.0101)
2. Not invited; unsure about Spring course	16	44	28	Biology (26.0101)
3. Not invited; consent not provided	25	48	23	Biological Science (26.0101)
4. Not invited; not taking Spring course	20	41	21	Biological Science (26.0101)
5. Invited; no response	18	38	20	Biology (26.0101)
6. Not invited; no contact information provided	20	39	19	Biological Science (26.0101)
7. Invited; no response	17	36	19	Biological Science (26.0101)
8. Invited; no response	22	40	18	Biological Science (26.0101)
9. Invited; no response	18	36	18	Microbiology (26.0502)
10. Not invited; not taking Spring course	13	31	18	Microbiology (26.0502)
11. Invited; no response	23	40	17	Biomedicine (26.0102)
12. Not invited; not taking Spring course	13	30	17	Biology (26.0101)
13. Not invited; consent not provided	26	41	15	Biological Science (26.0101)
14. Not invited; not taking Spring course	29	44	15	Biological Science (26.0101)
15. Not invited; not taking Spring course	20	34	12	Biological Science (26.0101)
16. Invited; no response	22	34	12	Genetics (26.0801)
17. Not invited; not taking Spring course	27	39	12	Genetics (26.0801)
18. Invited; no response	21	33	12	Biological Science (26.0101)
19. Invited; no response	18	30	12	Biological Science (26.0101)
20. Not invited; not taking Spring course	22	33	11	Genetics (26.0801)
21. Invited; no response	20	31	11	Environmental Engineering (15.0507)
22. Not invited; not taking Spring course	21	32	11	Biology (26.0101)
23. Invited; no response	18	29	11	Biochemistry (26.0210)
24. Invited	**21**	**32**	**11**	**Biochemistry (26.0210)**
25. Invited; no response	30	41	11	Biology (26.0101)
26. Invited; no response	19	29	10	Biology (26.0101)
27. Invited; no response	26	36	10	Biochemistry (26.0210)
28. Invited; declined	18	28	10	Biochemistry (26.0210)
29. Not invited; unsure about Spring course	25	34	9	Bioengineering (14.0501)
30. Invited; no response	23	31	8	Genetics (26.0801)

31. Invited; no response	23	31	8	Biology (26.0101)
32. Not invited; not taking Spring course	22	30	8	Biological Sciences (26.0101)
33. Invited	**25**	**33**	**8**	**Biological Sciences (26.0101)**
34. Invited	**24**	**31**	**7**	**Biological Sciences (26.0101)**
35. Invited; no response	29	35	6	Biochemistry (26.2010)

Table H2: Recruitment for Case 1a/2b (Deep Approach Students in A&P1). Presented in order that invitations were extended based on Differential Score rank. Study Participants are indicated by bold text.

Inclusion Decision	Surface Approach Score	Deep Approach Score	Differential Score	Major (CIP Code)
1. Invited; no response	19	45	26	Health Science (51.0000)
2. Not invited; consent not provided	24	48	24	Health Science (51.0000)
3. Not invited; major not within recruitment bounds	13	37	24	Psychology (42.0101)
4. Invited; no response	21	42	21	Nutrition (51.3102)
5. Invited; no response	20	41	21	Health Science (51.0000)
6. Not invited; major not within recruitment bounds	15	36	21	Psychology (42.0101)
7. Invited; no response	28	49	21	Nursing (51.3899)
8. Not invited; major not within recruitment bounds	26	46	20	Psychology (42.0101)
9. Invited; no response	21	41	20	Nursing (51.3899)
10. Invited; no response	21	41	20	Health Science (51.0000)
11. Invited; no response	25	45	20	Biology (26.0101)
12. Invited; no response	13	32	19	Health Science (51.0000)
13. Invited; no response	20	39	19	Health Science (51.0000)
14. Not invited; major not within recruitment bounds	19	38	19	Food Science and Human Nutrition (01.1001)
15. Invited	**18**	**37**	**19**	**Health Science (51.0000)**
16. Invited; no response	22	40	18	Nursing (51.3889)
17. Not invited; major not within recruitment bounds	21	39	18	Non-degree seeking
18. Invited; no response	20	37	17	Biological Sciences (26.0101)
19. Invited	**20**	**37**	**17**	**Microbiology (26.0502)**
20. Invited; no response	22	39	17	Genetics (26.0802)
21. Invited; no response	23	39	16	Biology (26.0101)
22. Not invited; major not within recruitment bounds	20	36	16	Psychology (42.0101)
23. Invited; no response	23	39	16	Language and International Health (51.0204)
24. Not invited; major not within recruitment bounds	21	37	16	Undeclared
25. Invited; declined	22	37	15	Nursing (51.3889)
26. Invited	24	39	15	Health Science (51.0000)
27. Not invited; major not within recruitment bounds	19	34	15	Psychology (42.0101)
28. Invited; no response	25	39	14	Biological Sciences (26.0101)
29. Invited; no response	21	35	14	Health Science (51.0000)

Table H3: Recruitment for Case 1b/2a (Surface Approach Students in Anatomy). Presented in order that invitations were extended based on Differential Score rank. Study Participants are indicated by bold text.

Inclusion Decision	**Surface Approach Score**	**Deep Approach Score**	**Differential Score**	**Major (CIP Code)**
1. Invited; no response	38	21	-17	Biology (26.0101)
2. Not invited; not taking Spring course	39	21	-16	Biology (26.0101)
3. Invited	**35**	**23**	**-12**	**Biology (26.0101)**
4. Invited; no response	34	22	-12	Biological Science (26.0101)
5. Not invited; consent not provided	32	22	-10	Biological Science (26.0101)
6. Invited	**30**	**21**	**-9**	**Biology (26.0101)**
7. Not invited; not taking Spring course	35	26	-9	Biological Science (26.0101)
8. Invited	**33**	**25**	**-8**	**Biology (26.0101)**
9. Invited	**35**	**28**	**-7**	**Biology (26.0101)**

Table H4: Recruitment for Case 1b/2b (Surface Approach Students in A&P1). Presented in order that invitations were extended based on Differential Score rank. Study Participants are indicated by bold text.

Inclusion Decision	Surface Approach Score	Deep Approach Score	Differential Score	Major (CIP Code)
1. Not invited; not taking Spring course	44	11	-33	Recreational Therapy (51.2309)
2. Not invited; no consent provided	39	21	-18	Psychology (42.0101)
3. Not invited; no contact information provided	31	16	-15	Not provided
4. Invited; no response	41	27	-14	Language & International Health (51.0204)
5. Invited	**38**	**25**	**-13**	**Nursing (51.3899)**
6. Not invited; major not within recruitment bounds	29	17	Psychology (42.0101)	
7. Invited; no response	37	25	-12	Nursing (51.3899)
8. Not invited; major not within recruitment bounds	42	31	-11	Sociology (45.1101)
9. Not invited; major not within recruitment bounds	30	19	-11	Finance (52.0801)
10. Not invited; major not within recruitment bounds	30	20	-10	Psychology (42.0101)
11. Invited; no response	32	22	-10	Health Science (51.0000)
12. Not invited; not taking Spring course	34	25	-9	Nursing (51.3899)
13. Invited; no response	29	21	-8	Nursing (51.3899)
14. Not invited; no consent provided	33	25	-8	Recreational Therapy (51.2309)
15. Not invited; major not within recruitment bounds	37	30	-7	Marketing (52.1401)
16. Invited	38	31	-7	Health Science (51.0000)
17. Invited; no response	31	24	-7	Biochemistry (26.0201)
18. Not invited; unsure about Spring course	33	26	-7	Nursing (51.3899)
19. Invited; no response	29	23	-6	Recreational Therapy (51.2309)
20. Not invited; major not within recruitment bounds	28	22	-6	Psychology (42.0101)
21. Invited; no response	24	18	-6	Animal & Veterinary Sciences (51.0808)
22. Invited; no response	33	27	-6	Biochemistry (26.0201)
23. Invited; no response	30	24	-6	Biological Sciences (26.0101)
24. Invited; no response	37	32	-5	Nursing (51.3899)
25. Invited	**26**	**22**	**-4**	**Health Science (51.0000)**
26. Invited; no response	30	26	-4	Nursing (51.3899)

Appendix I Bracketing Findings

I.1 Bracketing Prompts

1. What was my experience when taking A&P as a student? How did I study and learn in that class?

2. What have I observed as a teacher of A&P in student work and study habits?

3. What observations do I find or think to be "good/ positive" or "bad/ negative"? Be sure to define these terms ("Good/ positive" etc.).

4. What behaviors or attitudes have the participants displayed that have been perceived as negative? Positive?

5. What are my notions or impressions of each participant at this point in the study?

6. What are my notions or impressions of the curriculum differences (A&P1→2 vs. A→P) at this point in the study?

7. What are my notions or impressions of surface/ deep learner dichotomy at this point in the study?

8. What are my impressions of Instructor 1 and Instructor 2? What are my impressions of how Instructor 1 and Instructor 2 are impacting the student's engagement with the course and course material?

I.2 Code Book for Analysis

First Cycle Open Codes Pass 1- Related to Teaching Context

1a. *Pedagogical preferences.* Excerpts refer to specific course activities or design elements.

1b. *Course experience.* Excerpts refer to specific personal experiences as a student or instructor or may be an explicit statement of no experience in a particular area.

1c. *Student use of time.* Excerpts refer to a student's use of time in class. They may also refer to a personal desire for student's to learn in response to these activities.

1d. *Interpretation of actions.* Excerpts refer to specific assumptions made about students that were later recognized to be incorrect.

1e. *Curriculum.* Excerpts refer to specific tools or other helps available to students provided through course materials or the instructor.

1f. *Positive view of teaching context/ instructor.* Excerpts explicitly reference specific characteristics of the teaching context or instructor in a positive manner.

1g. *Negative view of teaching context/ instructor.* Excerpts explicitly reference specific characteristics of the teaching context or instructor in a negative manner.

Pass 2- Related to Student Characteristics

2a. *Specific characteristics of student.* Excerpts include traits or other characteristics of the student. Specific characteristics from the 3P Model [Biggs et al., 2001] are included: information processing, personality, age, prior knowledge of subject, motivation, prediction of success. Additional characteristics are included which are clearly held or possessed prior to the start of the class.

2b. *Student Need.* Excerpts reference some item or area that is needed by the student from the perspective of the researcher.

2c. *Group or class characteristic.* Excerpts reference a trait or characteristic that applies to a larger group or is evident in all participants from a particular class.

Pass 3- Related to Learning Activities

3a. *Hands-on activities.* Excerpts refer to specific hands-on activities during class time or in another venue.

3b. *Attend class.* Excerpts refer explicitly to class attendance. This include both positive and negative references.

3c. *Take notes.* Excerpts refer to the action of taking notes about course concepts or materials.

3d. *Study partners.* Excerpts refer to with whom students study for the class. This includes references to both study partners and to whether the participant studies alone.

3e. *Read textbook.* Excerpts refer explicitly to spending time reading the course textbook.

3f. *Short cuts.* Excerpts refer to a lack of assignment completion or submission. They may also reference "short cuts" taken by students to move through material or course requirements faster, with a perceived lack of learning.

3g. *"Game the system".* Excerpts refer to efforts by students to complete requirements of the class without learning the material. The term "game the system" may be used explicitly or themes of getting around instructor desire for learning are present.

3h. *Study time.* Excerpts refer to the presence of setting aside time outside of class to complete course requirements or to spend time with the course material.

3i. *Effort level.* Excerpts refer to the amount of effort put forth toward the class by a student. This may include positive or negative references.

3j. *Complaining.* Excerpts refer to the act of complaining.

3k. *Interest in topic.* Excerpts refer to the interest level of a student in the course topics. This is considered separate from "motivation" which is a Student Characteristic. Excerpts assigned this code reference specific course topics or the course itself, and were not clearly described as a trait the student brought into the course.

3l. *Attitude toward adults.* Excerpts reference specific ideas or actions toward the researcher or course instructors. This includes both positive traits, like responsiveness to adult requests, and negative traits, like displaying a disrespectful attitude.

3m. *Issue and solution.* Excerpts explicitly reference a student seeing an issue and a possible solution.

3n. *Activities related to research project.* Excerpts explicitly reference participation in the research study or specific activities related to the study, such as weekly diary completion, interviews, or sharing of course artifacts.

3o. *Asking for help.* Excerpts reference the request of a student to an adult, either instructor or researcher, for assistance in course or career related areas.

3p. *"Course is easy".* Excerpts explicitly reference a view that the A&P class is easy or not challenging.

Pass 4- Related to Learning Outcomes

4a. *Doing well in class.* Excerpts reference performance in the class related to grades. This may include an explicit reference to "grades" or statements about how a student is doing in the class.

4b. *Learning.* Excerpts contain an explicit reference to learning as an intended goal and are never connected to discussion of grades in the class.

4c. *Resaarch participation.* Excerpts contain explicit reference to a student's view of how participating in the research study has impacted their performance or motivation related to the class.

4d. *Struggles.* Excerpts reference a student struggling to learn within A&P or in general. These may also include references to struggling with the grades they are earning in the class without regard to learning.

Pass 5- Themes not captured in previous passes

5a. *"Problem student".* Excerpts explicitly use the term "problem student."

5b. *Memorable to researcher.* Excerpts describe a memory or attribute of a student within the mind of the researcher.

5c. *SPQ confidence.* Excerpts describe either confidence or lack of confidence in the SPQ instrument. This may also include discussion of the survey's ability to accurately group students as Surface or Deep learners.

5d. *Motive vs. strategy.* Excerpts describe thoughts on the subscales of motive and strategy in the SPQ instrument. This may include specific questions about their role and how they are displayed by the students.

5e. *Achieving.* Excerpts describe thoughts, ideas, or questions about the learning approach of Achieving. This may include descriptions, examples within the research sample, or thoughts on lack of inclusion in the SPQ instrument.

Second Cycle Axial Coding

1. Student Actions. Excerpts explicitly reference an action related to class that gives a tangible output or product.

2. Student Traits or Characteristics. Excerpts explicitly reference a trait or characteristic of the student themselves that is not specifically related to this particular course

3. SPQ Factors or Subscales. References deep, surface, achieving or the subscales of motive or strategy.

4. Outcomes. Tangible or intangible products produced while working on the class. May be an intermediate outcome, so something that could change but is the current location of the student.

5. "Meta-Actions" Excerpts reference internal actions, feelings, effort. These actions produce intangible products.

6. Awareness of View. Excerpts explicitly reference the researchers thoughts or biases about the study or participants.

Appendix J Final Code Book

J.1 Attribute Codes

Data Type

- **Weekly Diary Prompts**- Items coded to Weekly Diary Prompts were collected from the shared GoogleDoc between the researchers and each individual participant.
- **Interviews**- Items coded to Interviews were those meetings between the researcher and a participant. This may have occurred in person or utilizing an online meeting website, such as Zoom.
  - Interview 1- The first interview conducted with any participant or instructor.
  - Interview 2- The second interview conducted with any participant or instructor.
  - Interview 3- The third interview conducted with any participant or instructor.
- **Class Documents**
  - Student-provided documents: Any document shared by a participant as a hard copy or digitally. This may include documents that were emailed to the researcher directly or uploaded into the shared Google Folder.
  - Instructor-provided documents: Any document shared by a participant as a hard copy or digitally. This may include documents that were emailed to the researcher directly or uploaded into the shared Google Folder.

Date - Codes were assigned based on the date they were received by the researcher. Dates range from September 18, 2018 to May 6, 2019.

Speaker

- Angie
- Caitlyn
- K Diddy
- Kate
- London
- Michelle
- Sally
- Shay
- Reseacher, Staci N. Johnson
- Tigers123
- Walt Owens
- Waterskier

J.2 Descriptive Codes

Prompts Codes assigned to participant-provided content based on the prompts, either in the weekly diary or in an interview. Items with the prefix of 'D' indicate prompts from Weekly Diaries. Items with the prefix of 'I' indicate prompts from an Interview.

D1. Explain the main content from this week's classes in a way that a classmate who was absent could understand. If there are any connections to homeostasis, be sure to point them out.

D2. How did you go about learning the content your just described (in D1)? Elaborate on resources used.

D3. List anyone you studied with for your class this week.

D4. As you prepare for the exam, what concepts have you found most confusing so far? What concepts have been most clear?

D5. How will you spend your study time in preparing for the upcoming lecture and lab exams? If you are making any changes to your approach since the last exam, please describe this.

D6. Which content did you find interesting this week? Explain why. If there are any connections to homeostasis, please mention them.

D7. What has been difficult in your class this week? Be as detailed as possible.

D8. Describe the content that was included on the recent exam. Please be as specific as you can. If there are any connections to homeostasis, please mention them. *This prompt was sometimes updated to indicate a specific exam or lab practical. i.e.- "Describe the content that was included on Exam 2.*

D9. Describe the strategies you used to prepare for most recent exam. Include the amount of time you invested, how you expected to do on this exam, and whether you think your grade reflects your mastery of this material. *This prompt was sometimes updated to indicate a specific exam or lab practical. i.e.- "Describe the strategies you used to prepare for Exam 2.*

D10. What content did you encounter this week that is in conflict with your prior understanding? If there are any connections to homeostasis, please be sure to point them out.

D11. How did you go about studying the content from your course this week? Elaborate on resources used.

D12. Describe the relationship between the lecture and lab portions of this course. Please be as specific as you can.

D13. What was the most helpful use of class time in your (Biol 2230/3160) lecture or lab this week? Be as detailed as possible in your description of what happened and why it was helpful to you. *This prompt was altered following the first semester. It originally asked "What was the most helpful classroom activity in your [anatomy and physiology] lecture or lab this week?" Lack of detailed student responses led to revision of this prompt prior to the spring semester.*

D14. What was the hardest question for you on your most recent exam? What made it difficult? Explain why.

D15. What tools or resources could you have employed when preparing for the exam that would have made the question easier for you? Please be as specific as possible.

D16. How well do you think your current grade reflects your mastery of the course objectives? Be as detailed as possible.

D17. What tools or strategies are you planning to use to prepare for the final exam that you wish you had known about or used at the start of the semester? Be as specific as possible.

I1.1a. Describe your A&P class?

I1.1b. What do you think about the assignments (in your A& P class)?

I1.1c. What do you think about the grading procedure (in your A& P class)?

I1.1d. What do you think about the teaching style (in your A& P class)?

I1.2 How is this different from your previous biology physiology courses?

I.3a. How do you define "learning?"

I.3b. How do you define "memorizing?"

I.3c. How do you define "studying?"

I.3d. How do you define "understanding?"

I.4a. How would you rank these (cards labeled "learning", "studying", "memorizing", "understanding") in terms of your personal preference?

I.4b. How would you rank these (cards labeled "learning", "studying", "memorizing", "understanding") in terms of this A& P class?

I.4c. You ranked these terms in this way in September. (Refer to notes from previous interview.) Explain the differences between your rankings from September to now.

I.12 Talk at the end of the interview that may include instructions, questions, or conversation following the last question of the interview protocol but prior to participant departure.

I2.1 In the first interview in September, you mentioned that lecture and lab were very different. Can you me more about that/ can you give me an example?

What has happened that you didn't expect? What hasn't happened that you did expect?

I2.2 Study method follow up questions. Several participant specific prompts were designed to understand more about study methods and strategies. The following prompt responses were coded here.

- You said in interview 1 that you didn't want to just memorize but also talked about not having enough time. How have you approached (reconciled the conflict, etc.) the material as the semester has continued?
- In your diaries, you mentioned that you don't plan to use Chegg anymore as a study tool. Can you tell me more about this - give a play-by-play about what this looked like for you when you were using it?
- You also mentioned that you were going to [Instructor 1]'s office hours and talked about preparing for that. Can you tell me more about how you prepare for your visit's with [Instructor 1]? Why do you choose this approach? (Probe for other approaches - hand-written note cards, out loud processing, Quizlet).
- Do you feel like the above methods have been effective? How do you know this has been effective or that it is working?
- In your diaries, you have mentioned that you (*participant specific practice from interview 1 or weekly diary*). Can you tell me more about this? Give a play-by-play about what this looks like for you? Why do you choose this approach?
- In our first interview, you mentioned that all of the assignments at that point were good for "reinforcing the information. And none of it's... busy-

work." How do you currently view the assignments in the class? What is your approach to "busywork" assignments? How is this different than the approach you take to the assignments in this class?

- The first time we talked, you mentioned that there were "stories from lecture on the test that you were not aware of." Can you give me an example of this from exam 1, if you remember? Have these types of questions appeared on the tests you have taken since then? How have you adjusted your approach to the class to account for these questions?
- You've mentioned in your interview and in diary entries that you have struggled with the "all of the above" or "none of the above" questions on the lecture exam. How has your approach to exams changed to compensate for this challenge?
- In our first interview, you mentioned that your study habits could be attributed to laziness. Can you tell me more about why you describe your approach this way?
- In interview 1, you mentioned you were considering buying the textbook. Have you done that? (If yes) How has having the textbook changed your approach to the class? (If no) What have you done to compensate for not having the textbook?
-

I2.3 What would you describe as your biggest "WIN" of the semester? What has been your biggest "LOSS" of the semester? Can you tell me more about this? (Additional follow-ups include specific events noted in recent weekly diary prompts.)

I2.4 I have various activities that you have done in class or have been available to you for this class. Which of these has been the most important strategy? Which of these has been the least important strategy? Can you tell me more about why you have selected (or not selected these)? Are there any other activities that have been important to you that aren't included on the cards? Can you tell me about how you have used these activities within the course?

I2.5 Two questions were coded in this manner depending on the class the students were enrolled in.

- Describe your approach on your lecture quizzes. How do you use the 3 attempts on this assignment? Has this changed as the semester progressed?
- Explain the structure of Mastering homework assignments. Can you update answers? How frequently are these assigned? How do you approach this assignment?

I1.5a What do you think is the best approach to (participant's first choice from term ranking activity) in this A&P class? (*Variable based on response to Q4. Use first choice term.*)

I1.5b What do you think is the best approach to (participant's second choice from term ranking activity) in this A&P class? (*Variable based on response to Q4. Use second choice term.*)

I1.6 What do you hope to gain from this course?

I2.6 How has your approach to this course changed over the semester?

I1.7 *Provide copy of course learning objectives.* How do you think these learning objectives will help you meet your personal goals?

I2.7 During our first interview, you told me (*goals stated in Interview 1*). How has this goal impacted your approach to the class? In what ways has this course helped with that goal? Do you feel like this goal has been met? Why? How?

I.8 On this paper, can you list themes, words or ideas that come to mind when you think about "Homeostasis?" There are no right or wrong answers. Can you take the words that you have listed here and organize or group them on this sheet. As you do this, please explain how and why you are grouping them like you are. Now I would like you to connect each of your terms/ ideas/ themes back to the idea of Homeostasis and to each other. As you identify these connections, put down some words or phrases that describe the relationship that you see between them. Like before, please explain your thoughts and reasoning as you are writing. 10d. Are there additional links between the themes, words, or ideas? Looking at this diagram as a whole, are there any ideas, thoughts, or connections that are missing? Does this represent what you know and understand about Homeostasis?

I2.9 Overall, how do you think this Anatomy course is going?

Table J1: Definition groups assigned for four terms.

Code Name	Definition	Excerpt
LEARNING		
Acquisition of information	Excerpts reference a process of acquiring information but provide no information about an intended outcome.	"Acquiring new information on a topic or attempting to acquire information on a topic that you were not previously familiar with." (Walt Owens, Interview 1)
Acquisition of information leading to recall	Excerpts reference a process of acquiring information and define the outcome of that process to be the ability to recall the information at a later time.	"Typically learning would then mean knowing it and you point it out after that. Or at least knowing about it after that... a big part of learning is actually understanding, remembering, and being able to recall the information." (Sally, Interview 1)
Acquisition of information leading to understanding	Excerpts reference a process of acquiring information and define the outcome of that process to be the ability to understand the information.	"I think to hear something and internalize it, and kind of like understanding how it works. Be able to describe it to somebody else." (Kate, Interview 2)
Acquisition of information leading to application	Excerpts reference a process of acquiring information and define the outcome of that process to be the ability to apply the information to another situation or context.	"Taking in information and applying it... to everyday life things... consistently." (Angie, Interview 1)
Recall or Application	Excerpts reference the intended outcomes of recall or application of information. No process or action is provided in relation to how this outcome would be achieved.	"Being able to explain the material without notes. And in like a thorough manner. You're not just like spitting out like, something." (Shay, Interview 1)
UNDERSTANDING		
Ability to teach or explain information to others	Excerpts describe an outcome of being able to teach or explain information to others. No process or action is provided.	"If someone is able to ask you a question about it, and you're able to give them like an example or an answer that they understand. Or if you're telling them something and they ask a question to like, build off of it, you know the answer to that." (Shay, Interview 1)
Ability to apply or connect knowledge	Excerpts describe an outcome of being able to apply or connect knowledge to other tasks or situations. No process or action is provided.	"Studying for like long-term... Knowledge of the topic or skill. So rather than just memorizing it but knowing how it fits in with like everything else." (Walt Owens, Interview)
Knowing details or being able to retell in depth	Excerpts describe an outcome of having retained detailed information or having the ability to share details with another. No process or action is provided.	"Understanding would be taking a concept and being able to... reword it in your own language or your own... Yeah, in your own way." (K Diddy, Interview 2)
MEMORIZATION		
Provides recall	Excerpts describe an outcome of allowing for recall of information. No process or action is provided.	"[B]e able to recognize what you learned... you would be able to draw it back up. You wouldn't have to just look at something and you wouldn't be reading it. It would be coming out of your head." (Tigers123, Interview 1)

Short term memory	Excerpts describe an outcome of retaining information for a short amount of time. No process or action is provided.	"This word to me is short term... And it's often something that I don't care about or if it is, I'm just trying to get a good grade and I don't have a lot of time." (Kate, Interview 2)
Repetition resulting in recall	Excerpts describe the process of utilizing repetition of information to attain the outcome of recall of information.	"Continually going over information, until you know it like front and back... But just like through repetition." (Shay, Interview 1)
Repetition resulting in short term memory	Excerpts describe the process of utilizing repetition of information to attain the outcome of short term memory of information.	"It's just shoving as many things into my brain with, like repetition. And then I usually forget it pretty soon after." (Kate, Interview 1)
Not understanding	Excerpts describe the outcome of memorizing as a lack of understanding. No process or action is provided.	"Being able to... look at information and then repeat it back... without necessarily understanding of that information." (Walt Owens, Interview 2)
STUDYING		
A "process"	Excerpts explicitly describe an action as a "process."	"Studying is... basically the process of learning the material that was discussed in class on your own time outside of class... in your own way... through just whatever mechanisms you find most helpful." (K Diddy, Interview 2)
Use of time	Excerpts describe tasks or actions generally, but explicitly describe the need for "time."	"I guess [studying is] dedicated learning time." (Michelle, Interview 2)
Action leading to an extrinsic act (e.g. test)	Excerpts describe actions or tasks specifically linked to an extrinsic event or act, like a test.	"Taking what you learned in class... so that you master the topic... for an exam or whatever." (K Diddy, Interview 1)
Action leading to memorization	Excerpts describe actions or tasks specifically linked to the specific outcome of memorization.	"I rewrite all of my notes to study and compare like multiple sources together, like get all the information that I need. And then just repeat it over and over again until I remember it." (Caitlyn, Interview 1)
Action leading to understanding	Excerpts describe actions or tasks specifically linked to the specific outcome of understanding.	"Knowing the material enough to be able to like, answer questions without notes. But its being able to like go in depth and provide examples. So yeah, it's like reviewing the material enough times to be able to do that... in order to study, I have to be learning material, understanding it, and memorizing it at the same time." (Shay, Interview 1)

Table J2: Process Codes assigned during first round open coding of excerpts that were deemed important in relationship to Fyrenius/Approaches [Fyrenius et al., 2007] and Important/Pandey [Pandey and Zimitat, 2007]

Code Name	Definition/ Bounds	Example
Accessing explanations	Excerpts make explicit or implicit mention of receiving an explanation from another source, which could be a person or set of information like an online tool. This may include reference to "answering questions," getting feedback, or acknowledgment that they *could* receive an explanation. Explanations may be desired from instructors, teaching assistants, or peers. However, this differs from a discussion in terms of information transfer. There is explicit mention of "explain" and that one person is viewed as having power or more information to be given to someone else. This code differs from 'Needing an explanation" because the participant makes clear that they know where to go or what to do to receive the information needed.	"Personally, my subscription [on Chegg] I only use to look up answers, just because somebody on there can explain it very well. Like they'll come with the answer and they'll say like 'this is how I came up with it.' " Angie, Interview 2
Attending class	Excerpts reference either experiences of what happens in either the lecture or lab periods or the act or practice of going/not going to lecture or lab regardless of whether attendance is or is not explicitly connected to a learning act or goal.	"I mean for an hour and 15 minutes, [Instructor 2] lectures and we take notes. Usually... I know a lot of people variously take notes, but I use PowerPoint. The PowerPoints [they give] us- and just kind of add on to whatever he's saying." Walt Owens, Interview 1
Changing it up	Excerpts reference the switching of study methods in a finite period of time with the specific intent to prevent boredom.	"Like I said, that writing before, that solved the efficiency problem. And then the boring problem... I really like doing stuff this, like putting 9000 sticky notes or else like printing the outline and I was writing notes on one of them at one point and then just interacting with it in different ways really solves the boring. I think... Oh, another boring thing is just that... Like I said, I can't stay doing one thing for a really long time. But this is kind of like required for me to do in order to get to know the material a little bit. So like with these on jump around, or Quizlets, I'll jump around or just change up the way I'm doing it or I'll start like highlighting this, but that one I just have to sit there." Kate, Interview 3
Comparing performance to expectations	Excerpts reference expectations by the instructor, the student, or another individual. These are divided into multiple subcodes.	

1. Not meeting stated expectations	Excerpts reference a lack of meeting their own or someone else's expectations.	"I tend to take the feedback from the weekly prompts and interviews and change the way I approach the material every week. I have experimented with multiple study methods at this point but it seems very difficult to attain the grades I would like despite the different methods of effort I have tried." Angie, Semester 1 Diary
2. Not meeting assumed expectations	Explicit reference to NOT doing what is expected or desired by the instructor from the view of the student.	"I think she wants us to use it as a way to like, help ourselves study. Like maybe test it, like do it once before, and then study, and then do it again. Because we have three attempts on each one. So I'm... Yeah, I don't know, I guess. I just always kind of thought, anything that I do last minute, I'm like, oh she's gonna hate this. (laughing) But some people don't even do them. So I mean, I guess its probably better than nothing." Kate, Interview 2
3. Awareness of expectations	Excerpts reference an awareness of the instructor's or someone else's expectations for the course as a whole or for particular assessments.	"And then... I meet with him about those questions, about simplifying things, seeing what's expected of me." Waterskier, Interview 3
Comparing semesters	Excerpts make a comparison between the lecture, lab, or combination of these components between the fall and spring semesters of the anatomy and physiology sequence.	"I feel like... A lot of the stuff we did last semester was more straightforward almost, because like it is anatomy. So it's very like cut and dry like... Yes, it's still complicated but it's like it is what it is. And then physiology there's a lot more like, processes and you know feedback and what not." Caitlyn, Interview 3
Completing assessments	Excerpts explicitly mention the presence or process of completing specific course assessments or assignments. This may include a description of positive or negative outcomes or the process or fact that the assessment was completed. This code has been divided into the following subcodes: Lab homework, In-class lab quiz, Lab practical, Lecture quiz/ Mastering homework, Lecture exam, Other	"I try to do [content quizzes prior to exam] two days before the exam just because by that point I know I've gotten through all the PowerPoints in the entirety. And I can test my knowledge because it's like the most fresh in my mind." Angie, Interview 3

Connecting lab and lecture	Excerpts reference how lecture and lab sections of the course relate to one another. This is divided into two subcodes: Alignment and Lack of Alignment.	"I mean they're very aligned in what part of the body we're talking about. I think the way that they just go about it is different. Since the lab is really about memorizing individual parts of the big systems. And then I feel like in lecture, we do talk about that individual parts, especially like the microscopic anatomy and that kind of stuff, we talk about that both lecture and lab, but... I don't know, I can't exactly figure it out because I always... Like when I was answering that question, I was thinking okay. No, they just seem so different to me. But I guess... We definitely memorized so much more in lab. But I know you learn similar things in both, so..." Kate, Interview 2
Cramming	Excerpts contain explicit reference to the act of "cramming" course material or an outline of actions described by the student of occurring "at the last minute".	"But yeah, so it's kind of like a give and a take. I have to choose to prepare for like this as hard as I can. And then I have you know, two days, so I just have to like cram it all in. And like that's what happened for the last one." Caitlyn Interview 2
Creating your own study tools	Excerpts explicitly reference the act of making or creating your own study tool, e.g. creating your own questions or taking questions from another source and putting them in another format. Not all excerpts contain the words "make" or "create" but all indicate the participant's expression of agency in the task. This does not include references to *using* the tool, as these actions are captured in other code groups. This is divided into two subcodes: Digital, which includes PowerPoint creation and Quizlet making and Non-digital, which includes creating a study guide (could be on the computer or typed) or flashcards.	"Okay, so what I did... So they gave us 2 study guides. And so I took literally everything from that study guide and I... Made it like a question or like... something you could label. And I put it in a slide and then after... I shared it with bunch of friends. I answered most of the questions but like... After like I went in, answered everything, put in a bunch of diagrams. Like labeled all these diagrams of stuff we had to know, I covered everything up and so once you hit 'present,' you could like quiz yourself." K Diddy, Interview 2
Desiring understanding	Excerpts make explicit reference to a desire by the participant to understand the material. Must include "understand" and some word indicating understanding as a goal.	"I feel like that's one of the unfortunate things about college because as much as I really want to learn and understand anatomy, I just think it's impossible to find the time to devote to really learning and understanding it." Kate, Semester 1 Diary

Determining what's on the test	Excerpts make explicit reference to information on a test or knowing something specifically because it will be on a test. This may refer to specific expectations about items/topics or the test process or format, and the phrase "everything you need to know" may or may not be present.	"And YouTube... I know McNutt has a YouTube channel and it hasn't been super useful for the first two practicals. Which I don't really understand because she just goes through the models on there and points things out. And she has it all for the stuff that's going to be on the third practical but she didn't really have it for the models on the first two. She had it for the integument model and then nothing else. But it's just more models. Like she could have made the videos, I guess going through them. So... Because those are really helpful." Kate, Interview 2
Dividing and conquering	Excerpts explicitly reference dividing work, either assigned or voluntary, between a group either explicitly or implicitly in contrast to a process of collaboration or cooperation in its completion.	"If you were spying on me, that'd be me and the girl next to me doing experiment 1 and 2 and the dude and the other two girls doing experiment 3 and 4 and then getting all the information on the same sheet and leaving." K Diddy, Interview 3
Endeavoring	Excerpts reference, either explicitly or implicitly, the amount of effort given or expended by the participant. This group is divided into multiple subcodes.	
1. *Increasing effort*	Excerpts make explicit comparison or use comparative adjectives in describing previous and current effort or time investment, with current levels higher than previous or projected future levels higher than current.	"I definitely think I've been like... From the beginning of semester, I've been... I put more time into it." Walt Owens, Interview 2
2. *Under endeavoring*	Excerpts explicitly state that the effort level or time investment given by the participant is lower than the participant thinks it should or could be. This is not "I didn't spend much time."	"I believe I could have put more work into this class, especially when it came to test preparation." Walt Owens, Semester 1 Diary
3. *Linking effort to outcome*	Excerpts explicitly link a level or amount of effort or time to the participant's motivation, goals, or other outcomes. This may include grades, career goals, or interest level.	"So, this course obviously is important for my major but along with that, I am studying that because I want to have a better understanding of my own body and of how people's body systems work, in general, to provide advice and help and research, for how to better that." Waterskier, Interview 1
4. *Requiring effort*	Excerpts reference work or effort being required from the participant, but there is no mention of a change in the amount of effort, no link to any outcome, and no indication of struggling. This differs from "Trying" due to a lack of connection between the effort being given by the participant and that which is required.	"They really try, like I think like [Instructor 2] has designed the class really like... set you up to at least like, if you're willing to put in a little bit of work, to like do well." Walt Owens, Interview 2

5. *Struggling*	Excerpts reference the specific act or experience of difficulty. It is broken into several subcodes to distinguish the source or cause of the struggle.	
	A. Course pacing Excerpts reference the amount of material or speed of coverage of that course material as a hurdle to learning, understanding, or recording information in notes. Excerpts make reference to a defined time frame, such as a specific lecture or lab period, timing of an assessment, or the course in general.	"And like I said, I think the biggest thing with the class is just how much information it is. It makes it hard- whether or not she teaches it well." Sally, Interview 1
	B. Engagement during class activities Excerpts make explicit reference to loss of focus or attention during class time, either lecture or lab.	"I struggle a lot with even being able.. Which is half the time... Well, I go to class pretty frequently, but sometimes I just have a difficult time paying attention. And 50 minutes isn't that long but for some reason, some days I just really not feeling it." Kate, Interview 2
	C. Forgetting Excerpts reference forgetting or "not remembering" of course information. These excerpts are different than 'Mastering Skills' code because there is emphasis on trying to hold onto information and experiencing issues with that process.	"It was not a fun time and I have pretty much already forgotten everything that was on the test because I didn't have time to commit any of it to my long term memory." Kate, Semester 1 Diary
	D. Instructional choices Excerpts may reference various moves by the instructor during the class or at a specific point in time that lead to this state, which may include a change in topic during the class or the speed of content presentation or speech.	"So I sometimes don't have time to even like... You know finish what I'm writing and she's already starting on the next one. I have to like find my PowerPoint because I didn't think, you know, she would start another chapter with 3 minutes left in the class, but she does. A lot of students by that point start packing up and like nobody is really listening. And so the next time we start lecture she doesn't go back." Angie, Interview 3
	E. Mastering skills or concepts Excerpts reference difficulty at any time related to grasping or understanding the material or concepts. Excerpts may also mention confusion or feeling lost and are focused on the content or course concepts.	"Since we have a test on Monday I have been reading through the sections in the book that were most confusing or complicated to me during lecture. This takes longer than simply going through the PowerPoints, but I understand it much better after being able to read it in the book." Michelle, Semester 2 Diary

	F. Time management Excerpts references a lack of time to complete the work of the course or a perceived mismatch in what is being suggested or required by the course and their own available time or desire for more time. Common phrases used in this code are "if I had time" and "running out of time". This is distinguished from "Course pacing" because the reason for the struggle or time management difficulty is described as external to the course or an interaction between the A&P course demands and other responsibilities.	"I think I would have been better about doing Mastering long before it was due. Because it did come to just have the textbook open and being able to flip through it. And then... I know like a lot of people read his... they take his... outlines and then they go into the textbook and they like try to match things and they already have no... they come in with full notes. I don't have time to do that. So... But if I could, I would have done that." Tigers123, Interview 2
6. *Trying*	Excerpts express a level of effort or time spent in a positive manner. They may also reference "working hard" or "spending time" on course assessments or learning tasks. This differs from the 'Requiring effort' code because there is explicit or implicit reference to the participant's effort level rather than that which is required by the material.	"I have been working very hard this semester and have used several different study tactics to make the class less stressful but it has still been very challenging." London, Semester 1 Diary
Engaging with course material out of class	Excerpts reference an encounter with course material specifically occurring at a time outside of class meetings. Excerpts reference actions or events that do occur or as something that is desired to occur. For things that are desired, excerpts reference a lack of ability or time, e.g. the information has not yet been provided.	
1. Applying	Excerpts reference using newly gained or previously existing knowledge or skills to complete physical or cognitive tasks. Also included are excerpts previously coded as "Understanding- Apply" from definition from group 2, which defines understanding as the ability to apply or connect knowledge.	"And sometimes like I said, we did one where it was diffusion in... and it was like "Oh, I definitely know what diffusion is." (laughing) We try to demonstrate some of the processes. And like some of the BioPac ones, like the ECGs and stuff we'll talk about that in class and then we'll go do it in lab. And so that stuff is pretty cool. And a lot of this stuff is good." Kate, Interview 3
2. Completing worksheets	Excerpts explicitly reference the act of completing or "filling out" a worksheet related to course material. This also includes reference to answering questions from an outside source like the textbook. This differs from quizzing because there is no immediate feedback or answers provided.	"So, if I go to class, so like I have my own notes that helps you fill out the PAL worksheets, so I'm like contributing to the PAL. But then I use their worksheet at- because like that's... They know what [Instructor 2] wants, like obviously, they talk to him." Shay, Interview 1

3. Connecting	Excerpts describe a process or outcome of linking new information with previous knowledge or linking together two separate groups or bodies of knowledge.	"After taking my lab midterm and beginning to really go in-depth with the material for the next exam, I began to feel more comfortable with the reflex arc and its component functions. What I was conflicted about specifically had to do with the fact that the brain itself doesn't have a any real involvement nor is it given info when reflexes occur, although it is very much aware. I later remembered the difference between learned and unlearned responses, and a reflex being an unlearned response." Angie, Semester 2 Diary
4. Copying or re-writing	Excerpts explicitly reference the act of copying information, re-typing, or re-writing an instructor-provided PowerPoint or their own notes.	"To begin learning about the subject matter discussed in class, I take notes on the powerpoint slides that I print out prior to coming to class. After class I retake the notes in a notebook of the powerpoint slides and then a week before exams I outline the chapter of the book and review all of the notes collectively." London, Semester 1 Diary
5. Drawing or diagramming	Excerpts reference, either explicitly or implicitly, the act or wish for drawing or diagramming concepts, processes, or items related to the course. This may also include references to sorting or grouping of cards or other physical entities, as long as there is a visual representation of the sorting or grouping.	" I also wrote out the pathways on a white board and on paper to help see a visual representation of how they worked together." K Diddy, Semester 1 Diary
6. Engaging actively	Excerpts reference the act of participating in a learning activity that requires some type of specific cognitive activity. A common phrase in this code is 'figuring it out'. Excerpts may reference either an in or out of class activity and may be completed alone or in a group. This does not include the act of completing worksheets or answering questions from a book.	"They'll take the initiative and saying "hey, we're going to break down this... This process for you." So like with... Like neurophysiology, the process of like nerve impulse and like action potentials, they like at the beginning of one of the PALs were like, "hey, split up into groups" because it's different for like skeletal muscle versus smooth muscle. So they like split up into groups. This is like skeletal muscle- y'all put this together like in order of how these this process goes. Smooth muscle, y'all put this together in order. And we like went through it and they're like, "all right. So here the differences. Like here where they're similar" and stuff like that." Walt Owens, Interview 2

7. Integrating	Excerpts reference either explicitly or implicitly the process or result of seeing how parts of a system fit with the wholes. Common phrases may include "putting it together" or a description of how parts are related to one another.	"When they do line up I try to relate them. Because even if it's... Even if I'm not consciously going in my lab guide, or going to open lab to study for the lecture exams, I still can close my eyes and say, "okay. Yeah, like this happens in the nasal cavity because it's connected to this part of the body and goes through the pharynx. All that stuff." So I can close my eyes and picture it. But if I take an exam that I haven't... Seen, I've just seen things on his slides, the pictures, then I feel like I'm going to struggle with that." Waterskier, Interview 3
8. Quizzing yourself	Excerpts reference the act of or intention to quiz yourself, either alone or in a group. This is defined as using a bank of questions to test your own mastery of course material. The questions may be provided by the instructor, a PAL leader, another student or their resources, or generated by the participant. Excerpts also contain explicit reference to use of quizzing to get feedback on current mastery of material. This may include completion of course assessments with explicit mention of feedback for improvement. This may occur formally with the help of an instructor or teaching assistant or informally.	"So I like go through a chapter and then I will take the quiz on the chapter and I like don't look at anything. I just like try to take it like it was an exam. And so I do that and then see how I did. You know, then it's like you can see what you got wrong. So you can like go back in the notes and like look at what you got wrong and fix it. But I mean the first time I always try to just like.. I'll go over all the information first take the quiz on it, see what I got wrong, and then I'll go back and look at that." Caitlyn, Interview 2
9. Reading	Excerpts reference the act of reading the information from the course, either from notes, books, or other resources. This also includes reference the explicit description of the act of "looking at" written course materials, such as notes.	"To do this I have organized the slides and have started a word document that has key words in them. I am also going to go back to the chapters and look at the figures [they include] in [their] slides and read those sections to get some better understanding." K Diddy, Semester 1 Diary
10. Reviewing	Excerpts reference the act of reviewing the information, but provides no details to indicate specific actions or the level of cognitive effort utilized. Excerpts that state the participant "goes over" or "goes through" information are coded here.	"It's like even though it was very long [the time between lab practicals and quizzes in between them], we were still having to like go over that stuff, because it could still show up on the quiz." Shay, Interview 3
11. Reviewing between classes	Excerpts mention reviewing course material specifically in the finite time between class meetings either as something that occurs or as an explicitly perceived absence. Additional details of the actions taken may be present.	"Now sometimes [they]'ll give us questions in class, where [they say], you know, why? (pause) There was a question, you know, why do we have valves here but not here? So maybe I will go back before that next class just to like look at it before we go." London, Interview 2

12. Summarizing	Excerpts reference putting information into the participant's own words or summarizing information taken down in notes.	"It depends- so I kind of I separate them, but it's the same thing because what I do is like before class I'll type up the PowerPoint slides that I know we are going go over. And then I consider that like the outline because that's just the bones of it, basically is what's on the PowerPoints. And then in class, I add all of [their] notes and what [they say] and that is like what I consider the final study guide. And I kind of go through that and delete some of the other stuff that I know, that I know to just to make it a little cleaner." Kate, Interview 1
Expressing affect	Excerpts reference various affective traits and are divided into Positive and Negative and further subdivided to Content, Course Structure, and Instructor	
1. Positive affect	Excerpts specifically reference a positive emotion or reaction to the course. This may include, but is not limited to, fellings of interest or enjoyment.	
	A. Content Excerpts reference an interest or enjoyment level about the course or material by the student.	"This week I found lab to be the most interesting part. We did experiments on people's reflexes and it was very entertaining. I especially thought that the blind spot test was very interesting because I haven't ever really noticed it before." Kate, Semester 2 Diary
	B. Structure Excerpts reference positive feelings about the course calendar or pace, order of information presentation, or "the class" in general. There is no specific mention of the instructor in these excerpts.	"I think the technology that we used is really interesting and the experiment provides a good real-life parallel to the lecture." Caitlyn, Semester 2 Diary
	C. Instructor Excerpts reference personal feelings about the instructor, either the lecture instructor or lab assistant.	" I think [Instructor 2] is, like the professor. [They're] like really good. [They understand] that we're students, and I don't think like [they ask] too much of us. And like [they're] funny. [They keep] it like loose. [They] like [relate] to us really like well and interacts with us." Walt Owens, Interview 2
2. Negative affect	Excerpts specifically reference a negative emotion or reaction to the course. This may include, but is not limited to, feelings of frustration, being overwhelmed, stress, panic, or anxiety.	
	A. Content Excerpts reference an interest or enjoyment level about the course or material by the student.	"But when I try to quiz myself. I'm like, I don't know. (Laughing) And then I'm like starting to panic because its like more things you don't know than you do know." K Diddy, Interview 2

	B. Structure Excerpts reference positive feelings about the course calendar or pace, order of information presentation, or "the class" in general. There is no specific mention of the instructor in these excerpts.	"I think... In the beginning, I really felt like I could accomplish everything. You know, because school is not near as stressful and I was like, 'Oh, all right. This is fine.' Like I'm doing good so far and I can keep this up. And it's not that I don't think I can anymore. I just tried so hard and I just can't." Kate, Interview 2
	C. Instructor Excerpts reference personal feelings about the instructor, either the lecture instructor or lab assistant.	"So I'm like, I bet [they're] reading that note card thinking [their] judgmental thoughts, like... (laughing) the girl doesn't know anything. So, yeah, I don't know about those but I feel like I have to appreciate them because they're on the test." Kate, Interview 3
Facing distractions	Excerpts describe an outside influence that has prevented or conflicted with course effort or time spent on course tasks.	"So I think last semester, I was in... I had two very difficult classes that I had to be very committed to. I had Organic Chemistry one as well as this class. And I think I was very consistent in my Organic Chemistry studying and I was not as much so in this class. Which is... it makes it hard to keep consistent my other classes because so much time is devoted to this one. But I definitely see the more time I spend on it, the better I do. If it was the only class I was taking, I'd probably would be doing very very well, but it doesn't work like that." Waterskier, Interview 3
Focusing on details	Excerpts make reference "details," steps, or "small" items within the course material. This does not include specific discussion of content (such as describing a body system or mechanism), but participants discuss the need to know very particular information, either in reference to what is required for a high score on an exam or other assessment or in reference to the nature of the discipline or course in anatomy and physiology.	"I think... I think more of I wasn't expecting to.... need to know everything that [they] talked about but you do. So.... Really just knowing everything because you know, you can emphasize some things more than others. But I think that for like the first exam I was like, "oh, well, this probably isn't important." But you just needed to know everything. That [they] talked about that sort of thing." Michelle, Interview 2

Getting study advice	Excerpt references getting information, either solicited or unsolicited, from another person about how to study or approach the course material for better performance or understanding.	" So it's just kind of like dwelling on things, and like, one thing he's [Course instructor] taught me is like with the processes, like writing them on note cards and then putting the number on the back. And just like shuffling them up, putting them in order, taking some out, shuffling them, putting back in order again, until you get it right. And like another thing that he's helped me studying in that manner is... Once you shuffled it, put it in the right order, gotten it right.... Shuffled it again, taken a couple out, put it in order. Once you can do that three times in a row, five times in a row without messing up. You're done- put it away. Don't worry about it. You know it." Waterskier, Interview 3
Learning	Excerpts explicitly reference "learning". The term may be used as an outcome, goal, or process. Other goals or activities may be contrasted with learning, retaining or remembering. Subcodes align to participant definitions provided at interviews 1 and 3.	
1. Recall	Definitions from group 1 (defined as Acquisition of information only) or 2a (defined as acquisition of information and recall)	"Like whatever... Like I can just bring that information forward. So like if I were in a test situation, like I can just think about it, and bring that information forward. And I would say like that's whenever I know like I've learned something. Like, whenever I can just think about it and its there. I don't have to like dig." Caitlyn, Interview 2
2. Understand	Definitions from group 2b (defined as the combination of acquisition of information and understanding)	"I mean, I definitely have learned a lot. I haven't memorized every little detail, but I can definitely talk about some overall concepts and things that I couldn't before." Kate, Interview 2
3. Apply	Definitions from group 2c (defined as the combination of acquisition of information and application)	"Because most of the time I just leave after an hour because I took my pictures [of the models in the lab] and I just can learn it on my own." London, Interview 2
4. Outcome only	Definitions from group 3 (defined as the outcomes of recall or application only)	"But I also think I am actually like learning the material. Like I remember stuff from like previous units... Like not as well, because I've been focusing on the other stuff now, but... I definitely like do know the material." Shay, Interview 2
Meeting with instructor	Excerpts reference all meetings with the course instructor in a setting outside of class. This usually occurs in an office and also includes the act of visiting office hours. Contents or events reported from the meeting are captured by additional codes to assigned to relevant excerpts.	"Anything I was confused about I googled YouTube videos that further explained them or went to [Instructor 1]'s office hour and asked [them] questions." Michelle, Semester 1 Diary

Memorizing	Excerpts make explicit reference, either positively or negatively, to memorizing. This may include reference to specific content or practices to achieve memorization of material or may indicate the presence or explicit absence of desired memorizing. Subcodes align to participant definitions provided during interviews 1 and 3. Excerpts from groups 2 and 4, which reference repetition in the definition were also coded to "Using repetition".	
1. Recall	Excerpts previously coded here were combined to the "Remembering" code.	
2. Short-term memory	Definitions from group 2 and 4, which defined memorizing with the specific outcome of gaining short term memory.	"The most difficult thing so far this week is trying to memorize everything from last week." Kate, Semester 1 Diary
3. Not understanding	Definitions from group 5, which defined memorizing as a direct contrast to understanding.	" I believe that some of the material I simply memorized, without understanding, and that is why I do not have an A in the class." Walt Owens, Semester 1 Diary
Minimizing time	Excerpts reference acts or awareness of the amount of time required by a task and also include mention of steps to shorten the duration.	"But the problem with "Learn" and the multiple choice and the typing thing- it takes a lot of time. So like- sitting there like picking and then if you accidentally click the wrong thing- it like pushes you back like a point, just like based off of points. And then you have to like keep redoing it. And it does that because it thinks, like you legitimately got it wrong and it just wants you to do- like the repetition will help you remember it. So I when I'm on a time constraint, I just need note cards and just like going through this really quickly." Angie, Interview 1
Needing an explanation	Excerpts reference needing additional explanations or feedback in order to understand the course material and there is no description how those questions will be answered. This differs from 'Accessing explanations' since the participant recognizes that they have questions and those questions are currently unanswered.	"If you didn't understand what was said in lecture, It was very hard to teach yourself afterwards. And I don't know if that's because, I did have an older... Like last year's textbook. But it's because textbook wasn't even, like required. So I just like paid less for last year's. So it was hard for me to be able to go into text book and learn what [they] had said." Tigers123, Interview 2
Planning	Excerpts reference the act of scheduling or planning for how time will be spent in preparation for an exam or other course requirement or activity. This differs from 'Endeavoring-Struggling: Time management' because the participant does not reference a lack of time, but is mentioning pro-active steps they are taking to complete course requirements.	"But I basically, I'll create when I'm studying for anything... Like I had three exams last week and I'll just create a GoogleDoc of like what all I need to do for every single test and how long each thing's going to take." Kate, Interview 3

Ranking of processes	Block Code: Excerpts contain participant rankings of the terms learning, memorizing, studying, and understanding. It may also include comparisons or additional clarification of the rankings. Since this was a card sorting activity, excerpts may have few words of the participant as the interviewer states for the recording how the cards are ordered.	"I think definitely understanding is important. Because we do talk about a lot of processes. Like you can get away with just memorizing, which like, I have in this class for some of it. But like, when I find that I actually understand, like, the blood. Like I did a lot better on that section of the test because I knew it. Studying I think it's like second, third... Yeah, I would say studying is like second. Just... Just like without like actually taking the time to study, and without actually taking time to like try and learn the information... Like you're not gonna like learn it. And so like learning and studying kind of go together, I would say. And then memorizing would be last. Just because like you can get away with just kind of knowing it for a test, but... A lot [00:29:00] of it kind of does build on itself, especially... But certain aspects... So..." Walt Owens, Interview 3
Remembering	Excerpts explicitly reference "remembering", "retaining", or "knowing" course information as an outcome. Also included are excerpts discussing "memorization" from participants providing definitions for that term from group 1 and 3, which defined memorizing with the outcome of use or recall of information.	"I think the hardest part of this information is remembering not only the anatomical process but the physiological processes as well." Caitlyn, Semester 2 Diary
Seeking effective study methods	Excerpts reference specific changes to study methods or a continuing search or openness for new ideas or methods to study or learn the course material. Excerpts specifically reference ideas about practices for study, not the act of carrying out any of the methods.	"I feel like I'm still trying to figure that out. (pause) I think taking time, like I keep saying. A lot of classes you're able to study for the day before and do- at least for me- I'm able to study for most of the day before, but biology that is never the case." Sally, Interview 1
Studying	Excerpts explicitly reference "studying" and they provide little or no information about the details of that process. References may be positive, negative, or indicate an absence or lack of studying. Subcodes align to participant definitions provided at interviews 1 and 3.	
1. Action	Defintions from groups 1 and 2, which defined studying as either a process or a use of time.	"Yeah, it's definitely a lot of studying. I think I study for it a little bit every day. And then I really study for it more than any subject I'm taking right now." Angie, Interview 1

2. Leads to test	Definitions from group 3, which defined studying as some type of action leading to an extrinsic outcome, e.g. test	"So... I have a lot of breaks in my schedule. So for when I have... Other things going on, I have to like... Divide my time between you know. And so, like that time I only had Anatomy so every single break I had, I was just studying Anatomy. So if you put a lot uh... That much effort into it you're going to do better." Michelle, Interview 2
3. Leads to memorizing	Definition from group 4a, which defined studying as some type of action leading to memorization.	"Okay, like I can't separate which one you need more. Like, I think it all takes studying and like that is really crucial to the class." Sally, Interview 1
4. Leads to understanding	Definition from group 4b, which defined studying as some type of action leading to understanding.	"These have given me less time to study for the class. However, they have improved my time management skills for studying." Shay, Semester 2 Diary
5. Leads to memorizing and understanding	Definition from group 4c, which defined studying as some type of action leading to understanding and/or memorizing.	" Basically when you are memorizing your studying like- you're working off of ummm, like different terms in order to learn the material. So it's like how you're studying for it. And I mean you're learning when you're like, connecting them together. And so that's like studying for that and then ummm, understanding's when you're really like testing yourself. Like do I actually know this material, and can I pull examples from it? And like connect different questions to it? I think that's all part of studying because, it's just kind of like one big like, there are multiple like branches off of it if like... Doing all these things are helping you study for the class." Shay, Interview 1
Studying with others	Excerpts explicitly reference participation in a study group (either formal or informal), reviewing information in a group, or using other learning tools in a group. There is also a lack of explicit reference to the acts of discussing or explaining.	"Yeah. Me and... I don't know really what has been... I guess my two friends and I like we have... Like last semester, we had basically every class together. So I feel like we would always kind of be studying together, like in the library or whatever." Caitlyn, Interview 3
Taking notes	Excerpts reference the act of taking notes and what students are taking down or would like to take down at exposure to information during a class period or while viewing the lecture via a recording. This may include hand writing or typing on any destination (paper, printed PowerPoint notes, on the computer, etc.) and may reference changes in the processes or types of notes taken by the student.	"Something I did do different now- I would print my PowerPoints and bring them to class. And I would take hand written notes. Then I realized that I can't write fast enough to some of the things [they say]. So I stopped doing that. I would still print my PowerPoints but I would just bring my laptop to class and just take typed notes because that's so much faster and I could type a lot faster than write." Angie, Interview 2

Talking it out	Excerpts reference the act of talking or explaining, including explicit or implicit reference to conversations with ones self, classmates, tutors, or a peer about course material in any setting and with any number of people. Can include self-talk, one-on-one conversations, or conversations in bigger groups. It includes, but is not limited to, explicit or implicit reference to the act of "explaining or teaching someone else", "talking it out", or "discussing".	"Yeah, so I've had friends who... I'll ask a question about a process and they'll say 'no it's this way.' And I look at my notes and I'm like 'no no, it's this way and let me like, like explain why.' So we'll walk through like, 'Okay. Well first the receptor binds to the ligand. And then a conformational change occurs.' And so I think that we usually like to use white boards too. And I'll be like, 'this step and this step' and so by repeating it and then they kind of repeat it back, it makes more sense to both of us." Angie, Interview 3
Timing	Excerpts either provide specific amount of time spent on a course task, give the timing of tasks in relation to other course activities, reference "time" and provide little or no information on how the time is used. This differs from "Struggling- time management" in being a matter of fact retelling. There is no mention of lack of time, "didn't spend as much time", or similar sentiments. Excerpts are focused on the raw of amount of time rather than whether it was "enough".	"So usually I budget the outline taking me between 10 and 12 hours if I'm watching all the lecture videos again. Which it typically does by the time I rewind all it and stuff. And that's if I'm doing it straight through. And then... But now that I'm not doing that, it takes me about probably 30 or 45 minutes to type up the notes before class. Because I'll add pictures in there... And I don't know just going through the slides." Kate, Interview 3
Understanding	Excerpts explicitly reference "understanding". These reference may refer to an intended outcome or process. Subcodes align to participant definitions provided at interviews 1 and 3.	
1. Teach or explain to others	Definition from group 1, which defines understanding as teaching or explaining the content to others.	"I think [Instructor 2] tries to make it like, somewhat entertaining. [They] definitely like breaks things down for you, so you're able to understand." Shay, Interview 1
2. Apply or connect information	This code was merged into "Engaging course material-applying" since they had identical definitions.	
3. Knowing details	Definition from group 3, which defined understanding as knowing details and being able to recall or retell them in depth.	"I would definitely really like to just... Understand everything about the human body. I think it's really interesting and I want to be a physical therapist." Kate, Interview 1

Using provided resources

Excerpts reference specific items that are provided or recommended by the course instructor. Course resources have a specific tie to a recommendation or provision by the instructor, a teaching assistant, or the university. They may be mentioned in class, on the course syllabus, or within the course LMS page. When course assessments are coded here, there is explicit reference to using that material for study or learning, rather than solely the act of completing the assessment.

1. Instructor PowerPoint
2. Lab Notebook, Atlas: lab materials, handouts, or background material
3. Lecture objectives (A&P1→2 only)
4. Library Reserve items: bone box
5. Mastering and Practice Anatomy Lab (A&P1→2 only)
6. Open lab
7. Miscellaneous
8. PAL (Peer Assisted Learning)
9. Recorded lectures (A→P only)
10. Study guides (lab only)
11. Textbook
12. Tutoring
13. YouTube channel (A→P only)

"I just- I rewrite the PowerPoints with all my notes, that's what I like to do. And then, listen to lecture again. And like, add in anything I have missed- I like to write it... write out PowerPoints multiple times." Michelle, Interview 1

Using examples/mnemonic devices	Excerpts make explicit reference to a student's knowledge or use of examples or mnemonic devices in relation to course material.	"And like coming up with.. little tricks and tips, acronyms, things like that... to remember the things that I don't forget. A lot of times me and Gretchen will come up with things, and it's like... This is alphabetical this way, but what it corresponds to is the opposite way, so it's backwards. And then there were like three layers of... Inside of the uterus, I think? I don't know. There was some, some organ that had three let... Like layers and the words were really weird. And we just came up with like a... An acronym, I guess? Like GFR, I think it was or something like that. Oh, what was that? It was like the zona, granulosa, and reticularis, and then whatever that F is. Just like the order of that, so like coming up with like things like tha,t like easy ways to remember things." Waterskier, Interview 3
Using outside resources	Excerpts reference the use or awareness of online or offline tools that have been located by the student or their peers. There is no connection of this tool to the instructor or teaching assistant. 1. Chegg 2. Google: This includes all general references to searching for an answer on the internet, in addition to specific mentions of Google 3. Other people's resources: Includes notes, study guides, or worksheets but are specifically from another person, but not an instructor. 4. Quizlet 5. YouTube videos	"My lab group- one of the girls has the Premium, I guess you would call it. And the only function I use.... I've seen that is good for that is you can upload your own pictures. So, which [they] would take a picture of a model in lab. And there's an option to like... Draw out like a space. So [they] would point to like a specific part of the model and that's how we would study the models- if we couldn't go into lab and study them like in person. So that was really neat for Quizlet and that's not an option for like the free subscription. So, that's what I would use." Angie, Interview 2

Using repetition	Excerpts make explicit reference to "repetition" to describe a technique or their own practice. Some excerpts are included based on the participant's definition of memorizing which specified use of repetition (Angie- semester 2, Caitlyn- semester 1, Shay- semester 2)	"I feel like I'm pretty good at memorizing things. So if I just like repeat them over and over again, I feel like eventually I can like.... If not, just memorize it it's like if I see it on my exam, I can be able to like think back like, "okay, I saw this word like in my mind like what did I see with it? Like what definition do I have?" Like try to like... I don't really have like a photographic memory like that. But like I can visualize things sometimes so it can help if I'm really at a loss or something like that." Caitlyn, Interview 2
Using specimens	Excerpts reference the use of physical specimens (living, plastic, or dead) or photos of specimens.	"So like for example, right now we're doing bones and so like this past week, they gave us like a box of bones. And like we have an objective sheet, and like okay, like just 'play with the bones, like take pictures of you need them. You need to know all this stuff. So here in lab we're going to give you that opportunity to learn it.' " Walt Owens, Interview 1
Visualizing	Excerpts make explicit reference to the act of or use of "visualization". This can include using other resources, such as diagrams or videos, or to picturing specimens in the participant's mind.	"But before that I'll use the coloring guide and I'll go through that, because it has some of the processes that then just helps me visualize the things that we've learned auditorily... like by him lecturing." Waterskier, Interview 2
Wanting to handwrite	Excerpts contain explicit reference to the desire of the participant to write notes or other information out by hand with mention of a reason for doing so that is linked to outcomes, such as supporting or encouraging their learning.	"Writing my notes by hand has helped me a lot in understanding concepts, especially when trying to distinguish key words or phrases, for which I try to write down with a different colored pen or highlight." Angie, Semester 2 Diary

Table J3: Axial codes assigned during second round coding.

Code Name	Definition/ Bounds	Example
TASKS OR ACTIONS		
Absorb information	Excerpts reference the passive receipt of course information in any setting. This may include references to "paying attention," attending class or watching lectures, or taking or copying notes. In all cases, there is no evidence of additional cognitive engagement beyond retaining or holding onto the material. An instructor resource may be mentioned but is not the focus of the excerpt.	"She has recorded lectures for people that miss lecture and although its the same thing... Maybe you like just want to hear [them] say it again. " Angie, Interview 1
Alter study habits	Excerpts describe the action or intention of changing or switching study habits. This may include additional information about the specific changes being made or may only include a general discussion of changes with no specifics.	"I found that using a big study guide was the most effective for the course material of this class because it broke down the information into sections with plenty of content. This helped me study all the material in each section but also breaking it up so that it was not too overwhelming. For exam 1 I used the powerpoint slides and my notes, and for exam 2 I used the notes and the book, but I think from exam 3, the study guide was better because I included more information and went over the information multiple times instead of slowly working through the material and getting through it once or twice." London, Semester 1 Diary

Engaging with material	Excerpts reference an act that involves encountering, wrestling with, or working with class material in any setting. This may include reference to drawing, quizzing, answering questions, revising/ summarizing notes, recalling previously learning information. In all cases, additional mental engagement must be evident in the task or action. Some participant quotes are included here due to definition of Learning, Studying or Understanding.	" It's like through, I guess, when we're going over everything. So like, the way they write the worksheets is like your forced to like go step by step. And then a couple of the times, they have said like we've asked them, "hey, like, we're confused about this" and they'll ask us, "what are you confused about" or like wit... They'll take the initiative and saying "hey, we're going to break down this... This process for you." So like with... Like neurophysiology, the process of like nerve impulse and like action potentials, they like at the beginning of one of the PALs were like, "hey, split up into groups" because it's different for like skeletal muscle versus smooth muscle. So they like split up into groups. This is like skeletal muscle- y'all put this together like in order of how these this process goes. Smooth muscle, y'all put this together in order. And we like went through it and they're like, 'all right. So here the differences. Like here where they're similar' and stuff like that." Walt Owens, Interview 2
Getting outside help	Excerpts reference the solicited or unsolicited explanations or assistance in mastering course material received from instructors or others in any setting, which may be in-person or virtually.	"So I would go into [their] office and I go through everything I starred. And then I would hit on not only lecture things... I had questions for lab as well. So I would just do both." Angie, Interview 2
Hands on Tasks	Excerpts reference any use of physical specimens (living, plastic, or dead) or participation in experimentation. Use of photographs of specimens is not coded here.	"So I think what I like about lab is the fact that there's so many diagrams that are open to us. They open labs when we don't have lab so you can go in and relook at models... Everything like that. I think that's very, very important." London, Interview 2
Opting out	Excerpts reference an explicit choice to not utilize or give attention to specific course content, instructor presentation, or available resources in any setting related to course material. This may occur during class meetings, study groups, or individual encounters with material.	**SNJ:** You've listed Reserve items in the library as last in the lab in importance. Can you tell me why that's there? **Participant:** I... Because of the same thing, which is... Whenever I'm... I mean, they... I didn't use them. Michelle, Interview 2
Time crunch	Excerpts reference actions related to competition from other tasks or not having adequate time to master material or complete a course requirement.	"I have had to balance studying for this class along with studying for other classes. I have a job and am part of a couple of on campus organizations. These have given me less time to study for the class. However, they have improved my time management skills for studying." Shay, Semester 2 Diary

Use instructor provided resources	Excerpts reference the use of a resource provided by the instructor to the students in the class. This may include the act of loaning, documents containing course information (such as instructor study guides or lecture objectives), items placed on Library Reserve, or online or virtual tools recommended or created by the instructor. Photographs or specimens and reference to PAL sessions are also included here.	"[They have their] own YouTube channel of, when [they explain] concepts. So going through... Some of those videos. [Instructor 1] has recorded lectures for people that miss lecture and although its the same thing... Maybe you like just want to hear [them] say it again." Angie, Interview 1
OUTCOMES		
Awareness of discipline	Excerpts reference a new knowledge of the depth or breadth of information included in anatomy or physiology.	"What has happened that I didn't expect? Um, like I guess just the amount of information. Like, I guess I just didn't realize how much was in your body. (laughing) And I didn't realize how much we were going to have to learn. Like, when I read the course, it was Functional Human Anatomy. How to function, like human anatomy. I didn't think we were going to have to know... Every little thing. That was my thing, I guess." K Diddy, Interview 2

Application	Excerpts reference an existing knowledge object formed a combination of previous knowledge, course content, real-world experience, or career aspirations. A stated connection between any of these groups is required for inclusion. Some participant quotes are included here due to definition of Learning, Studying, or Understanding.	"And like going forward and obviously that's why we have to take it. But it definitely just like... Excuse me, there are like weird things that like... I connect the anatomy too. Like I went to the doctor today. I have this like, I hurt my shoulder and she's like talking to me and she's like, "yeah this, that yours got I mean shoulder" and I'm like "I'm in anatomy... Just science." (laughing) "Speak science to me because I'll know what you're talking about." Way better than if you try to like make it make sense to someone that like doesn't study biology and the body. So that's like a cool thing, to like understand and like... Like when my dad, my dad had.... umm vertigo last summer. And I had only taken that basic biology course, but then when he told me that he was doing physical therapy for his inner ear, I was like, "Oh, I know how that affects your balance and why you're so dizzy." And it all just makes sense. So then I like... We learned about that again and like... It just builds on top of like all these situations that are happening all the time. Whether it's like... Like... I trying to think... (pause) Yeah, just like relating it to my everyday life. Kind of like how I move, how I... Just how everything relates to each other. Because I feel like a lot of people don't... Really know how to like... Better them... Better their health and... Because just everything that I've been doing this past year has to do with Health, Fitness, Wellness. And just maintaining that, the balance of everything. So like, it all comes full circle when you know how that affects your body." Waterskier, Interview 3
Completing assessment	Excerpts reference completion of an assessment, such as an exam or quiz, in the past, present, or future. This may also include the impact of an assessment on the overall course grade or another outcome, but specific grades are not provided.	"However, writing out the materials and methods for this lab report took me three hours, because the instructions were so long, even though its sort of just transferring information. I understand why its important to be able to do, but as a biology major I have done it many times before and thought my time could have been better used." Michelle, Interview 2
Confusion	Excerpts reference the state of confusion or difficulty related to the course material.	"One of the most confusing topics on this exam for me was the content on pathways. There were many different divisions, types, and technicalities that made it hard to understand." Caitlyn, Semester 1 Diary

Fascination with content	Excerpts reference a participant's interest or fascination with course content but provide no details about the content. Passages that express these sentiments along with details of the content are coded in "Content knowledge".	"I do because I like... I do love, like I love like everything biology. I really do. Like I really love learning about the body. Like I think it's so interesting, like especially like this class in the Cell Biology like... Sometimes when I'm studying I'll just sit back and be like, "this is literally all happening inside my body right now." And I just like don't... Like, like it's just happening! Like and you don't know it but it's like... You wouldn't be surviving if it weren't- type of thing. So I think it's like so interesting." Caitlyn, Interview 3
Less-than-hoped class performance	Excerpts contain reference to a 'less than' or 'disappointing' performance in the class overall or on a specific assessment. Grades less than A are coded here if the participant provides no other indication of their opinion of the performance.	"I think if you look at it in the scheme of college classes, I think it's going fairly well. Like I am not doing terrible in it. I'll probably end up with a B. I feel like I'm able to accomplish a decent amount. Like get decent scores on everything and pay attention and go to class. And I feel like the class is structured fairly well. Like [they know] what [they're] doing... Just compared to some of my other instructors and stuff. In the scheme of like the physical therapy and life goals, like I said, I don't think that I'm quite reaching MY expectations for that. But I think that they were probably unrealistically high to begin with, because everyone knows that college is difficult. And that it's hard to really commit that much time to one thing. So... But I mean overall, I'm sure I'll come out of this class with a pretty good like basic understanding of overall anatomy. And then maybe when I go to PT school, that'll be the time for me to really memorize everything. So..." Kate, Interview 2
Remember	Excerpts reference a general mental "storage" of information by the participant without reference to the specific content with the ability to recall that information.	"I think it's kind of giving me a different way of like learning or like approaching questions, kind of. I think [theirs] are... There less like... This happens, what's like the answer. Or like what is like this? [Instructor 2] like kind of makes you like integrate it into the questions. So you have to think... Like one of the... Questions we had on our last test was asking like, like "how is calcium not used?" So I had to think of all the ways that like calcium was used, like it goes into like neurons, it makes the neurotransmitter come out. So I had to think about all those different ways rather than it being like "is calcium used with this?" Like something like that, you know. It made me like actually go through like each of the different things that it could be used for." Shay, Interview 2

Remember/ Understand	Excerpts provide details or specifics about course content or information. No connections to outside information are evident. This may in response to a prompt or question asking about what was learned or covered in a previous week or session or describe the outcome or process of retelling information. Some participant quotes are included here due to definition of Learning, Studying, or Understanding.	"We just took our second practical in lab this week. We were asked to label and discuss the structure and function of axial muscles, appendicular muscles, special sense organs, general senses, neurons, cranial nerves, microscopy of skeletal muscles, connective tissue coverings, levels of muscle, types/naming of muscles, skeletal muscle fiber anatomy, neuromuscular junction, cytology of nervous tissue, neuron classification, myelination, gross anatomy of the brain, gross anatomy of the spinal cord, spinal nerves, microscopic anatomy of the spinal nerve, nerve plexus, sheep brain dissection, and cow eye dissection. There was no direct connections to homeostasis in lab. We were mainly responsible for identification and general function." K Diddy, Semester 1 Diary
Successful class performance	Excerpts contain reference to a 'successful' overall or specific performance in the course or an assessment. 'Success' is either a grade of A on the specific product mentioned or is defined in this manner by the participant.	"But I can kind of feel to just going into the test how well I'm going to do. Actually... and even... I don't know... It's hard to tell because even for the second exam which I got a 90 on, I was so scared going in there. Like I did not feel very good. But the first exam I felt really good about." Kate, Interview 2
Understand	Excerpts describe the state of being able to explain course material to someone else. Some participant quotes are included here due to definition of Learning, Studying or Understanding.	"Furthermore, I benefited best in lab from participating in the dissection of the cat hands on instead of just watching. Also, we had a short group quiz at the end of lab to test our knowledge from that period. This forced me to focus on the dissection specifically and understand what I was looking at." Walt Owens, Semester 2 Diary
TASKS/ ACTIONS CONNECTED TO AN OUTCOME	Excerpts demonstrate one of the "Tasks or Actions" listed above in conjunction with one of the "Outcomes" listed above.	
FEELINGS/ AFFECT	Most of these codes were separated into Positive and Negative Feelings/ Affect, which is indicated in parentheses within the definition.	
Amused	Excerpts reference events or situations within the course that a participant finds amusing. This may be indicated by explicit words or verbal cues, such as laughing.	"As this topic can be "funny" to some students as our professor suggested, [they] wanted this to be serious and informational. In order to make us more comfortable this week about the topic we shouted "penis" and "vagina" three times each so that we could get out all of the giggles. While this activity may seem weird or funny, I think that it actually helped clear some of the tension in the room and I also think that it helped us get more comfortable with our professor and the discussion of the topic." London, Semester 1 Diary

Confused	(Negative) Excerpts reference, either explicitly or implicitly, a state of confusion or not understanding course concepts, policies, or order or presentation.	"I tried to make my own flow chart but I ended just getting even more confused and I have class during all of [their] office hours and other tests I had to study for so I ended up giving up on that idea." Kate, Semester 1 Diary
Determined	Excerpts make a specific mention of steps they have taken or are willing to take to succeed in the course or in their chosen career. If referencing future plans or career, the steps taken are being influenced by some aspect of the A&P course.	"Last semester was not easy for me, my GPA did not end up as I had hoped i would... therefore the realization was that I need to apply myself more and try to overcome the obstacles put in front of me by [C]lemson [U]niversity, one of these being this course. I have more motivation to conquer this course." Caitlyn, Semester 2 Diary
Discouraged	(Negative) Excerpts reference events or situations in which the participant expresses discouragement or disappointment. Phrases such as being "out of ideas" or not knowing what to do are also coded here. Anger or frustration about the situation or event is not evident.	"Like I work my butt off because like I have a huge passion to be a nurse and... I don't want to do bad at Anatomy. And like, you know, like that's kind of something... that like you shouldn't be bad at if you're trying to be nursing. But at the same time, it's just like this class has got so much stuff like... Not that I feel like I'm not going to need but like, it's just like... So much extra stuff that like I'm not sure I'll ever use. But I don't... I don't know. I really don't know. It's just a lot." K Diddy, Interview 2
Encouraged	(Positive) Excerpts reference events or situations in which the participant expresses encouragement or happiness about some aspect of the course. This code is the opposite of "Discouraged."	"But once we realized that [they] would explain these Powerpoints in more detail and like... [They were] just kind of showed that [they were] passionate about it. It made me want to pay attention and actually learn. And so I would leave lab knowing like "yeah, this is you know, the parts of the vertebrae" but I understood like why they are the parts. And how it fits into like the system. And I felt better knowing that I didn't have to study as hard after lab because I knew it in the moment. And then when I would go review I would remember like "yeah, I remember learning this in lab" like and have to yeah." Angie, Interview 2
Enjoyment	(Positive) Excerpts reference a state of liking, enjoying, or loving some aspect of the course. This may also include finding events or content "cool" or "fun."	"I think that I was like very, very nervous about this class. But I've come to see... Like I just enjoy it more." Caitlyn, Interview 2

Frustration	(Negative) Excerpts reference, either explicitly or implicitly, feelings of frustration, annoyance, or anger. Some passages may describe events or situations that they find "unfair."	"And like I just remember sitting here talking with one of my friends, when we were supposed to be studying and saying "this is physiology." Why are we talking about this in anatomy, and like getting really frustrated because we're like, this is not we're like trying to focus on right now. We're trying to focus on Anatomy. And there's some people who are just taking the anatomy part and not taking the physiology part. And like my friend, she's already taken the physiology part. She's like "I don't want to talk about this. I've already learned this' " K Diddy, Interview 2
Interested	(Positive) Excerpts reference content, either specifically or generally, that they find interesting. Other Affect codes may also be present, but explicit mention of interest moves the passage to this code.	"The material is definitely more interesting to me. I guess it's something that I'm like, I'm going to need to actually know. Forever, you know. So I think... it's easy. It's a lot easier for me to study when I'm interested in it." Michelle, Interview 2
Not fun	(Negative) Excerpts reference explicitly not liking or hating the course content or another aspect of the course. Passages may also reference some situation or event related to the course as "boring."	"It just feels really inefficient and is pretty much the most boring thing ever but if that's what I need to do for a good grade then I guess that's what I am going to do." Kate, Semester 2 Diary
Overwhelmed	(Negative) Excerpts reference, either explicitly or implicitly, a state of being overwhelmed or stressed. This may be manifested by giving up or stopping an activity the participant cannot keep up with or describing the pacing, amount of content, or other aspect of the course as "too much."	"So as we've gone into the semester the processes have gotten longer and more complicated. We can hit like three different systems just for one... one exam. So, like its really overwhelming and I could sit down and like look through my PowerPoint notes, but I have found that when I write it and like I'm actively understanding what I'm writing." Angie, Interview 3
Worried	(Negative) Excerpts reference a state of being worried or scared by some aspect of course content, policies, or events.	"I did not spend enough time studying for this exam and I went in very worried, I read through my notes and went over [P]owerpoints, however I should have been reviewing more throughout the unit while learning the material to have a better mastery of it." Waterskier, Semester 1 Diary
SELF-IDENTIFIED SHORTCOMINGS	Shortcomings must be something done by the participant that they believe should be done or has been completed but not to their standards.	

Mastering content	Excerpts reference either specific course content or general processes in the course content that have not yet been understood or mastered.	"The specific of the brain, or even more so, the cranial nerves and each of their functions. (This might fall more so under lab and what we have to know for that). There also is just a lot of information to know and understand that relates to the spinal cord and the nerves within the spinal cord; the hardest thing here for me to grasp has been the spinal nerve reflexes." Sally, Semester 1 Diary
Following along	Excerpts reference an inability to keep up for follow along with the train of thought presented during a lecture or lab period or while completing any course assessment. May include reference to "confusion" or mention the speed at which information is being presented in a class meeting as a deterrent.	"Okay, so for lecture, I've found that going through and watching the recorded lecture, I can, of course, pause the video. And because [Instructor 1] like will go through something really fast, I can backtrack and like replay it and replay it until I understand what [they were] really saying. While you know, like I can't do that in the moment in lecture. Which is why it's least important for me- to I still... I attend lecture but I don't think I captivate as much sitting there, as well as I can like sit in the library and go through it like a recorded lecture at my own pace and understand each section of what [they] said." Angie, Interview 2
Lacking focus	Excerpts reference the inability to pay attention or focus on the speaker, the material, or anything else related to the course.	"I think the recorded lectures is probably been the most important because, I struggle a lot with even being able.. Which is half the time... Well, I go to class pretty frequently, but sometimes I just have a difficult time paying attention. And 50 minutes isn't that long but for some reason, some days I just really not feeling it. And so those recorded lectures when I know I can take the time and just really sit and focus on exactly what [they're] saying. And then also if I miss something, sometimes I get frustrated because I'll be typing so fast and [they're] still going. So that allows me to go back and make sure I get everything [they] said. And just kind of really focus and make sure I'm listening to it." Kate, Interview 2
Lacking help	Excerpts reference the need to additional help that is not available or present.	"I really would have loved to have a PAL leader for this class. Someone to explain it in their own way and make up questions and worksheets would have been so helpful." K Diddy, Semester 1 Diary
Performance (less than hoped)	Excerpts contain reference to a 'less than' or 'disappointing' performance in the class overall or on a specific assessment.	"Lab quizzes are joke. Like... It's 10 questions on the lab the week before. And you're expected to remember three chapters... Three or four chapters in a week. It's not possible. And I... Fail every single one." Kate, Interview 2

Recognizing important content	Excerpt reference a struggle or inability to identify or recognize which content is important or required for success on course assessments. Passages may include examples of content that was important but was not recognized as so until after receiving a grade on the assessment.	"The most difficult thing so far this week is trying to memorize everything from last week. We have to learn all of these different muscles and muscle attachments and I found it to be relatively unclear how specific we have to be with the muscle attachment sites on the anatomy lab practical. Lecture has been relatively straightforward but I am definitely struggling trying to memorize everything for lab." Kate, Semester 1 Diary
Remembering	Excerpts reference a lack of remembering material, usually related to preparing for or completing a course assessment.	"Lab quizzes are joke. Like... It's 10 questions on the lab the week before. And you're expected to remember three chapters... Three or four chapters in a week. It's not possible. And I... Fail every single one." K Diddy, Interview 2
Study method	Excerpts reference an issue with a chosen method of study. They may discuss preferred or previously tried study methods and changes made to accommodate the current course or reference a lack of using a particular method to master the course material	"I wish I had re-watched the lecture videos for the first exam because I because I didn't really think about it till others told me that they were doing that." Michelle, Semester 1 Diary
Test or quiz questions	Excerpts reference the structure or wording of a question on an assessment that has caused an issue for the participant.	"On the last exam, I had a difficult time on the fill in the blank portion, specifically on the question that began with a special sense and its process throughout the brain. While the beginning portions had enough context clues for me to figure out which special sense it was and its function, the remaining parts had to the with the location of the sense in areas of the brain. I believe the wording of those sections were misleading for me. Although I knew where the special was located overall, I was not able to figure out whether the next parts asked for where it passed through or where it would be passing through after another specific part. Overall it was very confusing, and although we have the ability to ask questions for clarifications on questions I always leave the fill in the blank parts for very last. By the time I realized I would not be able to figure this out on my own, in the last 15 minutes of the exam, we were no longer able to ask questions." Angie, Semester 2 Diary

Time management	Excerpts reference a lack of time to properly prepare for or complete assessments. Passages may also provide examples of not being able to manage the demands of all of their courses and other responsibilities in a way that allows for a satisfactory performance in their anatomy or physiology course.	"I've been out of town a lot this semester, on the weekends and that's when one of the PALs is. And then, one of them is on like Tuesday nights and Tuesdays are like my really long days, and so it's like... Like I usually can't make it or it's like I kind of want to take a little bit of time just to like relax before I do the next thing. And then, just like involved with a couple extra curriculars here at school that have kind of like taking that time." Walt Owens, Interview 3

Table J4: *a Priori* Codes - Study Process Questionnaire [Biggs et al., 2001]

Code Name	Definition/ Bounds	Example
Deep	Excerpts explicitly or implicitly reference making connections within the material or understanding. This may also include explicit reference to the fact that memorizing isn't important or comes along with understanding. This may also include passages with no mention of memorization.	"I would definitely really like to just... Understand everything about the human body. I think it's really interesting and I want to be a physical therapist. So it's important to know how everything works together and how different people's injuries could affect their anatomy and how that could be treated, so...." Kate, Interview 1
Surface	Excerpts explicitly reference individual chunks of information from the course and a lack of long term retention.	"I feel like right now I'm not like remembering it because it's like 'okay, I gotta remember this for the test' and then it's like 'okay on to the next thing'. " K Diddy, Interview 1
Surface to Deep	Excerpts reference memorizing course content as a basis for learning. These may also reference understanding, applying, and connecting course content.	"Okay, so I feel like- yeah for memorizing like you have to know certain terms to be able to build on things. Like if you don't know what like "epithelial" means like- if you don't know that or like the two types of it... Then you're not able to apply it. So like, what it can do and things like that. So I guess that's uh- like the basis of it... And I want to know those terms you're able to know like you're able to like learn them and figure out how they connect together like so... "Oh like these two different things are related." So, you know the definition of them and then you know that they were like related then and kind of how they tie together." Shay, Interview 1
	Codes Aligned to R-SPQ-2F Items	
1. I find that at times studying gives me a feeling of deep personal satisfaction.	Excerpts provide a qualitative answer to the question presented in survey item 1. Feelings about studying or explicit references to studying are required.	"I'd say memorizing is my personal favorite because that comes easiest to me... And then after that, I would say studying. I feel like studying also goes along with memorization." Shay, Interview 1
2. I find that I have to do enough work on a topic so that I can form my own conclusions before I am satisfied.	Excerpts provide a qualitative answer to the question presented in survey item 2 and was divided into two sub-codes of "do enough work" and "form own conclusions".	

2a. Do enough work.	Excerpts explicitly reference time, but not specific amounts. Passage indicates a recognition of getting to a certain point in the work and decided that was enough due to a specific choice of the participant or other constraints. May also include references to participant's intention with their time.	"Try to go through- like I, I try to go through like a chapter each day, which like it depends on how busy you are that week. But I'll try to go through like a couple lectures each day before the exam. I try to study like at least 3 days in advance and then... Go through chapter a day. And then like when I go through it again and keep reading it I'll like make sure there's nothing I missed, basically. And like, like I said with the quizzes [they do], like if it's something on there like I didn't know like- it's like I can go back and look at it." Caitlyn, Interview 1
2b. Form own conclusions.	Excerpts reference conclusions or stopping point of studying or learning process.	"Taking time to understand a subject on a deeper level than just, what a lecture slide would show." Angie, Interview 1
3. My aim is to pass the course while doing as little work as possible.	Excerpts provide a qualitative answer to the question presented in survey item 3. Responses to Interview 1 Question 6 were coded since this question directly asked participants about their goal for the course. This item was divided into two subcodes "pass the course" and "doing as little as possible". However, no quotes were attributed to these two subcodes.	"Well, my goal is to- I'm working on it right now- to declare Nutrition. So, this course obviously is important for my major but along with that, I am studying that because I want to have a better understanding of my own body and of how people's body systems work, in general, to provide advice and help and research, for how to better that..." Waterskier, Interview 1
3a. Pass the course	Excerpts make explicit reference to the intended course performance of the participant.	No excerpts coded.
3b. Doing as little as possible	Excerpts make reference participant thoughts on work amount.	No excerpts coded.
4. I only study seriously what's given out in class or in the course outlines.	Excerpts provide a qualitative answer to the question presented in survey item 4. Excerpts explicitly discuss the study process and content for the participant.	"I rewrite the PowerPoints with all my notes, that's what I like to do. And then, listen to lecture again. And like, add in anything I have missed- I like to write it... write out PowerPoints multiple times." Michelle, Interview 1
5. I feel that virtually any topic can be highly interesting once I get into it.	Excerpts provide a qualitative answer to the question presented in survey item 5. Excerpts must reference topics outside of the course and provide participant thoughts about their interest in those topics.	"I think the idea of like, I don't know what it has to do with whether like that's, just like.... Stuff, I guess, I'm more interested in or just the fact that like.... I don't think my brain like works well, like thinking like to the atomic level or even the cellular level." Walt Owens, Interview 1
6. I find most new topics interesting an often spend extra time trying to obtain more information about them.	Excerpts provide a qualitative answer to the question presented in survey item 6. All excerpts refer to new topics in general and specifically those not related to the course. This item was divided into two subcodes, "I find new topics interesting" and "I often spend extra time obtaining more information about new topics".	

6a. I find new topics interesting	Excerpts refer to new topics in general and not necessarily related to the course.	"I think the idea of like, I don't know what it has to do with whether like that's, just like.... Stuff, I guess, I'm more interested in or just the fact that like.... I don't think my brain like works well, like thinking like to the atomic level or even the cellular level." Walt Owens, Interview 1
6b. I often spend extra time obtaining more information about new topics	Excerpts refer to participant response to a new topic.	"For me, definitely, at least... its just shoving as many things into my brain with, like repetition. And then I usually forget it pretty soon after- like memorization to me is a short term solution to- especially classes where I don't have a particular interest in." Kate, Interview 1
7. I do not find my course very interesting so I keep my work to the minimum.	Excerpts provide a qualitative answer to the question presented in survey item 7. This item was divided into two subcodes, "I do not find my course interesting" and "I keep my work to a minimum".	
7a. I do not find my course interesting	Excerpts refer to interest level in the current A&P course or the subject of anatomy and physiology.	"It's something that I'm really interested in." Waterskier, Interview 1
7b. I keep my work to a minimum	Excerpts refer to the work completed by a participant in relationship to this course.	"So I make study guides and so I'll do my big picture stuff and then I'll go through all the PowerPoints and I just type a big outline. And I kind of will compare the two and so I'll look at my big pictures and look at the outline and start looking at those smaller aspects- like maybe the molecules or the compounds and things that are like making up the different materials and all- just try to put things together, and I guess that's really..." Kate, Interview 1
8. I learn some things by rote, going over and over them until I know them by heart even if I do not understand them.	Excerpts provide a qualitative answer to the question presented in survey item 8. Excerpts describe the participant's learning practices and preferences in the course.	"But, with anatomy, I feel like it's most important to memorize because there's just so many... I mean there's so many things going on. Like... I mean all the muscles in the body, the bones of the body, like bone markings- like all of that. So it's like you don't really... Like yes, you're learning it, but the only way to learn those is to memorize them if that like makes sense. Like you... It's not really a concept, it's just a thing." Caitlyn, Interview 1
9. I find that studying academic topics can at times be as exciting as a good novel or movie.	Excerpts provide a qualitative answer to the question presented in survey item 9. Excerpts describe feelings about studying academic topics.	"Personally- don't love sitting down and studying information." Sally, Interview 1

10. I test myself on important topics until I understand them completely.	Excerpts provide a qualitative answer to the question presented in survey item 10. Explicit reference to quizzing or testing oneself as well as the intended outcome for that activity is required.	"Just really taking the time and answering the questions and knowing the "why everything is the way it is." And like I said- for any biology class, I feel like "what ifs" are good questions to ask. And I know teachers say that a lot too. Like if you read something, you say "what if this wasn't the case," like "how would that be?" And I think that helps a lot with... Understanding why things are the way they are. And what the case would be if it wasn't there, and why a part of body works that way. Or so just being able to answer questions as you're reading it and like making sure you're like processing it. And, and then, like I said just going back through it, I think, really helps to learn it." Sally, Interview 1
11. I find I can get by in most assessments by memorizing key sections rather than trying to understand them.	Excerpts provide a qualitative answer to the question presented in survey item 11. All statements referencing the learning approach, as well as those that describe the student's approach to completing an assessment are included.	"As more and more material just starts coming at you, and like like I said the time thing plays in- you kind of resort to the memorizing at one point." Angie, Interview 1
12. I generally restrict my study to what is specifically set as I think it is unnecessary to do anything extra.	Excerpts provide a qualitative answer to the question presented in survey item 12. This item was divided into two subcodes "restrict study to what is set" and "unnecessary to do anything extra."	
12a. Restrict study to what is set.	Excerpts reference how participants decide what to study. Explicit references to instructor information or other standards are included.	"Cause, like that way I... But what I also really like about [them] is that [they]'ll be like very upfront is to say that- I think the first day [they] said, 'I would never put something on the exam that wasn't on this lecture, wasn't on the PowerPoint', which I really appreciate." Angie, Interview 1
12b. Unnecessary to do anything extra.	Excerpts explicitly reference participant thoughts on 'doing extra.'	"But the problem with "Learn" and the multiple choice and the typing thing- it takes a lot of time. So like- sitting there like picking and then if you accidentally click the wrong thing- it like pushes you back like a point, just like based off of points. And then you have to like keep redoing it. And it does that because it thinks, like you legitimately got it wrong and it just wants you to do- like the repetition will help you remember it." Angie, Interview 1

13. I work hard at my studies because I find the material interesting.	Excerpts provide a qualitative answer to the question presented in survey item 13. This item was divided into two subcodes, "I work hard" and "I find the material interesting".	
13a. I work hard.	Excerpts contain all explicit references to effort level.	"Usually I take Dr. McNutt's PowerPoint and I go slide by slide. And if there's a definition, I'll say "Define this" and then I'll write the definition. And then a lot of thing... A lot of times it'll be like, like a bold at the top and then I'll have like all these things and I'll be like "explain the importance of blood vessels in the muscles" or whatever. I don't even know if that's a thing. But like... And then I'll bullet everything in [their] PowerPoint and then when I'm doing my flashcards, I always write on my flash cards and highlight on my flash cards while I'm going through them just to reiterate every time I go over them. And then I try my best to look at them before the test and especially those like highlighted terms." K Diddy, Interview 1
13b. I find the material interesting.	Excerpts contain explicit references to interest level toward course topics.	"I don't know standing in lab the other day and just looking at... Like playing with the bones and stuff, I was like, "oh this is actually kind of cool" like whether I'm actually like learning it right now or not, because like I do have like a week to study for it and get ready and stuff like that, but it was just kind of cool." Walt Owens, Interview 1
14. I spend a lot of my free time finding out more about interesting topics which has been discussed in different classes.	Excerpts provide a qualitative answer to the question presented in survey item 14. This includes reference to how they deal with interesting topics in terms of time.	"Because if I do commit something to memory and long-term, like I'll think about it pretty frequently after a while. So I would rather just be thinking about things like Anatomy more constantly than I would plants." Kate, Interview 1
15. I find it is not helpful to study topics in depth. It confuses and wastes time, when all you need is a passing acquaintance with topics.	Excerpts provide a qualitative answer to the question presented in survey item 15. This includes explicit mention of participant's depth of study and the reasoning for that action.	"So, I think having a- like- because... This is is pretty detailed. I think more detail than I was expecting, but I'm not going to remember in two years those little details." Michelle, Interview 1

16. I believe that instructors shouldn't expect students to spend significant amounts of time studying material everyone knows won't be examined.	Excerpts provide a qualitative answer to the question presented in survey item 16. This includes explicit mention of both time spent in study and the expectation of content on exams.	No excerpts coded.
17. I come to most classes with questions in mind that I want answering.	Excerpts provide a qualitative answer to the question presented in survey item 17. This may include reference to viewing course material early or whether lecture is the first exposure to the material.	"what I do is like before class I'll type up the PowerPoint slides that I know we are going go over. And then I consider that like the outline because that's just the bones of it, basically is what's on the PowerPoints. And then in class, I add all of [their] notes and what [they say] and that is like what I consider the final study guide." Kate, Interview 1
18. I make a point of looking at most of the suggested readings that go with the lectures.	Excerpts provide a qualitative answer to the question presented in survey item 18. This may include references to textbooks.	"Because if there's like four weeks of material before tests or three weeks of material, that's like four chapters of the book and the book is a very dense book. Like there's no pages that you didn't need to know. (laughing) So I think... like studying means, like taking time to go through the book, understand the book, and then doing it again." Sally, Interview 1
19. I see no point in learning material which is not likely to be in the examination.	Excerpts provide a qualitative answer to the question presented in survey item 19.	"Understand everything about the human body. I think it's really interesting and I want to be a physical therapist. So it's important to know how everything works together and how different people's injuries could affect their anatomy and how that could be treated, so...." Kate, Interview 1
20. I find the best way to pass examinations is to try to remember answers to likely questions.	Excerpts provide a qualitative answer to the question presented in survey item 20.	"Like if I can think about it and like ask myself a question like they'll be... Its talking about... I don't know... like a layer of the skin and I'm like "what does this do?" You know- like, how does that affect the other layers of the skin? So like I think understanding is being able to ask yourself questions about it and know the answers." Michelle, Interview 1

Appendix K Code Map

K.1 2nd Iteration (Categorizing 1st Cycle Codes)

1. **Actions linked to outcomes**
    - Comparing semesters
    - Learning: Acquisition and recall
    - Learning: Acquisition and understanding
    - Learning: Acquisition and application
    - Studying: Leads to test
    - Studying: Leads to memorization
    - Studying: Leads to understanding
    - Studying: Leads to memorizing and understanding
2. **Identified Shortcomings**
    - Desiring understanding
    - Comparing performance to expectations: Awareness
    - Needing an explanation
    - Wanting to handwrite
    - Endeavoring: Struggling: Course pacing
    - Endeavoring: Struggling: Engagement during class
    - Endeavoring: Struggling: Forgetting
    - Endeavoring: Struggling: Instructional choices
    - Endeavoring: Struggling: Mastering skills/ concepts
    - Endeavoring: Struggling: Time management
3. **Outcomes**
    - Comparing performance to expectations: Meeting
    - Comparing performance to expectations: Not meeting
    - Comparing performance to expectations: Not meeting assumed expectations
    - Understanding: Teach/ explain to others
    - Understanding: Knowing details
    - Learning: Outcome only (recall or application)

- Memorizing: Short-term memory
- Memorizing: Not understanding

4. **Physical tasks/ actions**

    - Accessing explanations
    - Attending class
    - Changing it up
    - Creating own study tools (digital and non-digital)
    - Dividing and conquering
    - Completing assessments
    - Engaging with course material: Completing worksheets
    - Engaging with course material: Copying/ re-writing
    - Engaging with course material: Drawing/ diagramming
    - Engaging with course material: Quizzing yourself
    - Engaging with course material: Reading
    - Getting study advice
    - Meeting with instructor
    - Seeking effective study methods
    - Taking notes
    - Talking it out
    - Studying with others
    - Using provided resources
    - Using outside resources
    - Using examples/ mnemonic devices
    - Using repetition
    - Using specimens

5. **Cognitive tasks/ actions**

    - Connecting lab and lecture
    - Engaging with course material: Applying
    - Engaging with course material: Connecting
    - Engaging with course material: Integrating
    - Engaging with course material: Summarizing

- Focusing on details
- Facing distractions
- Visualizing

6. **Tasks or actions**
    - Cramming
    - Endeavoring: Increasing effort
    - Endeavoring: Requiring effort
    - Endeavoring: Under-endeavoring
    - Endeavoring: Trying
    - Engaging with course material: Engaging actively
    - Engaging with course material: Reviewing
    - Engaging with course material: Reviewing between classes
    - Determining what's on the test
    - Endeavoring: Linking effort with goals
    - Planning
    - Remembering
    - Studying: Action only
    - Minimizing time
    - Timing
7. **Feelings/ Affect**
    - Expressing positive affect: Content
    - Expressing positive affect: Structure
    - Expressing positive affect: Instructor
    - Expressing negative affect: Content
    - Expressing negative affect: Structure
    - Expressing negative affect: Instructor

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