IMPACTS ON STUDENT LEARNING AND THE GROSS ANATOMY EXPERIENCE IN MEDICAL EDUCATION WITH THE IMPLEMENTATION OF RECIPROCAL PEER TEACHING AND SELF-DIRECTED LEARNING

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DEDICATION

This dissertation is dedicated to Kip, a beloved father and grandfather. You were not here at the end of this adventure but did so much to help and encourage me for 36 years. Without your love, support, and encouragement, I would not be the person I am today. I will love and miss you always.

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Stacey Marie Dunham

IMPACTS ON STUDENT LEARNING AND THE GROSS ANATOMY EXPERIENCE IN MEDICAL EDUCATION WITH THE IMPLEMENTATION OF RECIPROCAL PEER TEACHING AND SELF-DIRECTED LEARNING

Ongoing changes to medical education curricula in the United States require continued evaluation of best practices for maintaining and enhancing anatomical education in medical schools. The purpose of this study was to identify the impacts of incorporating an alternating dissection schedule, peer teaching, and self-directed learning (SDL) in the Human Gross Anatomy (A550-551) laboratory for students in the first year of medical school at Indiana University School of Medicine, Bloomington (IUSM-BL). The researcher sought to determine the impacts of peer teaching and dissection on student gross anatomy grades, to explore the underling perceived effects of peer teaching on the student gross anatomy experience, and to explain how a gross anatomy course, specifically the laboratory component, could contribute to the development of SDL. A mixed method design was selected to combine the analytic strengths of quantitative and qualitative methods. Quantitative analysis using a *generalized estimating equation* determined the act of dissection had an impact on students' abilities to correctly identify structures on human gross anatomy assessments. An *analysis of variance* determined that student gross anatomy final grades, lecture exam averages, laboratory practical exam averages were unchanged when incorporating peer teaching and alternating dissections into the laboratory sessions. A grounded theory methodology identified perceived changes in the student experience in A550-551 through analysis of student interviews, instructor interviews, and course assignments. In conclusion, the researcher determined

that active dissection is a critical component in gross anatomy; however, peer teaching and alternating dissections offset the negative impacts of reduced dissections hours through: increased active dissection time, decreased intragroup conflict, new opportunities to develop teaching and communication skills, and increased efficiency in the anatomy laboratory classroom. Additionally, this research described suggestions for future successful implementations of SDL in A5500-551. These findings provide information for educators at IUSM-BL as they make revisions to meet curricular demands and inform ongoing discussions in anatomy education related to the importance of dissection, time for laboratory experiences, and the continued goal for excellence in educating students.

Valerie O'Loughlin, Ph.D., Chair

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LIST OF ABBREVIATIONS

A550-551: Gross Human Anatomy A550-A551

AAMC: American Association of Medical Colleges

ANOVA: Analysis of variance

BAT: Blooming Anatomy Tool

CGT: Constructivist grounded theory

CPMM: Convergent parallel mixed method

FERPA: Family Educational Rights and Privacy Act

GEE: Generalized estimating equation

GRAT: Group readiness assurance test

GT: Grounded theory

HOCS: High order cognitive skills

LCME: Liaison Committee on Medical Education

LEQ: Laboratory Experience Questionnaire

IRB: Institutional Review Board

IUB: Indiana University Bloomington

IUSM: Indiana University School of Medicine

IUSM-BL: Indiana University School of Medicine, Bloomington

MCQ: Multiple choice questions

OGT: Objectivist grounded theory

PELVIS: Pelvis and perineum

PTL: Peer teaching laboratory

PTL+: Peer teaching laboratory plus laboratory

SDL: Self-directed learning

SRL: Self-regulated learning

TA: Teaching assistant

TACAV: Thoracic and abdominal cavity

TL: Traditional laboratory

VT©: VoiceThread©

ZPD: Zone of proximal development

CHAPTER 1: INTRODUCTION

Medical education in the United States is in a state of flux, as medical schools are moving toward integrated curricula in which clinical experiences are increasingly included as part of early medical education and basic science faculty are working to modify and develop courses to accommodate these curricular changes (Abali et al., 2014). In addition to changing curricula, medical schools are also tasked with providing excellent education in a field in which there is a constantly growing body of knowledge and ongoing development of new technology (E. O. Johnson, Charchanti, & Troupis, 2012). As a result, basic science educators in medical schools have seen decreased contact hours with students, increased clinical experiences in early years of medical education, and increased technology in the classroom (Drake, 1998, 2014; Drake, Lowrie, & Prewitt, 2002; Drake, McBride, Lachman, & Pawlina, 2009; Drake, McBride, & Pawlina, 2014; McBride & Drake, 2018). As changes are implemented, it is critical not to simply consider the structural impact on the curriculum but also the cognitive impact for students (Kulasegaram, Martimianakis, Mylopoulos, Whitehead, & Woods, 2013). New approaches must be undertaken with care and based on sound learning theories. How medical educators adapt educational environments will impact students learning and development as practitioners of medicine. Anatomy, as a key component of the basic sciences in medical education, is in the midst of having its curricula refined to meet these changes in medical education.

Gross Anatomy in the Medical Curriculum

Anatomy education has undergone many changes over its history and is on the precipice of more changes in the future. Recent years have seen significant reductions in course hours allotted to anatomy. Since 1955 there has been a 55% decrease in the number of hours allocated to anatomy in medical education (Drake et al., 2002; Drake et al., 2009) . A majority of schools also must assess competencies such as professionalism and role recognition, effective communication, and intrapersonal skills during anatomy courses in addition to anatomical content knowledge (Drake, 2014; Drake et al., 2009; McBride & Drake, 2018). Evidence had positively indicated this reduction had slowed and potentially stabilized (Drake et al., 2014), but McBride & Drake (2018) identified a statistically significant decreased in allocated course hours for gross anatomy, specifically a reduction in laboratory contact hours. It was suggested that the most recent decreased in laboratory hours may be the result of the shift of most institutional toward an integrated medical curriculum (McBride & Drake, 2018). The significant reduction in course hours, along with the move toward an integrated curriculum, requires that the educators in anatomy must evaluate and adapt the curriculum to be concise yet provide the necessary training for adequate medical practice. To address these issues, instructors need to adopt new teaching methods, implement the use of new technologies, and continue to negotiate the fit of anatomy into the broader medical curriculum (Drake, 2014). As anatomy educators make these changes it is important to strive to ensure these changes are measured, thoughtful changes with purpose to positively contribute to both anatomy education and medical education generally.

Gross anatomy in medical education typically is taught with both a lecture and laboratory component and both components have seen significant changes in recent years. In the gross anatomy lectures, there are increasingly new techniques being employed to account for the reduction in face to face class time and to promote increased clinical relevance, such as flipped classrooms (Fulton, 2012; McLean, Attardi, Faden, & Goldszmidt, 2016; Pickering & Roberts, 2018), team based learning (Michaelsen, Knight, & Fink, 2002; Michaelsen & Sweet, 2008, 2011, 2012; D. Parmelee, Michaelsen, Cook, & Hudes, 2012; D. X. Parmelee & Michaelsen, 2010), and problem based learning (Alleyne et al., 2002; Barrows & Tamblyn, 1980; Colliver, 2000; Dahle, Brynhildsen, Fallsberg, Rundquist, & Hammar, 2002; Dochy, Segers, Van den Bossche, & Gijbels, 2003; Ertmer, 2015; Evensen, Salisbury-Glennon, & Glenn, 2001; Hmelo-Silver, 2004; Wood, 2003).

The gross anatomy laboratory experience is changing as well. Most schools continue to report gross anatomy laboratory experiences using either dissection or prosection (Drake et al., 2014; McBride & Drake, 2018), but there are also increasingly more anatomy labs teaching and using ultrasound, radiology, and other medical technologies (Aydin, 2012; Butter et al., 2007; Drake, 2014; Jurjus et al., 2013; McBride & Drake, 2018; Sugand, Abrahams, & Khurana, 2010; Trelease, 2008; Turney, 2007; Webb & Choi, 2013). Yet, all of these changes and additions must occur within the reduced number of gross anatomy contact hours and still provide the necessary preparation for practicing physicians. In gross anatomy, human dissection offers a learning experience for students that is necessary for the development of competent medical practitioners. The hands-on process allows for active engagement and a deeper understanding of the three-dimensional structure of the human body (Azer & Eizenberg, 2007; Dinsmore, Daugherty, & Zeitz, 1999; Hofer, Brant Nikolaus, & Pawlina, 2011; J. H. Johnson, 2002; Pather, 2015; Pawlina & Lachman, 2004; Rizzolo & Stewart, 2006). Counter to previous views, Wilson et al. (2018) found that there was no greater impact on short term learning through dissection, prosection, or simply the use of models suggesting that dissection may not be as beneficial as previously thought. However, Wilson et al. (2018) only examined short-term impacts measured by comparing average grades achieved on gross anatomy laboratory exams. However, some medical schools have moved to pass/fail scoring eliminating the possibility of this measure (Bloodgood, Short, Jackson, & Martindale, 2009; Rohe et al., 2006; Spring, Robillard, Gehlbach, & Moore Simas, 2011), and even schools with traditional grading, scores can be skewed toward a high average making the effects of different curricular designs hard to distinguish. This research advocates maintaining the dissection experience in medical education is important and that this is supported by data beyond exam grades.

One common step, taken in recent years to accommodate required reductions in anatomy course hours in many medical schools, is a shift to an alternating dissection schedule. Traditionally, students would be present during every dissection throughout the semester with various levels of participation in the lab. In an alternating dissection schedule, students only actively participate in half of the dissections. For example, if a group of 4 students work with a single donor, in an alternating schedule the group would subdivide into 2 groups (A and B) each comprised by 2 students. Group A would complete the first dissection while group B does not attend the dissection. During the next lab the groups switch, and group B completes the dissection while group A is off. This alternating pattern then continues throughout the semester. This alternating lab approach therefore allows for a reduction in contact hours for students in the lab while continuing to provide valuable dissection experiences (Dunham, 2014; Lazarus, Dos

Santos, Haidet, & Whitcomb, 2016; Marshak, Oakes, Hsieh, Chuang, & Cleary, 2014; McWhorter & Forester, 2004; A. B. Wilson, M. Petty, J. Williams, & L. Thorp, 2011).

Because the alternating schedule limits active student participation in all gross anatomy labs, it becomes necessary to provide students an opportunity to learn structures covered in unattended dissections. Therefore, most labs using an alternating approach incorporate a short period of time at the start of each lab when both groups briefly attend to transition between dissections. Designated time provides an opportunity for students to identify relevant structures and discuss important findings. Anatomy programs have come to identify labs using alternating schedules and teaching time for students as a **peer teaching laboratory model** (Hendelman & Boss, 1986; Krych et al., 2005; Lazarus et al., 2016; Marshak, Oakes, Hsieh, Chuang, & Cleary, 2015). In the literature, there are many terms used to reference peer teaching and those will be discussed in depth in the next chapter, but for this dissertation the focus is specifically on reciprocal peer teaching. **Reciprocal peer teaching** is defined as a process in which students at the same level teach or tutor each other in a subject common to both students and all students have the opportunity to act as both the teacher and the learner (Boud, Cohen, & Sampson, 1999; Goldschmid & Goldschmid, 1976; Topping, 2005; Whitman & Fife, 1988). The incorporation of reciprocal peer teaching in anatomy programs has proven to be a means to reduce course hours while still providing hands on dissection experience for students.

A peer teaching laboratory also provides an opportunity to implement self-directed learning (SDL) opportunities for students, a necessary component of medical education. SDL was first advanced in relation to the theory of adult learning, andragogy, and identifies a self-direction as a key component of adult learning (Knowles, 1973, 1975). A commonly cited, early definition from Knowles (1975) stated that in SDL "individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes" (p. 18).

Recently the Liaison Committee on Medical Education (LCME) (2015), an accreditation body for allopathic medical institutions in the United States, emphasized the importance of SDL in medical education. The LCME identified that SDL plays a role in enabling medical students to become lifelong learners; therefore, SDL is a critical component of medical education. SDL is defined by the LCME stating it "includes medical students' self-assessment of their learning needs; their independent identification, analysis, and synthesis of relevant information; and their appraisal of the credibility of information sources" (LCME, 2015, p. 8). As medical schools move through the process of accreditation, it is important that individual courses provide opportunities to meet the necessary SDL skills for students, but the LCME does not address how to incorporate SDL into the curriculum. The need for SDL in medical education has been recognized (Dunham, 2015; D. J. Gould, Mi, & Patino, 2017; J. Gould, Arseneau, Dalziel, Petropolis, & Mann, 2015; Keator, Vandre, & Morris, 2016; Shokar, Shokar, Romero, & Bulik, 2002), but there is limited literature discussing the best approaches for the incorporation of SDL in the medical curriculum. This dissertation will begin to help fill this gap.

Previous studies (Hendelman & Boss, 1986; J. H. Johnson, 2002; Krych et al., 2005; Marshak et al., 2014; Adam B. Wilson et al., 2011) examining laboratory formats using alternating dissection schedules and peer teaching have focused primarily on impacts to grades and secondarily identified benefits such as improved communication between students and increased responsibility to peers. Since peer teaching and alternating dissection schedules are increasingly being used in anatomy it is important to look deeper into the impacts on students and student learning to ensure it is the best choice for the anatomy laboratory curriculum.

Research Questions Examined in This Dissertation

This dissertation examined the impacts of the alternating dissection, reciprocal peer teaching, and SDL on medical students enrolled at the Bloomington campus of the Indiana University School of Medicine (IUSM-BL) enrolled in the Gross Human Anatomy A550-551 course (A550-551). The research addressed two specific gaps in related to peer teaching and SDL in anatomy education. First, it addressed the need in anatomy education to better understand the underlying changes that can occur when introducing alternating dissections and peer teaching, beyond simply identifying if student grades increased, decreased, or stayed the same. Second, it developed a method for the incorporation of SDL activities in the anatomy laboratory curriculum, evaluated the method, and offered suggestions for developing and implementing SDL activities in other anatomy laboratory settings.

The study focused on first-year medical students enrolled in A550-551 from the fall of 2010 through the spring of 2016 and three specific research questions were examined:

(1) What were the impacts of peer teaching on student grades in Human Gross Anatomy (A550-A551) at IUSM-BL?

(2) What were the underlying impacts of implementing alternating dissections and peer teaching in gross anatomy laboratories that were not easily identified simply by examining exam grades and course performance?

(3) How could a gross anatomy course, specifically the laboratory component of A550-551 at IUSM-BL, effectively contribute to the accreditation process and directive to use SDL required by Standard 6.3 from the LCME (LCME, 2015)?

Overview of Methodology: Mixed Methods

This dissertation was a mixed methods study that offered the advantage incorporating quantitative data analysis used to analyze of student grades and exams in A550-551 with qualitative data analysis of interview data and student generated course work to for a more complete understanding of the impacts on the student experience in the classroom. Using mixed methods provided a more well-rounded understanding of the problem of interested in this research than could be acquired from either method individually. Quantitative analysis compared the course, lecture exam, and laboratory exam grades to determine if the changes to the laboratory format changes impacted the grades of students enrolled in A550-551. Additionally, analysis of the laboratory practical exams from the 2015-2016 school year compared student performance on 2 types of laboratory test questions to determine how the act of dissection impacted the ability to answer related questions exams. The questions used in the comparison were (1) the questions based on dissections the students performed versus (2) the questions covering material students did not dissect but learned through the peer teaching process. Based on previous studies, it was anticipated there would be no difference in performance between student enrolled in the peer teaching laboratory format and those enrolled the traditional laboratory format.

Concurrently, this dissertation research also performed a grounded theory analysis (Birks & Mills, 2015; Charmaz, 2014; Corbin & Strauss, 2014; Glaser & Strauss, 1967; A. Strauss & Corbin, 1990) of student interviews, instructor interviews, and student work to provide an in-depth examination of the use of peer teaching and SDL in the gross anatomy laboratory. Grounded theory analysis allowed for the development of theoretical categories to explain the impacts of peer teaching and SDL in A550/551. In doing so, this study will provide information for educators at the Indiana University School of Medicine (IUSM), specifically IUSM-BL, as they revise the curriculum to meet curricular demands as well as continue to strive for excellence in education of students. Additionally, the information can be used more broadly to inform anatomy educators about the role of dissection and the impacts of the peer teaching laboratory model, and considerations for its use, and finally the importance of well-designed SDL curricular requirements and key considerations in the development of SDL opportunities in medical education.

Organization of This Dissertation

This dissertation will first discuss the current literature and place this study in context. It will review the understanding of peer teaching in the broader education environment and then specifically the use of peer teaching within anatomical education. It will also examine the role of SDL in medical education. Next the methods used to complete the study will be described, then the quantitative results and analysis will be presented followed by the qualitative results and analysis. Then, the discussion will merge the results of the quantitative and qualitative analysis to explore what was learned in this research. Finally, it will conclude with a summary of the key results and identify future directions related to this research.

CHAPTER 2: LITERATURE REVIEW

This chapter provides the background from which this dissertation is derived. It begins with a brief review of medical education in the 20th century in the United States, and a discussion of how the current anatomy curriculum has changed and developed within medical education. The chapter then reviews how anatomy curricula in medical education have adapted to meet increased calls for clinical integration and active learning in medical education. Next the chapter reviews peer teaching literature in both general education and gross anatomy education. This is followed by a discussion of lifelong learning and the terms self-directed learning (SDL) and self-regulated learning (SRL), related constructs that arose from different educational research blocks, that are often poorly understood and ill-defined in education literature. The chapter concludes with a discussion about what questions remain unanswered and how this dissertation will contribute to the gap in the literature.

Brief Review of Medical Education in the United States

As the United States approached the 20th century, medical education lacked uniformity and standards; therefore, practicing physicians ranged dramatically in their knowledge and skills. The need to ensure physicians received adequate training and could perform to a set of basic standards led to the dramatic reformation in medical education early in the 20th century. A significant driver in medical education reform was the Flexner report published in 1910 (Flexner, 1910). This report created a medical education model that prevailed for most of the twentieth century. Flexner called for university based medical schools, high admission standards, and teaching medicine using an academic model. Additionally, the Flexner report identified the need for quality facilities staffed by professional faculty who would teach basic science and provide clinical training. The resulting 4-year medical education program, 2 years of basic science followed by 2 years of clinical training (2 + 2), became the standard for medical schools throughout the United States, and remained so for most of the century.

By the 1980s, there were new calls for reform as scientific advancements rapidly increased the content of basic science courses and medical advancements added to a growing body of clinical knowledge (Drake, 2014; Drake et al., 2002; Drake et al., 2009; McBride & Drake, 2018). Medical educators also recognized the need to incorporate different education practices identified to be effective in the growing body of education research (Drake, 2014). One specific call for reform to medical education in 1984 was from the Association of American Medical Colleges (AAMC). The AAMC released a report called *Physician for the Twenty-First Century: The Report of the Panel on the General Professional Education of the Physician and College Preparation for Medicine* that called for improved integration between the biological sciences and clinical training components of medical education. This identified a need to bring clinical knowledge into the basic science courses offered in medical school. It also identified the need to promote the development of "active, independent learners and problem solvers, rather than passive recipients of information" in medical education (AAMC, 1984, p. 13). The 1984 AAMC report, along with additional similar reports (AMA, 1982; Swanson & Anderson, 1993) formed the basis for the curricular changes made at the end of the 20th century (Drake, 2014).

Despite the calls for active learning and integration, many medical schools still used primarily didactic learning approaches and the 2+2 model from the Flexner years.

In 2010, the Carnegie Foundation published the report *Educating Physicians: A Call for Reform of Medical School and Residency* examined the state of medical education and identified necessary areas of reform (Cooke, Irby, & O'Brien, 2010). Again, there was the call for increased integration across the medical curriculum, active learning, and the development of lifelong learning skills. It was noted that practicing physicians must integrate knowledge from across a variety of disciplines to solve problems. Thus, medical school should strive to teach as much as possible in an integrated format rather than segmenting instruction. Additionally, the Carnegie report (Cooke et al., 2010) noted the need for physicians to develop lifelong learning skills through a commitment to inquiry, desire to pursue excellence, and an ability to identify gaps in knowledge. Medical and scientific advancements have changed the role of the physician. A doctor is no longer expected to know all; but rather, have the ability to seek out information and discern its value. Lifelong learning skills give physicians the tools to update their medical knowledge as new research is released; to seek out, evaluate, and employ information as necessary; and to continue to grow in expertise over time.

Anatomy Education Responding to Calls for Improvements in Medical Education

Curricular changes impacting medical schools also affected anatomy education. Anatomy departments were tasked with development of active learning approaches in the classroom, basic science and clinical integration, and promoting lifelong learning skills (AAMC, 2009; Cooke et al., 2010; Swanson & Anderson, 1993). But curricular change has been complicated due to the growing body of scientific knowledge, the decrease in the number of faculty available for anatomical instruction, and a reduction in the number of hours devoted to anatomy in the medical curriculum (Drake, 2014; Drake et al., 2009;

Drake et al., 2014; McBride & Drake, 2018). Drake et al. (2009) noted that since 1955 there has been a 55% decrease in the allocation of course hours for teaching anatomy. Gross anatomy, on average in 2015, was taught in 147 course hours (Drake et al., 2014), a figure that is similar to the 2009 number of 149 hours but a significant decrease from the average of 196 in 2002 (Drake et al., 2002; Drake et al., 2009). At Indiana University School of Medicine – Bloomington (IUSM-BL), gross anatomy was allocated a mere 118 course hours prior to integrated curricular reform in the fall of 2016, so IUSM-BL was acutely aware of the need to maximize the benefits of each hour of class.

It was believed that the reduction in gross anatomy course hours had stabilized, but the newest research from McBride and Drake (2018) identified a significant decrease in course hours dedicated to gross anatomy with an new average of 129 (SD ± 56) hours and the authors partially attributed this decrease to the increased prevalence of integrated curricula in medical education. Specifically, the most recent reduction in gross anatomy course hours were taken from the laboratory portion of the courses surveyed (McBride & Drake, 2018). Other significant changes that have impacted the anatomy curriculum in medication education include: 94% of gross anatomy courses are part of an integrated curriculum (McBride & Drake, 2018) and many transitioned from discipline based courses (e.g. anatomy, histology, and physiology) to integrated systems-based courses (e.g. nervous system, cardiovascular system, and musculoskeletal system) (Sugand et al., 2010).

In medical education, integration describes a curriculum in which basic sciences, clinical sciences, or basic and clinical sciences are taught together (Bolender, Ettarh, Jerrett, & Laherty, 2013; Cooke et al., 2010; Drake, 2014; Paulsen, Klement, & Wineski, 2015). The goal of integration in the medical curriculum is to provide medical students authentic learning experiences and impart the decision making ability necessary in medical practice (Drake, 2007; Paulsen et al., 2015). Early calls for integration in medical education intended to bring the basic science and clinical components of medical education together to demonstrate the relevance of basic science in clinical practice (AAMC, 1984, 2009).

McBride and Drake (2015) emphasized the importance of longitudinal learning opportunities, incorporation of anatomy throughout the four years of medical school, to improve student retention of anatomical knowledge. A recent longitudinal cohort study at Radbound University Medical Center, demonstrated decreased loss of retention of anatomical knowledge in horizontally and vertically integrated curriculum when compared to traditional, non-integrated medical curricula (Doomernik, van Goor, Kooloos, & ten Broek, 2017).

Integrating anatomy has occurred through both horizontal and vertical integration. Horizonal integration incorporates anatomy instruction into other basic science courses that generally comprise the first 2 years of medical school. Retention can be further improved through vertical integration, continuing anatomy education during clinical education and providing opportunity for specialized emphasis, clinical integration, and reinforcement of basic anatomical knowledge in later years to increase retention and further knowledge (Bhangu, Boutefnouchet, Yong, Abrahams, & Joplin, 2010; Brauer & Ferguson, 2015; Drake et al., 2014). Figure 2.1 provides a visual representation of horizontal and vertical integration in the medical curriculum. As changes to integrated curricula continue, horizontal and vertical integration offer an opportunity for anatomy to be included throughout the medical curriculum (Drake, 2007, 2014).

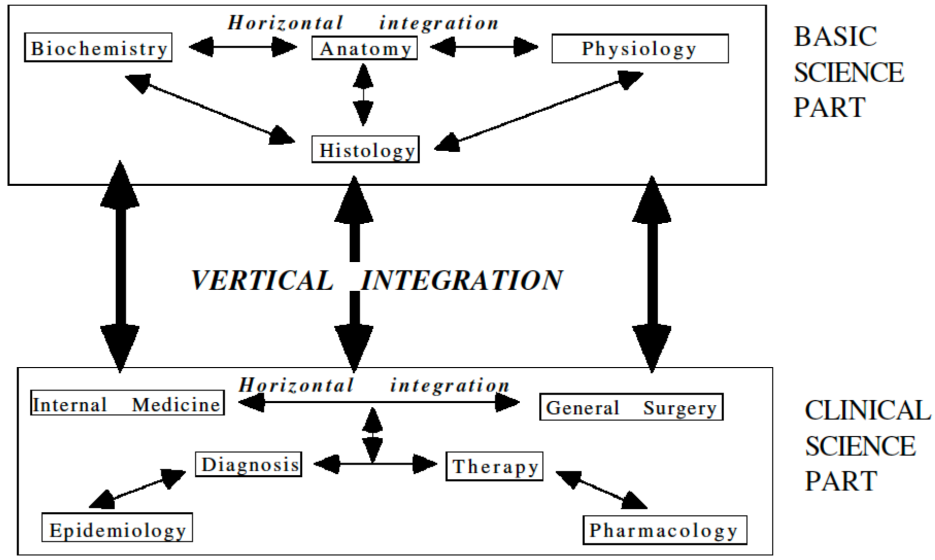


Figure 2.1. Horizontal and Vertical Integration in Medical Education. An illustration of the concepts of horizontal and vertical integration in the medical curriculum from (Dahle et al., 2002, p. 281). Horizonal integration is across subjects and clinical experiences whereas vertical integration interweaves basic science and clinical science components of medical school.

Instruction in anatomy education has changed significantly since the days of the 'sage on the stage'. While anatomical education has a long tradition of didactic teaching methods ending with summative assessments in the form of multiple choice exams, it is not necessarily the best approach to anatomy education (Older, 2004). As medical curricula are revised, there is increased pressure to reduce faculty-student contact hours, maintain strong educational objectives, increase student participation in the classroom, shift more responsibility to students, and incorporate additional competency training such as communication and professionalism (Drake et al., 2014; McBride & Drake, 2015, 2018). Active faculty engagement is necessary for development of an integrated curriculum. If faculty are not engaged, it is possible that changes will fizzle after the initial implementation.

Learning theories have played an important role in guiding changes in anatomical education as courses have adapted to changes in medical education. The following sections will discuss in more depth how pedagogical choices have impacted anatomy education and its changes in medical education to both improve anatomical knowledge and fit within the changing demands of medical education.

Learning Theory as Potential Guides to Anatomy Education

Research in higher education, medical education, and anatomy education provides a valuable source of knowledge as anatomy educators design and implement changes in curricula. Significant and select pedagogical concepts will be discussed individually in the following sections: higher order cognitive skills, active learning, constructivist learning theories, and metacognition. These concepts were chosen based on the selective changes implemented at IUSM-BL as well as identified as some of the most common curricular revisions made based on the current literature related to anatomical education in the medical curriculum. This will be followed by discussions of peer teaching and SDL and their role in anatomy education.

Constructivist learning theories. There is no single theory that explains how people learn, but constructivist learning theories strongly support the need for activity to promote learning (Bransford, Brown, & Cocking, 2000). Collectively, **constructivist learning theories** state “that learners arrive at meaning by actively selecting, and cumulatively constructing, their own knowledge, through both individual and social activity” (Biggs, 1996, p. 348). Driscoll (2005) identifies five conditions for learning in a constructivist model: learning occurs in complex and realistic environments, requires collaboration amongst individuals, employs varied perspectives and modes of representation, instills ownership for learning, and enables metacognitive practices for learners. Constructivist learning theories can be broadly categorized as either **cognitive constructivist**, derived from early works of Piaget, or **sociocultural constructivist**, derived from the work of Vygotsky (Cunningham & Duffy, 1996). Cognitive constructivists focus on how learning occurs within an individual through active reorganization of prior knowledge and an incorporation of new knowledge while acting within a group. Sociocultural constructivists emphasize the impact of the interaction between the learner and the environment in the development of knowledge and the process of learning. Next, examples of theories developed in education research will be described to better understand the distinctions between cognitive constructivism and sociocultural constructivism.

Examples of cognitive constructivist theories include information processing theories, metacognition theories, and theories related to accessing prior knowledge. **Information processing theories** are interested in the mental processes and specific mental operations used in problem solving and learning (Mayer, 2010). Information processing theories emphasize the need to develop the long-term memories that allow for continual access and modification. In medical education, information processing theory identifies the need to consider how verbal instruction and images are perceived and processed by the student to result in learning. For example, when introducing new information such as ultrasound imaging and radiology, the importance of demonstrating how the images relate to the three-dimensional nature of the human body and helps reduce the cognitive load for the student interpreting the images (Jamniczky et al., 2015).

Metacognition. Metacognition is "monitoring of cognitive goals, experiences, and actions" (Flavell, 1981, p. 39). Flavell (1981) developed a complex model of metacognition where cognitive goals, cognitive actions, metacognitive knowledge and metacognitive experiences all interact to create metacognition. The increased individual awareness of how an individual responds and actively considers learning is part of the metacognitive process that enables learning (Bransford et al., 2000). Metacognition may include learner recognition of learning situations, identification of desired learning, and even emotional reactions to learning tasks. Gross anatomy is regularly included in the first-year curriculum for medical students. As a student group, medical students have generally demonstrated success in prior education; however, medical school presents new and unique demands on students that may require individuals to reexamine learning approaches. Being metacognitively aware is a skill, and students may need guidance and opportunities to develop better approaches to metacognition. The role of metacognition in the development SDL and SRL, its relationship to medical education, and its relevance to this research will be expanded later in this chapter.

Finally, cognitive constructivist theorists note that students are not blank slates and they have prior experiences with material being studied. In order to maximize learning, instructors need to build and expand earlier learning rather than simply starting again and ignoring prior experience (Driscoll, 2005). For example, **learning progressions** are a means to build on prior knowledge of students (Duschl, Maeng, & Sezen, 2011). Learning progressions can connect learning across months and years, in both an individual course as well as across courses. The importance of connecting prior knowledge and new knowledge is a skill that is critical for instructors. Students do not simply list their prior knowledge when entering a class. In anatomy, simple memorization of terminology and basic facts discourages a deeper more nuanced understanding of the human body (Pandey & Zimitat, 2007). Part of what must occur in the classroom is an extraction of the prior knowledge by the instructor to develop a more complex understanding of the content.

Sociocultural constructivists differ from cognitive constructivists in that they are interested in examining the complex environment of the learner. In classroom learning, the environment might include other learners, experts (the teacher), influences from home, and individual student participation. Sociocultural constructivist theorists believe that one cannot separate out the cognitive process of the learner, but rather that one must examine the entire context of the learning environment (John-Steiner & Mahn, 1996). Within the group everyone contributes knowledge, background, culture, and their own view of the world. By bringing all of this together, learning is impacted for everyone involved (Cole & Engeström, 1993). Therefore, a researcher must examine the classroom environment through interactions with all stakeholders such as students, instructors, and the classroom itself.

Sociocultural constructivist theory emphasizes the importance of authentic learning experiences and the role of collaborative learning (Brown, Collins, & Duguid, 1989). The idea of apprenticeship and knowledge transfer is related to the sociocultural idea of the zone of proximal development and scaffolding to develop knowledge. The **zone of proximal development (ZPD)** is the space between what a child is able to accomplish alone and what that same child can accomplish with adult guidance of peer (Danish, Peppler, Phelps, & Washington, 2011; John-Steiner & Mahn, 1996). It is in the ZPD that learning is occurring as students are increasingly moved beyond current understanding into new knowledge. For students working together, they can use their collective knowledge to help push the group forward. In the classroom, the instructor is involved in scaffolding learning for the students by initially providing students with more help and then slowly backing off and allowing students to accomplish tasks independently (Hmelo-Silver, 2006). This research will demonstrate the role of scaffolding student SDL experiences in anatomical education.

As an instructor and researcher, I align myself primarily with the social constructivist understanding of learning. I find that in all classrooms, students benefit from engaging their current understanding prior to learning new material. I also believe scaffolding offers an opportunity to introduce new skills to students, while eventually encouraging independent action. In addition to my understanding of leaning through the lens of social constructivism, I also recognize the importance of developing cognitive skills of student and using active learning in the classroom. The next two sections will explore the role of higher order cognitive skills and active learning.

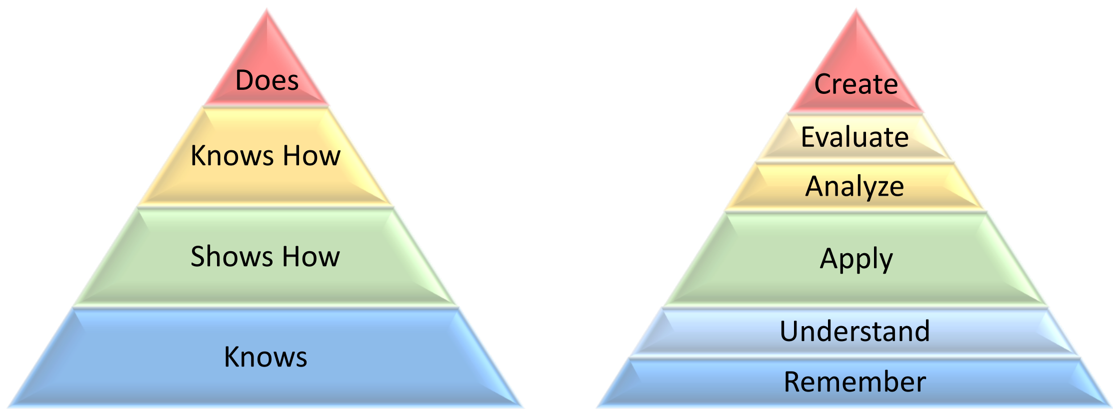
Higher order cognitive skills. Scientific advances are constant and new medical treatments are continuously being developed. A physician needs the ability to locate relevant information, evaluate the information, and then apply knowledge effectively to solve a problem (Zohar & Dori, 2003). Developing the higher order cognitive skills (HOCS), also identified as *higher order thinking skills*, is one component of medical education (Cooke et al., 2010; Zoller, 1993). HOCS lacks a single accepted definition in the literature but may be best defined by the attributes exhibited when students use HOCS. The following describes the complex nature of HOCS.

> Higher order thinking involves a cluster of elaborative mental activities requiring nuanced judgement and analysis of complex situations according to multiple criteria. Higher order thinking is effortful and depends on self-regulation. The path of action or correct answers are not fully specified in advance. The thinker's task is to construct meaning and impose structure on situations rather than to expect to find them already apparent. (Resnick, 1987, p. 44)

If anatomy educators want to encourage the development of HOCS, coursework and assessments must require practicing of the desired skills and avoid emphasis on rote memorization of basic anatomy facts (Zoller, 1993). Thompson and O'Loughlin (2015) developed the Blooming Anatomy Tool (BAT), a discipline specific tool, to aid in the development of and analysis of multiple choice questions (MCQ) that target the first four levels of Bloom's taxonomy: remembering, understanding, applying, and analyzing. Exams that target various levels of Bloom's taxonomy ensure assessments ask students to engage in increased levels of cognition. Since MCQ exam questions cannot be used to test the highest levels of Bloom's taxonomy, other activities and assessments must be included in the curriculum to address engager students in HOCS.

In addition to teaching disciplinary knowledge such as vocabulary, development of a three-dimensional understanding of the body, surface and deep anatomy, and embryology, anatomy educators in medical education must also emphasize the importance of applying the understating of anatomy in medicine (Deng & Luke, 2008). Bloom's taxonomy of educational objectives provides a basis for understanding the types of skills that can lead to HOCS (Anderson, Krathwohl, & Bloom, 2001; Bloom, 1956). Miller's pyramid, a framework for the development of clinical skills, is similar to

Bloom's taxonomy in that it identifies the different levels at which students can demonstrate learning of clinical skills (Miller, 1990). Miller identifies the 4 levels as knowing, knowing how, showing how, and doing. This framework provides additional guidance for anatomy educators as they work to develop HOCS in the classroom. Figure 2.2 shows how the 4 categories of Miller's pyramid overlap with Bloom's taxonomy.



Miller's Clinical Pyramid **Bloom's Taxonomy**

Figure 2.2. Comparing Miller's Clinical Pyramid to Bloom's Taxonomy Pyramid. This figure was developed through modification from the learning assessment pyramid from Shumway and Harden (2003) and Bloom's taxonomy pyramid modified from Adams (2015). Levels of the pyramid in the same colors indicate how the two pyramids share commonalities. In medical education it is important to provide the base for students, but also to ensure students have the skills necessary to succeed at the peaks of the pyramids.

From Bloom's taxonomy, the levels of analysis, synthesis, and evaluation correspond to the attributes of HOCS (Resnick, 1987). HOCS involve the student demonstrating the ability to actively use anatomy knowledge to solve clinically relevant problems presented in the classroom or other learning formats. When developing anatomy curricula for medical education, educators need to target classroom activities and assessments beyond MCQ exams to encourage the development of the HOCS. In addition to incorporating HOCS, educators have identified the importance of active learning in the classroom (Bean, 2011; Bonwell & Eison, 1991; Bonwell & Sutherland, 1996; Graffam, 2007; Prince, 2004).

Active learning. Activity as a part of the process of learning has long been identified as a desirable characteristic in education (Dewey, 1916). For many educators, learning is considered an active process because it results in the acquisition of knowledge and some change to the learner. In the last 40 years, there has been an increased emphasis on the role of activity in learning. Bonwell and Eison (1991) identified five characteristics associated with active learning: more than listening occurs in the classroom, there is an emphasis on skill development not just information transfer, promotion of higher-order thinking, engagement of students in activity, and student reflection on attitudes and values. **Active learning** may be defined as a method engaging students in the learning process (Prince, 2004).

What does active learning look like in higher education? Active learning in the classroom results in the shifting of responsibility for learning from the teacher to the student (Drew & Mackie, 2011). In anatomy education, this requires the movement away from didactic lectures and towards increased activity in the classroom. There are many suggestions for how to incorporate active learning in the anatomy classroom. Relatively simple incorporation could be classroom assessment techniques such as short in-class activities such as group discussions, think-pair-share moments, and short writing assignments (Angelo & Cross, 1993).

Gross anatomy laboratories also represent opportunities for active learning (Winkelmann, 2007). Dissection provides hands on experience to explore the three-dimensional nature of the human body (E. O. Johnson et al., 2012; Sugand et al., 2010).

However, there is a need to address other components of active learning such as students being actively engaged in their own learning and making decisions that will then impact that learning process. From this point of view, dissections that are too prescriptive do not provide a true active learning experience (Nwachukwu, Lachman, & Pawlina, 2015).

Another pedagogical approach, and the approach that is the focus of this dissertation, is Peer Teaching. Peer teaching has long been a focus in education and the use of peer teaching in anatomy education increased substantially in recent decades. This approach is discussed at length in the following paragraphs, first examining peer teaching generally and then I discuss its application in the gross anatomy classroom.

Peer Teaching

Peer teaching refers to students teaching students. It has a long history in education. From the days of a one room school house, student's collaborations contributed to the education process. First, I will discuss general education literature concerning peer teaching. Then I will specifically address the role of peer teaching in anatomy education.

Peer teaching in education. Active strategies that involve learning with other learners, rather than trained teachers, are classed as peer teaching (Topping & Ehly, 2001). Old perceptions of peer teaching suggested that peer teachers needed to be the best and the brightest students, but evidence has shown that students of all levels benefit from being both the tutor and tutee (Topping, 2005). General education studies have indicated that peer teaching contributes to a collaborative environment between students (Topping, 2005), reduced competition between students (Damon & Phelps, 1989), increased knowledge retention of students (Abedini, Mortazavi, Javadinia, & Moonaghi, 2013), and the provided opportunities for other skills such as communication (Topping & Ehly, 2001).

Peer teaching is a term seen often in education literature, and describes an umbrella of terms that in which students are acting as teachers such as *cooperative learning*, *collaborative learning*, *reciprocal peer teaching*, *peer assisted learning*, *peer instruction*, *peer tutoring*, and *near-peer instruction* (Goldschmid & Goldschmid, 1976; Topping, 2005; Wagner & Gansemer-Topf, 2005; Whitman & Fife, 1988). This dissertation is specifically focused on **reciprocal peer teaching**, in which students at the same level act as both the teacher and the learner in alternating interactions with peers (Boud et al., 1999; Hendelman & Boss, 1986; Krych et al., 2005; Topping et al., 1997). Reciprocal peer teaching is different from a similar term, *near peer teaching,* which involves older students who have previous experience with a course or subjects acting as the teacher through the interaction with a learner (Bruno et al., 2016; Burgess, McGregor, & Mellis, 2014; Evans & Cuffe, 2009; Goldschmid & Goldschmid, 1976; Whitman & Fife, 1988; Yarrow & Topping, 2001; Yu et al., 2011). As previously stated, this dissertation will focus on reciprocal peer teaching, but for simplicity the term **peer teaching** will be used in place of reciprocal peer teaching for the remainder of this dissertation.

Peer teaching is more than just students teaching students. Peer teaching provides an opportunity to develop skills of communication and cooperation and aids student led reflection, exploration, and self-identification of learning needs (Berkhof, van Rijssen, Schellart, Anema, & van der Beek, 2011; Boud et al., 1999). Assessment of peer teaching activities ensures the participation of all students and provides an opportunity to examine additional learning outcomes beyond simply course content (Boud et al., 1999). Peer teaching in the classroom can also alleviate difficulties within group interactions. In larger groups, we see a range of student types and not every student participates but in smaller groups, all student participation is necessary in order to accomplish tasks (Balasooriya, di Corpo, & Hawkins, 2010). Finally, peer teaching has been shown to increase achievement and satisfaction, while reducing feelings of stress (Fantuzzo, Riggio, Connelly, & Dimeff, 1989).

The brief summary in this section highlighted how general education research has identified the positive benefits for using peer teaching in a curriculum. This next section will discuss how peer teaching has been adopted in anatomical education and describe how this research will add the understanding of the impacts of using peer teaching in a gross anatomy laboratory setting.

Peer teaching in anatomy laboratories. Peer teaching is a topic of current relevance in anatomical education. Peer teaching offers an opportunity to students beyond simple memorization of structures and to begin incorporation of clinical and lecture content during the teaching time in the gross anatomy lab, extending learning goals beyond simply memorization to more complex understanding. In anatomy laboratories, alternating dissection schedules have been paired with peer teaching to reduce the number of hours spent in the lab while still giving students the opportunity to observe all the outcomes of all dissections. Various authors have demonstrated that the use of alternating dissection schedules in the gross anatomy lab has mixed impact on student grades (Hendelman & Boss, 1986; J. H. Johnson, 2002; Krych et al., 2005;

Marshak et al., 2015; Adam B. Wilson et al., 2011). The general consensus has identified a slightly positive increase in student grades; however, the effect of the change in grades is generally very small (Abedini et al., 2013; Bentley & Hill, 2009; Granger & Calleson, 2007; Marshak et al., 2015; McWhorter & Forester, 2004; Nnodim, 1997; Rhodes, Fogg, & Lazarus; Adam B. Wilson et al., 2011). Additionally, it has been noted that peer teaching provides a learning opportunity as students teach each other (Berkhof et al., 2011). Potentially, peer teaching offers an opportunity for students to go beyond simple memorization of structures and extend learning to more complex understanding.

Secondarily, studies in anatomy education note other benefits of peer teaching such as opportunities to develop communication skills, increased hands-on dissection time for students, improved faculty to student ratios, and additional free time in the schedule allowing students to complete other necessary work or have time for recreation develop communication skills, (Hendelman & Boss, 1986; J. H. Johnson, 2002; Krych et al., 2005; Manyama et al., 2016; Marshak et al., 2015; Topping & Ehly, 2001). Lazarus et al. (2016) incorporated a handoff protocol for laboratory sessions. The transition time between the alternating laboratory sessions to practice for the skills necessary to transition patients between medical caregivers in a clinical setting. Students had to provide the necessary and relevant information to their partners. In this research, students expressed an increased sense of responsibility and personal investment in their own learning, as well as the need to reformulate and compact ideas in order to effectively communicate information to fellow students. The authors did note student concern on the receiving end of information and a lack of trust in the accuracy of fellow classmates (Lazarus et al., 2016). Lazarus et al. (2016) identified that there are benefits and disadvantages to using a peer teaching approach and that it can incorporate clinical skills; however, there are few publications addressing the perceptions and experiences of students in a peer teaching gross anatomy laboratory setting and this research is intended to fill part of that gap.

Finally, peer teaching provides experience for medical students related to their future profession. The role of a physician is not simply that of a healer, but also a teacher. During both the training process and later in practice, physicians will need to fill the role of teacher to both patients as well as other physicians and medical students. Amorosa et al. (2011) demonstrated that prior to a near-peer teaching experience, second year students did not readily identify the role that teaching plays in medicine. In order to acquire the abilities of a teacher, practice is needed. In addition to demonstrating the value of peer teaching, Krych et al. (2005) advocated the use peer teaching to prepare physicians for roles as teachers. A review of literature related to training residents as teacher indicates a majority of programs emphasize "active learning and offering opportunities for practice and feedback in the development of teaching; these programs also emphasize learner-centered rather than teacher-centered approached" (Jarvis-Selinger et al., 2011, p. 6).. The use of peer teaching in anatomy laboratories can provide an opportunity for students to act as teachers, and to practice the necessary skills for teaching others.

This first section has discussed several specific theories or approaches to learning pedagogical have been or could be used to guide changes in anatomy education. The next section is going to discuss lifelong learning and how the focus on lifelong learning impacts curricular choices currently being made in anatomical education

Developing Lifelong Learners: The Role of Self-Directed Learning and Self-Regulated Learning

In higher education, including medical education, universities and colleges identify the development of lifelong learning in their students as a goal in education (LCME, 2015). There is no ideal single definition for **lifelong learning**, but the following is a definition that can clarify the goals for developing lifelong learning in medical education.

> Lifelong learning is more than adult education and/or training—it is a mindset and a habit for people to acquire. Lifelong learning creates the challenge to understand, explore, and support new essential dimensions of learning such as self-directed learning, learning on demand, collaborative learning, and organizational learning (Fischer, 2000, p. 265).

It is no longer possible to teach every skill, technique, and bit of factual knowledge that is required for a practicing physician. Rather, our students need the ability to find answers to undefined problems that may require seeking out additional resources. Lifelong learning is required for physicians to maintain and to increase skills in the profession. While licensure requirements ensure continuing education, ideally physicians have a strong desire for lifelong learning that was developed or enhanced during their initial training. The challenge to medical educators is to develop curricula that enhance the development of lifelong learning

Lifelong learning is often associated with two related terms, SDL and SRL. Each of these terms will first be defined, compared, and then discussed in the context of medical and anatomical education. As the development of lifelong learning is an explicit goal for medical education, it is important to have a thorough understanding of the underlying concepts of lifelong learning.

Self-directed learning. SDL has become a prominent theme of discussion, particularly in adult education. SDL has also been identified in the literature, perhaps incorrectly, as *independent learning*, *self-study*, *self-teaching*, and *self-education* (Brookfield, 1984; Gade & Chari, 2013; L. M. Guglielmino, 1978; Knowles, 1975). In summarizing the various perspectives about SDL, Merriam et al. (2007) identified the three main goals of SDL as " (1) to enhance the ability of adult learners to be self-directed in their learning, and (2) to foster transformational learning as central to self-directed learning, and (3) to promote emancipatory learning and social action as an integral part of self-directed learning (p. 107)."

Many individuals have contributed to the foundation and growing prominence of SDL in education. Early work concerning adult learning projects and SDL were undertaken by Tough (1968) and he identified that 90% of adults engaged in at least one self-directed learning project each year. Tough (1979) considered SDL particularly in a context outside of schools, which is different from its current use with involved incorporating SDL within classroom education, though not necessarily in the classroom specifically (Jarvis, 2004).

Knowles advanced the theory of andragogy, a theory of adult learning and distinguished it from childhood learning, and identified self-direction as a key component of andragogy (Knowles, 1973, 1975, 1996). Knowles identified that as individuals age and grow, self-directed learning skills develop and become a key component of adult learning. Over time Knowles identified six assumptions related to adult learners. Adults have: (1) have a need to be self-directed, (2) experiences to supplement learning (3) a willingness to learn to solve relevant problems, (4) an orientation toward problem solving, (5) motivation to learn, and (6) a need to know (Merriam et al., 2007). Knowles believed that these assumptions could be used to guide theory development. Knowles defined SDL as a process when "individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes" (Knowles, 1975, p. 18). This basic definition is commonly cited as the definition of SDL. While Knowles was an early advocate of SDL, there are others that have contributed significantly to the understanding of the meaning of SDL and will be discussed below but Knowle's identification of the importance of SDL helped to move that into general consideration.

Further research followed concerning SDL. Key researchers included: Lucy Guglielmino, Ralph Brockett, Roger Hiemstra, Stephen Brookfield, and Philip Candy. Guglielmino (1978) explored the concept of SDL and identified its use in both teacher-based classrooms and individual learning projects. Guglielmino (1978) noted that characteristics of the learner likely impact the use or degree of use of SDL in learning. (L. M. Guglielmino, 1978). Brockett and Hiemstra (1991) expanded the concept of SDL to self-direction in adult learning, a term they believed allowed for a breadth necessary for understanding the concept of SDL. Additionally, the authors distinguish the use of SDL as an instructional strategy and a personality characteristic, two distinct concepts that must be independently defined and researched separately. Thus the modified definition of self-direction in learning is defined as "both the external characteristics of an instructional process and the internal characteristics of the learner, where the individual assumes primary responsibility for a learning experience" (Brockett &

Hiemstra, 1991, p. 24). The writings of Stephen Brookfield have increased the focus on the cognitive aspects of SDL. He recognized that SDL research lacked consideration for the social and political aspects in learning. Brookfield (1984) noted that it is through SDL that individuals process changes to their interpretations of the world to new thoughts and beliefs. This idea was later examined through the lens of constructivist learning theories, noting that in SDL an individual's experience impacts their interpretation of and knowledge gained (Candy, 1991).

For success in SDL with students, the teacher must still play an integral role in the development and implementation of the curriculum. This is an evolved role that casts the teacher as the facilitator of learning so that students without experience in SDL have an opportunity to understand the process and expectations without failing. Without guidance and understanding, students may be challenged by the process, anxious, and uncertain and so it is necessary to provide scaffolding (Hmelo-Silver, 2006; Palincsar, 1986; Yarrow & Topping, 2001). By teaching SDL and guiding its development, the teacher can encourage students to acquire SDL skills. Teachers also need to be both experts in the field and experts in teaching in order to facilitate the process of becoming an increasingly competent in SDL (O'Shea, 2003).

Self-regulated learning. Though there are many definitions of **SRL**, Nilson (2013) summarizes previous definitions put forth as "self-regulated learning is a total-engagement activity involving multiple parts of the brain. This activity encompasses full attention and concentration, self-awareness and introspection, honest self-assessment, openness to change, genuine self-discipline, and acceptance of responsibility for one's learning" (Nilson, 2013, p. 4). Early development of the theory of SRL comes from

Bandura's theory of self-efficacy (Bandura, 1977; Zimmerman, Bandura, & Martinez-Pons, 1992). A 3 stage model of SRL was identified by Zimmerman (2008; 1992). The model identifies three stages of SRL that occur for the learner. The three stages are forethought, performance/volitional control, and self-reflection (Zimmerman, 2008; Zimmerman et al., 1992). Further understanding of SRL was further developed by Nilson (2013).

Nilson (2013) breaks self-regulated learning into 3 types of knowledge: strategic knowledge, knowledge about cognitive skills, and self-knowledge. *Strategic knowledge* is related to an individual's ability to identify how to specifically approach learning for a given situation. *Knowledge about cognitive skills* is related to the ability to evaluate and understand the directions, task, and difficulty level of a given task. Finally, *self-knowledge* addresses the ability to choose and implement necessary learning and thinking strategies for the situation (Nilson, 2013). Emotion, positive experiences and feedback, are critical for success in self-regulation as it is part of a self-feeding cycle.

Benefits of self-regulated learning

1. Students' improved performance/achievement
2. The amount and depth of student thinking
3. Students' conscious focus on their learning
4. Development of reflective and responsible professionalism

Nilson's (2013) book includes suggestions for including SRL in college courses. Instructors can assign readings and discussions on learning and thinking, implement goal setting, discuss self-assessment of self-regulated learning skills, require self-assessment in course knowledge and skills, incorporate reflective writing at start of course, and offer knowledge surveys. SRL can also be incorporated during live lectures though active knowledge sharing, clicker questions, pair and small group activities, and 'quick thinks'.

The relationship between self-directed learning and self-regulated learning

Because of the similarities between SDL and SRL, the terms are sometimes considered to be interchangeable (Garrison, 1997; Siadaty et al., 2012). However, while they share several characteristics and the constructs have each moved closer to each other as the constructs have developed, there are distinctions that need to be noted between SDL and SRL. Table 2.1 provides an overview of the origins, similarities, and differences of SDL and SRL.

SDL emerged from the adult learning education community. It focuses on instructional processes [external constructs] in SDL, and personal characteristics of the learner [internal constructs] (Saks & Leijen, 2014). Much of the research concerning SDL has focused on learning outside of formal classrooms, likely due to its emergence from adult education. SDL research also puts significant emphasis on the degree of control wielded by the learner (Cosnefroy & Carré, 2014).

In contrast, SRL developed in the field of educational psychology and from its early emergence has had a strong focus on the cognitive aspects involved in learning. While considering both internal and external aspects of learning, SRL puts significant emphasis on the internal behaviors of the learner (Cosnefroy & Carré, 2014; Saks & Leijen, 2014). Due to its development from educational psychology, much of the SRL research involves students in traditional K-12 situations. Finally in SRL research the metacognition and self-efficacy/motivation are key areas of research (Cosnefroy & Carré, 2014).

Table 2.1
Comparing Self-Regulated Learning and Self-Directed Learning

	Self-Regulated Learning	Self-Directed Learning
Definition	**Self-regulated learning (SRL)** "is a total-engagement activity involving multiple parts of the brain. This activity encompasses full attention and concentration, self-awareness and introspection, honest self-assessment, openness to change, genuine self-discipline, and acceptance of responsibility for one's learning" (Nilson, 2013, p.4).	**Self-directed learning (SDL)** is a process when "individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes" (Knowles, 1975, p.18).
Researchers	Early development of the theory of SRL comes from Bandura's theory of self-efficacy (Bandura, 1977; Zimmerman et al., 1992). Schraw's (1998) three stage model included: planning questions before activity, monitoring questions during the activity, and evaluating questions after the activity (Schraw, 1998). Zimmerman's (2008) model identified three stages of SRL and the actions necessary for each stage: 1. forethought: task analysis and self-motivational belief 2. performance/volitional control, self-control and self-observation 3. self-reflection, self-judgement and self-reaction	Guglielmino (1978) explored the concept of SDL and identified its use in both teacher-based classrooms and individual learning projects. She noted that characteristics of the learner likely impact the use or degree of use of SDL in learning and focused on the development of the Self-directed Learning Readiness Scale SDLRS (Guglielmino, 1978). The SDLRS gained prominence as an instrument for measuring readiness for SDL (Guglielmino, 1978; Long and Agyekum, 1983; Brockett and Hiemstra, 1985). Brookfield (1985) increased the focus on the cognitive aspects of SDL. He recognized that SDL research lacked consideration for the social and political aspects in learning. He noted that it is through SDL that individuals process changes to their interpretations of the world to new thoughts and beliefs.

Table 2.1 (cont.)
Comparing Self-Regulated Learning and Self-Directed Learning

	Self-Regulated Learning	Self-Directed Learning
Researchers (cont).	Nielson (2013) described self-regulated learning as 3 types of knowledge required for SRL: strategic knowledge, knowledge about cognitive skills, and self-knowledge. 1. Strategic knowledges is related to an individual's ability to identify how to specifically approach learning for a given situation. 2. Knowledge about cognitive skills is relate to the ability to evaluate and understand the directions, task, and difficulty level of a given task. Self-knowledge relates to the choice and implementation of necessary learning and thinking strategies for the situation.	Brockett and Hiemstra (1991) expanded the concept of SDL to self-direction in adult learning, a term that allowed the breath necessary for understanding the concept of SDL. The authors distinguish the use of SDL as an instructional strategy and a personality characteristic, two distinct concepts that must be independently defined and researched separately. Candy (1991) explored SDL through the lens of constructivist learning theories, noting that in SDL an individual's experience impacts their interpretation of and knowledge gained. Merriam et al. (2007) summarized the various perspectives of SDL and identified the three main goals of SDL as "(1) to enhance the ability of adult learners to be self-directed in their learning, and (2) to foster transformational learning as central to self-directed learning, and (3) to promote emancipatory learning and social action as an integral part of self-directed learning (Merriam et al., 2007, p. 107)."
Similarities	SDL and SRL are related constructs that focus on active learning processes with a defined goal in which the individual/student is metacognitively aware (Loyens et al., 2008; Pilling-Cormick and Garrison, 2013; Cosnefroy and Carré, 2014; Saks and Leijen, 2014). Both SDL and SRL consider components of learning within the learner and components external to the learner (Saks and Leijen, 2014).	

Table 2.1 (cont.)
Comparing Self-Regulated Learning and Self-Directed Learning

	Self-Regulated Learning	**Self-Directed Learning**
Differences	Developed in the field of educational psychology and from its emergence had a strong focus on the cognitive aspects involved in learning. Considers internal and external aspects of learning but emphasizes the internal behaviors of the learner (Cosnefroy and Carré, 2014; Saks and Leijen, 2014). Due to its development from educational psychology, much of the SRL research involves students in traditional K-12 situations. Metacognition and self-efficacy/motivation are key areas of research (Cosnefroy and Carré, 2014).	SDL emerged from the adult learning education community (Knowles, 1975). It focuses on instructional processes, external constructs, and personal characteristics of the learner (Saks and Leijen, 2014). Much of the research concerning SDL has focused on learning outside of formal classrooms, likely due to its emergence from adult education. SDL research also puts significant emphasis on the degree of control wielded by the learner (Cosnefroy and Carré, 2014).
Role in Education	Benefits of self-regulated learning (Zimmerman, 2008; Nilson, 2013) • Improving student performance/achievement • Increasing amount and depth of student thinking • Focusing the student on their learning • Developing reflective and responsible professionalism Suggestions for SRL in college (Nilson, 2013). Instructors can make assignments on learning and thinking, implement goal setting, discuss self-assessment of self-regulated learning skills, require self-assessment in course knowledge and skills, incorporate reflective writing at start of course, and offer knowledge surveys.	For success in SDL with students the teacher must still play an integral role. This is an evolved role that casts the teacher as the facilitator of learning so that students without experience in SDL have an opportunity to understand the process and expectations without failing (Merriam, 2007). Without guidance and understanding, students may be challenged by the process required for SDL and so it is necessary to provide scaffolding and coaching to help students develop SDL skills (Dornan et al., 2005; Keator et al., 2016).

Both SDL and SRL provide strong research evidence that can be used to guide pedagogy and curricular development. However, it is important to understand and identify how history of the constructs impacts the products. Increasingly, SDL research is emphasizing more of the cognitive aspects explored in SRL literature (Pilling-Cormick & Garrison, 2013). For education researchers is may be useful to use and explore the SRL research to help develop and improve those lesser constructs in SDL research.

Self-directed learning and self-regulated learning in medical education. While SDL and SRL share commonalities, it is important to be explicit and intentional in word choice in research. In medical education, along with other educational research, there are occasions when authors conflate and misuse these two terms, or simply reference research related to one construct to support another construct. The inclusion of SDL in the Liaison Committee on Medical Education (LCME) (2015) standards for medical school accreditation has increased the focus on SDL in medical education . SDL has been viewed in medical education for years as a need to promote lifelong learning in physicians and a critical skill needed. According to the LCME (2015), SDL enables medical students to become lifelong learners; therefore, SDL is a critical component of medical education. SDL is defined by the LCME stating it "Includes medical students' self-assessment of their learning needs; their independent identification, analysis, and synthesis of relevant information; and their appraisal of the credibility of information sources" (LCME, 2015, p. 8).

While the emphasis of SDL has increased due to its identification by the LCME, there are still very few ways for schools to directly measure and evaluate SDL that is implemented in medical education. Additionally, the development of an instruments, researchers need to evaluate and consider what might be gained in examining SRL instruments that have wide use and established validity Also, researchers need to be aware of how SDL and SRL relate to each other and use both constructs to help guide pedagogical and curricular choices. Certainly the emphasis on adult education (Knowles, 1975; Merriam et al., 2007) and the relationship to lifelong learning (Candy, 1991) create a strong relationship between SDL and medical education. However, SRL contributes significant understanding about metacognition and self-efficacy, which are constructs that relate to SDL and need additional emphasis to more fully develop our understanding of SDL (Pilling-Cormick & Garrison, 2013).

Conclusions

As found by McBride and Drake (2018) in the most recent survey of anatomy programs in medical education, there is still ongoing pressure to decrease time students spend in the gross anatomy laboratory. Increasing integration in medical education, both within basic science courses and between basic science and clinical experiences, requires that the anatomy laboratory curriculum design consider way of integrating into the broader medical curriculum (Brauer & Ferguson, 2015; Drake, 2014; Drake et al., 2014; McBride & Drake, 2015, 2018). While peer teaching and alternating dissections have been used in gross anatomy laboratories for over a decade (Bentley & Hill, 2009; Brueckner & MacPherson, 2004; Evans & Cuffe, 2009; Hendelman & Boss, 1986; Krych et al., 2005; Nnodim, 1997), research on peer teaching in the gross anatomy laboratory has focused primarily on impacts to grades or explored how peer teaching gives students teaching experience. Finally, the inclusion of SDL in the standards for allopathic medical school accreditation, make it necessary for educators in medical education to understand the definition of SDL and develop approaches to incorporating SDL into the curriculum.

This dissertation addresses several the gaps remaining in anatomy education research. Specifically, this research focuses on peer teaching, SDL, and expanding the understanding of the impacts on the student experience in gross anatomy. A mixed method research design was selected to allow for an in-depth analysis of the student experience in a peer teaching laboratory to expand our understanding of how peer teaching impacts students in medical education, specifically anatomy education; while the quantitative analysis further confirms previous findings that peer teaching and alternating dissections generally have no impact or a slightly positive impact on student grades (Bentley & Hill, 2009; Krych et al., 2005; Nnodim, 1997; A. B. Wilson, M. Petty, J. M. Williams, & L. E. Thorp, 2011). This research also uses a qualitative analysis to examine how the incorporation of SDL impacts the student experience in gross anatomy, identifies the challenges of incorporating SDL in an anatomy laboratory, and provides suggestions for improving SDL experiences in the future.

When looking to change and improve an education system, it is critical to not fall prey to the quick fix. All of those involved in teaching anatomy in medical education need to delve deeply into the literature regarding education both inside and outside of their discipline to look for the best path forward. With this as an objective, this dissertation looks to provide evidence-based suggestions that can be used at IUSM-BL, the larger IUSM community, and the most broadly by anatomical educators involved in medical education.

CHAPTER 3: METHODS

The purpose of this dissertation research was to examine the impacts of reciprocal peer teaching and self-directed learning (SDL) in the gross anatomy laboratory. For simplicity, reciprocal peer teaching will simply be referred to as peer teaching in this dissertation. This study considered both impacts to the gross anatomy grades of the students, as well as, impacts not as easily identified through course assessment. I chose a mixed method research approach as it provided the best opportunity to examine the questions I wished to answer through my research. In this chapter, I first describe the data sources and the instructors and student groups that comprised the samples for the study. Next, I review the three research questions this dissertation addressed. Then I discuss the rationale for choosing a mixed method design. Finally, I conclude with detailed descriptions of the quantitative and qualitative methods used in this research.

Materials

This study focused on first year medical students enrolled in a year-long gross anatomy course, Gross Human Anatomy A550-551 (A550-551), at Indiana University School of Medicine – Bloomington (IUSM-BL). A550 was the course number for the fall semester and A551 was the course number for the spring semester. This materials sections describes the course and the sources of data used in this dissertation. First, I describe general aspects of the course that remained constant for all 6 years included in this research study. Next, I explain the differences between the traditional laboratory (TL) format used in the 2010-2011 and 2011-2012 school years, the peer teaching laboratory format (PTL) used in the 2012-2013 and 2013-2014 school years, and the peer teaching plus laboratory (PTL+) format used in the 2014-2015 and 2015-2016 school years. Changes to the gross anatomy class structure included incorporating alternating dissections, peer teaching, VoiceThreads© (VT©), and lab structure lists. Finally, I describe the data sources obtained for this research project including student work, grades, interviews, and exams.

The Course

A550-551 was a year-long human anatomy course offered through IUSM-BL until the Fall 2016 semester (when the medical curriculum underwent revision, and courses were restructured). The course covered developmental and regional gross anatomy of the human body and included both lectures and cadaver-based dissection. A550-551 was divided into six, approximately four-week long instruction blocks. Each block concluded with a lecture exam and laboratory exam. The three fall semester blocks included: back, spinal cord, and superficial thorax; thorax and abdomen; pelvis and perineum. The three spring semester blocks included: superficial head and neck, deep head and neck, and limbs. Embryology was integrated throughout the course as related to the regions of study.

A550-551 met twice a week, each class session included a one-hour lecture followed by a two-hour laboratory dissection session. One instructor taught the lecture session, and lecture sessions included didactic instruction interspersed with active learning opportunities, such as 'think-pair-share' activities. Laboratory sessions had the instructor present along with two graduate teaching assistants (TA). TAs are primarily selected from students completing the Anatomy Education Graduate Program at IUSM-BL. These graduate students have previously taken A550-551 and completed additional dissection experiences as well as some pedagogical training. The gross anatomy laboratory has 9 dissection tables available in the room. Additional recourses for instruction include 3D plastic models, skeletal material, and radiological images.

The learning goals for students in A550-551 include learning anatomical vocabulary, developing a three-dimensional understanding of the body, learning surface and deep anatomy necessary for physical examinations, understanding the clinical relevance of specific anatomical areas, understanding embryology and developmental abnormalities, developing an appreciation for human variation, and learning to complete a typical autopsy report upon completion of donor dissection. In addition, students in gross anatomy are assessed for the competencies of effective communication; life-long learning; self-awareness, self-care, and personal growth; professionalism and role recognition; and basic clinical skills.

Each year there are approximately 32 - 36 first year medical students enrolled in the class. The class A550-551 was a required course for all first-year medical students until the curricular changes in the fall of 2016. Additionally, 2-3 graduate students from various degree programs enrolled in the course each semester. However, for this study, no graduate student data was examined due to the limited number of graduate students and the differences between the graduate and medical student populations. This study examines A550-551 when it was taught as core science classes in the medical curriculum. Other first year core medical science classes included: Microbiology, Physiology, Neuroanatomy, Biochemistry, and Histology.

Changes to the Laboratory Component of Gross Human Anatomy

This study examines the impacts of changes that were made to the laboratory portion of A550-551. Table 3.1 identifies the school years and the changes implemented in the A550-551 curriculum. From fall 2010 through spring 2012, A550-551 used a TL format in which all students attended and participated all dissection sessions. Students worked in groups of four to five to dissect a single donor following a regional approach, the study of anatomy based on body areas rather than body systems, over the course of the school year. In the fall of 2012, it became necessary to reduce the number of hours spent in the anatomy laboratory so that the course hours aligned with other Indiana University School of Medicine (IUSM) campuses. IUSM-BL is part of the larger IUSM that offers years 1 and 2 of medical school at 9 campus locations throughout the state.

Table 3.1

Class Years in Gross Anatomy and the Changes That Were Implemented

Year	N	Implemented Changes			
2010-2011	34				
2011-2012	32				
2012-2013	35	Alternating Dissection	Peer Teaching		
2013-2014	35	Alternating Dissection	Peer Teaching		
2014-2015	36	Alternating Dissection	Peer Teaching	VoiceThread©	Structure Lists
2015-2016	36	Alternating Dissection	Peer Teaching	VoiceThread©	Structure Lists

To accommodate the reduction in course hours, the laboratory curriculum transitioned to a **peer teaching laboratory (PTL)** incorporated alternating dissections.

The PTL format was used from the fall of 2012 through the spring of 2014. Students still worked in groups of 4-5 students per donor, and 2 dissection sessions were scheduled each week. However, each group further subdivided into A and B dissection teams. Each week the A team completed one dissection and the B team completed the other dissection. Figure 3.1 provides a diagram explaining the dissection procedure used in A550-551. The peer teaching and alternating dissection schedule will be discussed more in the next two sections.

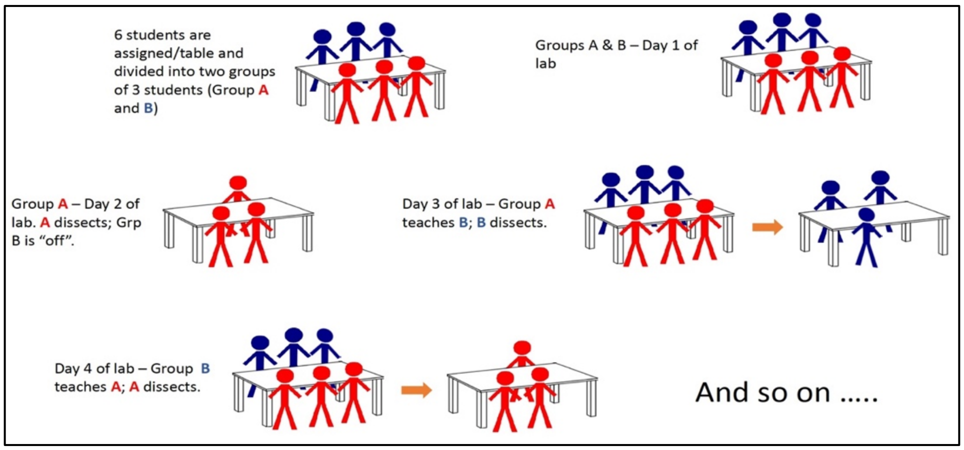


Figure 3.1. Diagram of an Anatomy Laboratory Employing Alternating Dissections and Peer Teaching. A and B teams are represented by the blue and red figures. Only one team dissects at a time, but the entire group is present for a short teaching session at the start of each lab (Seifert, 2014)

Finally, from the fall of 2014 through the spring of 2016 additional curricular changes were implemented to supplement the peer teaching process, that is referred to as the **peer teaching plus (PTL+)** format. These curricular changes were developed after preliminary findings of this dissertation research indicated the need to guide the peer teaching process that students engaged in during the laboratory sessions (Dunham, 2015). Changes included the addition of VT© assignments and laboratory structure lists that will be explained later in this section.

In the following paragraphs, I describe in detail the changes that were implemented in A550-551. Refer to table 3.1 for the years of implementation of each change. The research questions (described in the next section) examine multiple years of data from this course. In general, data from 2010-2016 was examined, with some exceptions (and those exceptions will be noted later in this chapter).

Alternating dissection. Starting in the fall of 2012, alternating dissection was introduced and continued through the spring of 2016. Students were first divided into groups of 4-5 and assigned to one of nine donors available in the A550-551 laboratory. Each dissection group then split into an A and B teams. Students self-selected both their large groups as well as the A and B teams. Students then alternated completion of dissection sessions. For example, group A would dissect on Tuesday and group B would dissect on Thursday. This rotation continued throughout the course. Students were given approximately 1.5 hours to complete the dissection, but some groups would stay past the end of class to complete a dissection. The group performing the dissection was responsible for having it completed prior to the next laboratory session. In the alternating dissection format students only actively participate in half of the dissection sessions completed in A550-551.

Peer teaching. Peer teaching was implemented at the same time as the alternating dissections, in fall 2012. Peer teaching was intended to be paired with the alternating dissection approach to ensure students were familiar with all dissections completed in the A550-551 lab. The first 30 minutes of every laboratory session were reserved for peer teaching. All students, A and B teams, attended the first 30 minutes of lab. With the entire dissection group present, the team that completed the dissection in the previous lab section used the 30 minutes to teach the other team what was found, identify important structures, and discuss any issues with the dissection.

The changes discussed in the next several sections, in addition to being part of the interventions for this research project, are sources of data for analysis. These data sources include VT© slideshows and anatomy structure lists. Both the VTs© and the structure lists were used only in the PTL+ format. The details of the intervention are explained as well as noting the type of data that was retained for this study. Table 3.2 identifies all sources of data for this research and specifies the individuals that generated the data.

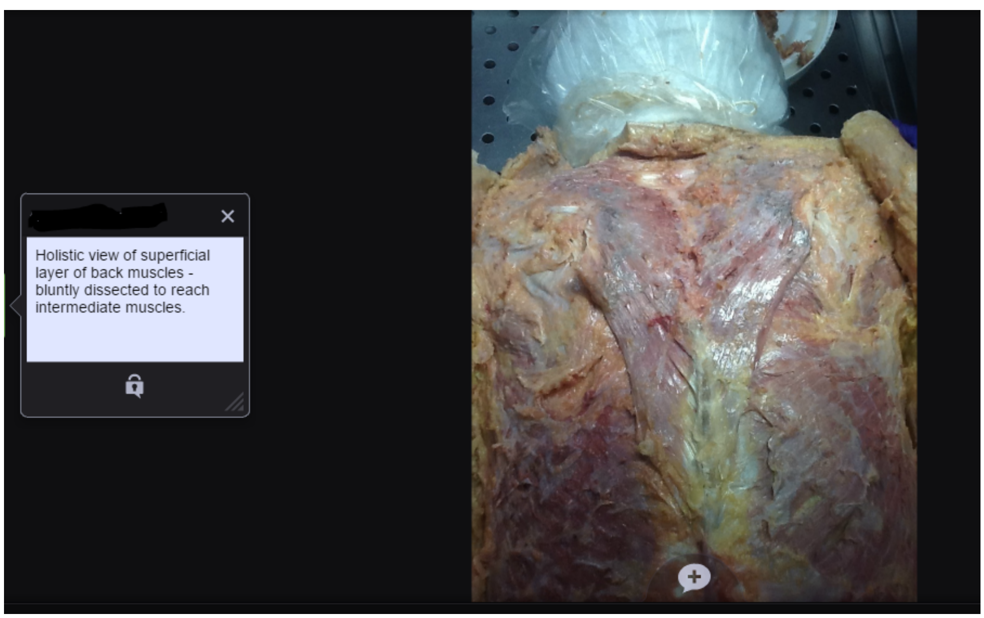
Table 3.2
Participants and the Data They Generated

Participants	Class Grades	Voice-Thread©	Structure Lists	Lab Exams	Interviews	Lab Experience Survey
2010-2011 Students	n = 34	n/a	n/a	n/a	n/a	n/a
2011-2012 Students	n = 32	n/a	n/a	n/a	n/a	n/a
2012-2013 Students	n = 35	n/a	n/a	n/a	n = 0	n/a
2013-2014 Students	n = 35	n/a	n/a	n/a	n = 8	n/a
2014-2015 Students	n = 36	n = 394	n = 383	n/a	n = 10	n/a
2015-2016 Students	n = 36	n = 390	n = 381	n = 155	n = 0	n = 36
2010-2016 Instructors	n/a	n/a	n/a	n/a	n = 5	n/a
Totals	n = 208	n = 784	n = 764	n = 155	n = 23	n = 36

VoiceThread©. VT© is a digital application that allows photos and videos to be uploaded to create a single slideshow (VoiceThreadLLC, 2017). The author of the video can then narrate and annotate the slideshow and organize images and videos as desired. VT© was selected as the platform to host student slideshows because it allowed for creation of unique content and was password secured through university computing servers. During the fall of 2014, the use of VT© was introduced into the A550-551 anatomy course as part of the curriculum for the 2014-2015 and 2015-2016 school years. Using VT©, students created narrated slideshows of dissections and highlighted structures or issues of significance. Picture 3.1 shows a screen capture taken from a student VT©. On the image, annotation marks made by student can be seen. All students had access to all VTs© during the course and groups received points for completion of their slideshows.

Picture 3.1. Image Captured From VoiceThread© With Added Annotations. An image created by student in A550-551 with circle annotations around placed pins to identify specific structures.

The dissection team not present at the dissection was required to view the VT© prior to coming to class. By watching the VT© prior to coming to class, students had the opportunity to familiarize themselves and better prepare for class. The program also allows comments and questions to be left within the VT©, so students could interact directly through the program. Prior to coming to class, students had to view the VT© and post a message that was used as an indication the student completed the viewing assignment. Picture 3.2 shows how students can leave written messages and notes to each other through the VT© application. These narrated slideshows are a data source for this dissertation. Digital files that capture the VTs© were obtained from the course director. Student consent was obtained by the researcher to view the VTs©. These files are retained on a secure university server. Additional data sources will be discussed in the following sections.



Picture 3.2. Image Captured the VoiceThreads© With Message. Created in A550-551 with written message used as communication between students.

Gross anatomy laboratory structure lists. The LCME has set a standard for medical schools requiring schools to incorporate self-directed learning (SDL) in the medical curriculum. According to the LCME, SDL includes assessing learning needs, independent identification and analysis of information, and judging the credibility of source information (LCME, 2015). Requiring students to create their own gross lab dissection structure lists, in an order of importance as determined by the student, fulfills these requirements as SDL learning activity in the anatomy laboratory. Students were directed to create a word list of the structures that were to be dissected during the laboratory session. Prior to each dissection, students enrolled in A550/551 were to read the dissection instructions from the class-assigned dissector. After reading the directions, students then created a list of structures to be dissected based on their perceived order of importance of the structures. At the end of the list, students then needed to justify how they choose to organize the list. The directions for creating a structure list stated

> Prior to each lab you will need to create a list of structures that you are looking for in the lab. Use your lab guide to help you generate a list and categorize the structures as primary, secondary, and tertiary. You can create your categories however you wish, but at the end of the list write a brief statement describing how you decided to categorize the structures. You may want to add additional information to help when studying and review for exams, such as tips for how to identify structures. Be sure this is the first slide in you VoiceThread© presentation. (A550 Syllabus, 2014).

Students created a complete structure checklist before each laboratory session. Figure 3.2 is an example of a structure list created by a student for the Intermediate and Deep Back dissection session. Digital copies of the structure lists were obtained and used as a source of data for this dissertation, following all Institutional Review Board (IRB) and Family Educational Rights and Privacy Act (FERPA) guidelines.

Intermediate and Deep Back

Primary Structures:

- Rhomboid major/minor (re-identify)
- Latissimus dorsi (re-identify)
- Dorsal scapular nerve
- Transverse cervical artery
- Serratus posterior superior
- Serratus posterior inferior

Secondary Structures:

- Splenius Capitus
- Splenius Cervicis
- Illiocostalis
- Longissiums
- Spinalis

Tertiary Structures:

- Transversospinal muscle group
  - Semispinalis capitus
  - Greater occipital nerve
  - Semispinalis cervicis
  - Multifidus
  - Rotarores longi/brevis

Grouping Scheme:

Our groupings are based on the progressions through the physical layers during dissection. The primary structures are the first structures we will be looking at in dissection, the intermediate muscles of the back, as well as some re-identification of superficial muscles as landmarks for orientation. The secondary structures will be identified as we begin to dissect the "outer" and "middle" layers of the deep back muscles. The tertiary structures are the muscles of the "inner" layer of the deep back. We will be identifying specific muscles in the transverse spinal muscle group, lesser importance is placed on knowing these muscles specifically than in the

Figure 3.2. Student Generated Structure List. An example of student generated structure list created before completion of in class dissection sessions.

Additional Data Sources

Class grades. I obtained deidentified grades from the course director of A550-551 for the 2010-2011, 2011-2012, 2012-2013, and 2013-2014 school years. Grades used in this dissertation included final course grades, 6 individual laboratory exam grades, and 6 individual lecture exam grades. Identified grades were obtained for the 2014-2015 and 2015-2016 courses for which all students agreed to release grades and student work (exams, VTs©, structure lists) for the study. Signed consent was obtained from each student. Again, grades used in this dissertation included final grades, laboratory exam grades, lecture exam grades.

Gross anatomy exams. For each block students were assessed through a lecture exam and a laboratory exam. Each is described individually.

Lecture Exams. Gross anatomy lecture exams covered the material taught in the lecture portion of the course. Exams included multiple choice and short answer/essay questions. For this dissertation, only student grades for the lecture exams were used in the analysis. The individual exams were not examined.

Laboratory Exams. In A550-551, laboratory exams tested students using the donors dissected by students during class sessions; plastic models; and X-ray, MRI, and CT images. A laboratory exam was taken at the end of each block. Students first took the lecture exam followed immediately by the laboratory exam. Prior to the laboratory exam, the instructors of the course worked together to create questions primarily based on identifying structures highlighted in the dissection instructions, but exams also contained higher order questions that integrate lecture and laboratory content. All students in the class took the exam at the same time and rotated through individual question stations. Students had 1 minute at each station to answer fill in the blank questions.

For the 2015-2016 school year, laboratory exams were collected from the course director and used as a source of data for this dissertation. Exams have been retained and stored in a secure location at the University. Each question was examined and dissection session during which the structures were related was identified. The dissection sessions attended by each student were identified. In the pelvis and perineum block, additional factors such as sex of the donor and if the pelvis remained whole or was hemisected created many additional variables in addition to whether a student actively dissected a region or was peer taught. Based on this information, each structure identification question was classified as either dissected or not dissected by a student and if the student answered correctly or incorrectly. Higher order questions integrated lecture and laboratory content and so active dissection may not have been required to be able to answer these questions correctly. Both, higher order questions and exams for the pelvis and perineum block, were excluded from the analysis due to confounding variables beyond active dissection by the student.

Interviews with students and instructors. Semi-structured individual interviews were conducted with medical students and gross anatomy instructors, both faculty and TAs, over a period of time from the spring of 2014 through the fall of 2017. Interview documents are included in Appendices A-D. Interviews covered a range of topics including peer teaching, alternating laboratory sections, VTs© and perceptions of the lab experience. The questions asked were similar for all interviews, but students that participated in the PTL+ were asked about the experience of using VT© in the lab whereas students in a TL or PTL were not asked about VT© as it was not used in those classes. All interview participants signed an Informed Consent document granting permission to use the interview for research. Digital recordings were made of the interviews. The interviews were then deidentified, transcribed, and digital files were saved on a secure University server.

Laboratory Experience Questionnaire. The questionnaires are completed by all students in A550-551. These were retained from the students enrolled in the 2015-2016 school year. A complete copy of the Laboratory Experience Questionnaire (LEQ) is in Appendix E. Four of the questions that had information relevant to this study are listed below. Student answers were deidentified, transcribed, and stored on a secure University server.

1. What did you learn about yourself during this lab? What potential strengths or weaknesses about yourself became evident as you dissected in lab?
2. Has your lab group worked well together? Describe some specific instances where there was good teamwork, and not-so-good teamwork.
3. What are some ways that teamwork could have been improved?
4. What are some ways that would enhance the dissection experience and/or enhance respect for the donor?

All participants signed the relevant Informed Consent Document found in Appendices F and G. Now that the critical components of A550-551 have been described and all data sources used for this dissertation have been identified, I will next discuss how the data will be used to address the research questions.

Research Questions

This dissertation is interested in addressing three research questions. The nature of the research question dictates the methods used to answer the question. Below I will discuss the materials and methods to be used in the study to answer the questions.

Research question 1. What were the impacts of peer teaching and on student grades in Human Gross Anatomy (A550-A551) at IUSM-BL?

Question 1 examined changes in student grades and therefore was best answered using quantitative data analysis. Statistical analysis was performed using Analysis of Variance (*ANOVA*), student course grades from the fall of 2010 through the spring of 2016 were analyzed to determine if there was a significant change in grades between the traditional laboratory format, the peer teaching laboratory format, and the self-directed peer teaching format. The general consensus in the literature indicates that alternating dissection formats and peer teaching do not negatively impact student performance and may actually improve performance in an anatomy laboratory course (Granger & Calleson, 2007; Hendelman & Boss, 1986; J. H. Johnson, 2002; Krych et al., 2005; Manyama et al., 2016; Marshak et al., 2015; McWhorter & Forester, 2004; Adam B. Wilson et al., 2011). Based on this previous research it is hypothesized that there is not a significant change in student grades when altering the format of the gross laboratory class.

Question 1 also addressed the impacts to student grades using a second set of data. For medical students in the 2015-2016 A550-551 course, copies of the laboratory exams were retained. Statistical analysis was performed using a Generalized Estimating Equation (*GEE*) to analyze the data. The *GEE* indicates if there is a significant difference in the likelihood of a student correctly answering a lab exam question when the question is related to course the material the individual student dissected as opposed to when the question is related to material dissected by group members and then taught through peer teaching. It was hypothesized there is no significant difference in exam performance based on learning material through dissection or peer teaching.

Research question 2. What were the underlying impacts of alternating dissections and peer teaching gross anatomy laboratories that were not easily identified by only analyzing exam grades and course performance?

Question 2 examined PT in the context of the gross anatomy laboratory. I was interested in understanding the impact of interactions between student, interactions between students and instructors, and the impacts within an individual student. This question requires analyzing students' and instructors' behaviors and thoughts, so a qualitative method is best able to address this question. Using a grounded theory approach, interviews of students and instructors were analyzed to identify and explore the impact of peer teaching in the laboratory classroom.

Research question 3. How could a gross anatomy course, specifically the laboratory component of A550-551 at IUSM-BL, effectively contribute to the accreditation process and directive to use SDL required by Standard 6.3 from the LCME (LCME, 2015)?

Question 3 was interested in determining if a peer teaching approach, along with specific assignments could contribute to meeting the need for SDL in the medical curriculum. Interviews with students, LEQs, and student work in the form of VT© and lab structure lists were examined using a grounded theory approach (Charmaz, 2014). The results were used to provide recommendations to IUSM-BL, IUSM, and anatomy educators involved in medical education in the United States.

Methodology

This methodology section describes the specific methods used for this research and is separated into three sections: mixed methods, quantitative methods, and qualitative methods. To answer the research questions this study employs a mixed method approach. In the first section, I describe the background of mixed methods in education research. Followed by the specific mixed method approach for this research. The second section details the quantitative methods used in this study. Finally, the third section explains the qualitative methods used to address the research questions.

Mixed methods. In order to answer the three research questions, a mixed method (quantitative plus qualitative) approach was used. I believe a mixed method approach was best for understanding the complex social situation that is the classroom environment. Mixed methods allow for a more comprehensive understanding in complex situations by combining the strengths of quantitative analysis in examining numerical data and the benefits of in-depth, descriptive qualitative approaches in which meaning can best be derived from the data (Creswell, 2014). As mixed methods research has grown in popularity and acceptance, an increasing amount of literature is able to guide researchers on the theoretical underpinnings and techniques for grounded research. Green (2007) identifies that mixed methods may be an appropriate choice for research that addresses data that is not all suited to either a strictly qualitative or quantitative approach and to address unsettled questions and topics in a field.

History of mixed methods. A mixed method approach has not always been accepted in educational research. Quantitative or qualitative (but not combined) were the dominant methods throughout the second half of the 20th century, but research focused on a single method. Historically, quantitative research was based in positivist philosophy in which hypothesis testing verified and established facts and primarily utilized quantitative methods (Lincoln, Lynham, & Guba, 2011). In recent years the positivist philosophy has given rise to the more widely accepted post-positivist philosophy. The post-positivist paradigm seeks objective inquiry and generalizable results, but acknowledges that there are unknowns and hidden variables that may impact results (Lincoln et al., 2011). Qualitative research uses an in-depth approach of looking at scope and detail and generates an in-depth analysis that can then be used to understand other problems, but is not directly generalizable to all similar populations (Creswell & Clark, 2007; Greene, 2007). There are those that have argued that statistical characteristics and generalizability of quantitative methodologies and the narrative, subjective, and non-generalizability of qualitative methodologies, make the integration in a mixed method impossible (R. B. Johnson & Onwuegbuzie, 2004). However, the current prevailing view is that mixed method research is a valuable approach and is accepted by the general education and medical education communities (Creswell, 2014; Creswell & Clark, 2011; Greene, 2007).

Pragmatism. The goal of a mixed method approach is to draw on the strengths of both quantitative and qualitative methods. My approach to mixed methods was influenced by Green and a philology that embraces and engages multiple epistemologies, acknowledges contradictions, and uses multiple methods to enhance a study (Greene, 2007). The guiding paradigm used in this research was that of **pragmatism**. Pragmatism is commonly used as a worldview in mixed methods (R. B. Johnson & Onwuegbuzie, 2004; Teddlie & Tashakkori, 2003), but it should be selected through consideration not expediency. Pragmatism advocates interweaving other worldviews, in this instance post-positivism and constructivism, in a single research project to bring out the strengths of both worldviews and to derive the best possible answers (Creswell, 2014). Pragmatism enables a researcher to adopt a post-positivist worldview when addressing quantitative methods and a constructivist worldview for qualitative analysis.

The classroom in human gross anatomy was a complex educational environment. By adopting a pragmatic worldview, I was able to explore my research questions through both a quantitative and qualitative lens. Few studies have used mixed methods when examining peer teaching in anatomy and so this research will that gap left in the research. Through the quantitative analysis of class grades, I compared three student groups, TL, PTL, and PTL+, and examined the impact of dissection on individual laboratory exams within a single class year. Qualitative methods explored the interviews and student work to better understand the impacts in the classroom and on individual students. There are various mixed method approaches; the next section justifies and explains the choice of a convergent parallel mixed method design for this study.

Convergent parallel mixed method design. A **convergent parallel mixed method (CPMM)** design emphasizes the strength of both quantitative and qualitative research methods (Creswell & Clark, 2007). Data collection is pursued simultaneously and independently, followed by independent analysis of the results. Mixing of the quantitative and qualitative methods only occurs in the final discussion and interpretation of results. Figure 3.3 diagrams how the convergent parallel method mixes quantitative and qualitative approaches. The benefits of a convergent parallel design include efficiency and independence.

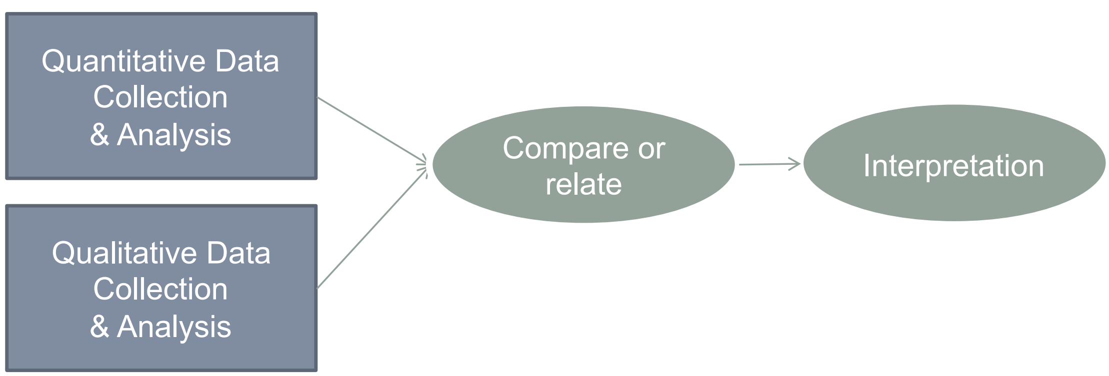


Figure 3.3. Convergent Parallel Mixed Methods. A graphic display of a convergent parallel mixed method design modified from Creswell and Clark (2007).

The merging of the data used the method identified by Creswell and Clark (2007). The convergent mixed method analysis used five steps.

1. Collected quantitative and qualitative data simultaneously.
2. Independently analyzed quantitative and qualitative data. Quantitative analysis included analysis of variance (*ANOVA*) and generalized estimating equation modeling (*GEE*). Qualitative analysis used grounded theory.
3. Identified dimensions, big ideas, that could be compared across the quantitative and qualitative methods.
4. Identified specific results and analyses, that could be compared across the quantitative and qualitative methods.
5. Completed refinement of quantitative and qualitative analyses as necessary for comparison.

This research used a quasi-experimental approach research to analyze the impact of a peer teaching approach on student grades. It also used the quasi-experimental approach to analyze how student performance on gross anatomy laboratory exams was impacted by having dissected the material in the question as opposed to being peer taught the material in the classroom by fellow students. The qualitative analysis of this research is two parts as well. Grounded theory (GT) was used to explore the impact of the peer teaching and alternating dissections on the student experience in the gross anatomy classroom and to examine how SDL could effectively be incorporated into the anatomy laboratory classroom.

Validity. **Validity** is more difficult in a mixed method study because it must be addressed individually in the quantitative and qualitative methods as well as the overall mixed method study. However, in both quantitative and qualitative methods, validity "serves the purpose of checking on the quality of the data, the results, and the interpretation" (Creswell & Clark, 2011, p. 210). The specific validity checks for the quantitative and qualitative strands will be discussed in each section respectively. Here I will discuss issues of validity specifically related to conducting a mixed method study.

Triangulation. **Triangulation** decreases threats to validity in mixed method research by using multiple methods and multiple sources to analyze the same problem or situation and to determine if the outcome yields comparable answers or conclusions (Creswell & Miller, 2000; Jick, 1979). "The effectiveness of triangulation rests on the premise that the weaknesses in each single method will be compensated by the counter-balancing strengths of another" (Jick, 1979, p. 139). Triangulation increases confidence in the results, can help to identify unexpected elements through data collection and analysis, and can lead to integration of theories. How the results of both quantitative and qualitative methods are integrated is just as important as setting up the individual methods. While looking for congruence, to support triangulation, it is equally as important to consider discrepancies between findings (Jick, 1979). Triangulation was used in this study to merge the two methods, qualitative and quantitative.

Validity when merging data. Table 3.3 identifies threats to validity as well as the suggested strategies for minimizing those threats. Creswell and Clark (2007) identify threats to validity when merging data in a convergent parallel mixed method design.

Table 3.3

Validity Threats When Merging Data in a Concurrent Parallel Mixed Method Design

Potential Validity Threats When Merging Data	Strategies for Minimizing the Threat
Data Collection Issues	
Selecting inappropriate individuals for the qualitative and quantitative data collection	Draw quantitative and qualitative samples from the same population to make data comparable.
Introducing potential bias through one data collection on the other data collection (adding qualitative data into a trial with the trial is going on)	Use separate data collection procedures, and collect data at the end of an experiment.
Collecting two types of data that do not address the same topics	Address the same question (parallel) in both quantitative and qualitative data collection.
Data Analysis Issues	
Using inadequate approaches to converge the data (e.g., uninterpretable display)	Develop a joint display with quantitative categorical data and qualitative themes or use other display configurations.
Making illogical comparisons of the two results of analysis	Find quotes that match the statistical results.
Interpretation Issues	
Not resolving divergent findings	Use strategies such as gathering more data, reanalyzing the current data, and evaluating the procedures.
Giving more weight to one form of data than the other	Use procedures to present both sets of results in an equal way (e.g., a joint display) or provide a rationale for why one form of the data provided a better understanding of the problem.
Not relating the stages or projects in a multiphase study to each other	Consider how a problem, a theory, or a lens might be an overarching wat to connect the stages or projects.

Note. Adapted from Creswell and Clark (2007, pp. 240-241).

These threats are broken into three categories: data collection validity threats, data analysis validity threats, and interpretation validity threats. Strategies for minimizing the treats to validity were used as a basis for maintaining the validity when preparing to and merging the data from the quantitative and qualitative strands of this research.

The product of mixed methods. The goal of this research was to improve the understanding of the impact of peer teaching and SDL in gross anatomy at IUSM-BL through a thorough analysis using mixed methods. Previous studies have primary focused on quantitative approaches and so the use of mixed methods in this study offers a new approach to understanding peer teaching. The results of this study will provide evidence to be considered in curricular changes at IUSM-BL in the anatomy laboratory classroom as well as to the regional IUSM anatomy faculty responsibly for aligning anatomy medical education curricula across the 9 IUSM campus locations. Finally, this study provides information concerning peer teaching and SDL for anatomy educators and medical educators generally. In addition, this study informs anatomy educators about the learning experience and knowledge gained in an anatomy laboratory. While not specifically generalizable to all classrooms, this study adds to the literature concerning the student experience in the anatomy laboratory. Next, I will describe the qualitative methods used in this research.

Quantitative methodology. Quantitative methods were used to analyze course and exam grades of the A550-551 students. Refer back to table 3.2 for a summary of the class grades and lab exams obtained for the participants in A550-551. This data was used to address research question 1. The methods are further explained below.

Sample for the quantitative methodology. The individuals of interest in this study were the students (first year medical students) enrolled in Human Gross Anatomy at IU Bloomington in the 2010-2016 school year. This included students who were in the traditional laboratory (TL), the peer teaching laboratory (PTL), and the peer teaching laboratory incorporating additional interventions. (PTL+). Table 3.4 summarizes the lab approach and classification for group of participants. Students in the TL, 2010-2011 and 2011-2012 school years, served as the historical control. Students in the PTL, 2011-2012 and 2012-2013 school years, were the first experimental group. Students in the PTL+, 2013-2014 and 2014-2015 school years, were the second experimental group. Each year A550-A551 had approximately 2-4 graduate students enrolled in the course. These students were from a variety of degree programs and had very different education backgrounds from the medical students. For this reason, their grades were not included in this study.

Data Sources. Deidentified class grades were obtained from the course director for students from the 2010-2014 school years. Identifiable grades for students from the 2014-2016 were obtained as well, due to having informed consent from the students in these two school years. Grades for all students, points and percentages, included final course grades, 6 individual lecture exam grades, and 6 individual laboratory exam grades. For the 2015-2016 school year, copies of the six block laboratory exams were obtained from the course director. Students had access to their lab exams in the medical student office, and without the knowledge of the instructor, several exams were removed and were not able to be obtained for use in this study.

Table 3.4

Points Allocated for Each Block Laboratory and Lecture Exam and Total Points Possible for Each Class.

Class	Block Lab Exam						Block Lecture Exam						Total
	1	2	3	4	5	6	1	2	3	4	5	6	
2010-2011	60	100	100	90	80	100	140	100	90	90	80	100	1130
2011-2012	60	100	100	90	80	120	130	100	90	90	80	120	1160
2012-2013	60	100	100	80	80	120	120	100	90	80	80	120	1130
2013-2014	60	100	100	80	80	120	120	100	90	80	80	120	1130
2014-2015	60	100	100	80	80	100	120	100	90	80	80	100	1090
2015-2016	80	100	100	80	80	100	120	100	100	80	80	100	1120

Recruitment. All students involved in A550-551 during the 2014-1015 and 2015-2016 school years were contacted in class and asked to participate in the study. Students had the option to consent to allowing their course work to be used in the study, to participate in an interview, both, or neither. Students indicated their preferences on a signed informed consent document. All students agreed to have course work used, and exams and course grades were obtained from the course director. Institutional Review Board consent (IRB Study #1404683093) was obtained for the outlined procedure and the finalized documents are included in Appendices F and G.

Data Collection for the quantitative methodology. The quantitative methods for this study used two different sets of data, each is described separately. The first section addresses the data for analyzing course grades; the second section addresses the data for analyzing laboratory exams.

Data collection for course grades. Digital copies of course grades, including final course grades, 6 lecture exam grades, and 6 laboratory exam grades, organized in Microsoft Excel files were obtained from the course director for A550-551 for classes from the fall 2010 through the spring of 2016. Grades were given in point totals. All point totals were adjusted to percent to account for slight variation in points available each school year. Table 3.4 lists each the total points available for each school year and the points allocated to each of the 6 lecture and laboratory exams. All grades, given as percent, were combined into a single Microsoft Excel file and were used in the analysis for this study.

Students were assigned to three groups based on the laboratory format of the A550-551 class. Students from 2010-2011 and 2011-2012 formed the **traditional**

laboratory (TL) group. In the TL format, all students attended each dissection session throughout the entire course. Students from 2012-2013 and 2013-2014 formed the PTL group. In the PTL format, A and B teams alternated dissection session attendance and used the first 30 minutes of each class to "teach" about the previous dissections. Finally, students from 2014-2015 and 2015-2016 formed the PTL+ group. In the PTL+ format, students continued to use an alternating dissection schedule with 30 minutes of allocated peer teaching time and students completed additional assignments designed to increase the quality and length of the peer teaching process. Table 3.5 identifies the school years and number of students in each group.

Table 3.5

Laboratory Format for Each School Year from 2010-2016.

Laboratory Format	School Years	# Students
Traditional (TL)	2010-2011, 2011-2012	66
Peer Teaching (PTL)	2012-2013, 2013-2014	70
Peer Teaching Plus (PTL+)	2014-2015, 2015-2016	72

Data collection for laboratory exams. Gross anatomy laboratory exams were collected at the end of the semester from the student files maintained in the medical school office. The topics for each laboratory block exam are described in Table 3.6. For each student, there should have been 6 block exams. Block 3 covered pelvis and the male and female donors, dissections were further subdivided with half of the donors being hemisected. Due to the increased variability of the dissections students completed, Block 3 exams were not included in in this analysis. Of the 36 medical students, 8 students had removed at least one exam from the file. These were unable to be obtained from the

Table 3.6

Block Exam Topics and Descriptions of Dissection Sessions

Block Exam	Abbrev.	Title	Dissection topics covered
1	BKTK	Back & Trunk	Superficial Back, Deep back, Spinal Cord, Body Wall (Thorax), Body Wall (Abdomen)
2	TACAV	Thorax & Abdominal Cavities	Pleural Cavity, Lungs, External Heart, Internal Heart, Superior and Posterior Mediastinum, Peritoneum and Peritoneal Cavity, Celiac Trunk, spleen, liver, gallbladder, Mesenteric vessels and intestines, Duodenum, pancreas, and hepatic portal vein
3	PELVIS	Pelvic Cavity	Posterior abdominal viscera (kidneys, adrenals, aorta), Posterior abdominal wall, Pelvis, external genitalia, spermatic cord, scrotum, Gluteal region; Perineum: Anal Triangle, Pelvis; Perineum:, Female Urogenital triangle, Male Urogenital Triangle, Female Pelvis, Male Pelvis, Determining sex of pelvis
4	HDNK1	Head & Neck 1	Face, Scalp, Parotid region, Meninges, Brain, Lateral Cervical Region, Anterior Cervical Region, Temporal/infratemporal regions, Root of neck
5	HDNK2	Head & Neck 2	Orbit, Pharynx, disarticulation of head, Nasal cavity and sinuses, bisection of head, Pterygopalatine fossa, Oral cavity, tongue & palate, Larynx, Ear
6	LIMBS	Limbs	Skeletal and surface anatomy of limbs, Anterior and medial thigh, Gluteal Region, Posterior thigh, Lateral and anterior leg and dorsum of the foot, Popliteal fossa, posterior leg, sole of foot, Brachial plexus, pectoral region and axilla, Shoulder, arm and cubital fossa, Forearm and dorsum of hand, Palm of hand, joints

Students. Therefore, the data analysis was completed without the missing exams. Table 3.7 displays the number of exams for each block used in the analysis and the number of questions classified on each exam.

Table 3.7

Laboratory Block Exams Collected for Data Analysis

Block	Exam	# Exams Present	# Exams Missing	# Questions	Total Questions (# Exams Present x # Questions)
1	BKTK	28	8	49	1372
2	TACAV	29	7	62	1798
4	HDNK1	31	5	56	1736
5	HDNK2	31	5	58	1798
6	LIMBS	36	0	51	1836

The course director individually examined all of the questions on the laboratory exam. Each question was identified based on the type of question and the dissection session to which the question pertained. For this study, only questions related to dissected structured were considered. Questions that related to lecture material, general bone questions, or surface anatomy questions, and radiology questions were not evaluated for the study. This study specifically was interested in only examining the impact of dissection, and so these other questions were not included in the evaluation. For each dissection question, the lab session that dissected the structure was identified. If a structure was dissected and identified in more than one dissection session, each session was noted. The student dissection team involved in each dissection was also identified based on course records. Each exam was then evaluated and the questions of interested were classified based on if the student dissected the question and if the student correctly answered the question. See table 3.8 for the classifications for each question.

Table 3.8

Classification System for Laboratory Exam Questions

Student ID	Block Exam	Question #	Dissected	Correct
1 - 37	1, 2, 4, 5, 6	1 - 61	0 = Not Dissected 1 = Dissected	0 = Incorrect Answer 1 = Correct Answer

Classification data was entered into a Microsoft Excel document. No identifying student data was entered into the spreadsheet. Each student was assigned a number, each student was determined which labs were dissected, then each question that had been identified as structure related question were marked as correct or incorrect and dissected or not dissected. Refer to table 3.7 for number of questions selected from each exam. classified based on the

Data analysis for the quantitative methodology. The quantitative methods used two different sets of data, each is described separately. A professional statistician, Michael Frisby, M.S., consulted and advised for all statistical tests used in this research. Prior to all statistical analysis, the assumption of normality was confirmed by determining that the variables of interest were normally distributed and that . The first section addresses the data for analyzing course grades; the second section addresses the data analyzing laboratory exams.

Data analysis for course grades. To test the hypothesis that there was no difference in gross anatomy exam scores or final grades between the traditional lab format, the peer teaching format, and the peer teaching plus format, a comparison between the groups was conducted using **analysis of variance (*ANOVA*).** This study used a posttest only design with an historical group control, TL to examine the between-variation of laboratory exam grades, lecture exam grades, and final exam grades for students in the three lab format groups (Edmonds, 2013). All statistical analyses were performed using IBM SPSS Statistical for Mac OS X, version 24.0 (IBM Corp., Armonk N.Y., USA). Microsoft Excel files containing deidentified grades given as percent were transferred into SPSS to complete statistical significance testing.

Data analysis for laboratory exams. Statistical analysis to determine if dissection participation increased the likelihood of correctly answering exam questions was complicated due to the correlated nature of the data. A **generalized estimating equations (*GEE*)** modeling offers an approach to analyzing data that accounts for correlated data obtained from repeated measures of the same population (Hardin, 2005). These models also accommodate binary data. In this experiment, the data obtained had repeated measures and binary data measurements making GEE the best choice for statistical significance testing. All statistical analyses were performed using IBM SPSS Statistical for Mac OS X, version 24.0 (IBM Corp., Armonk N.Y., USA).

Validity. Specific threats to validity were identified to mitigate their impact on the study. Identified *internal validity threats* included changes to instrumentation and sample selection. *External validity threats* included threats due to the interaction of the selection and treatment and the setting and treatments (Edmonds, 2013). The instruments of measure were the A550-551 exams. All measures were converted to percentages to ensure the comparison of scores was equivalent. While the exam questions were similar across the six years of the study, they were not identical and therefore could impact internal validity. This is a limitation of the study that will be discussed later.

Participants in the study were students from A550-551. Graduate student data were eliminated to decrease selection threats to validity. The population of interest were the medical students, by limiting the selection the study targeted the population of interest. Threats to external validity are related to the degree of generalization possible from this study due to the limited population and treatment setting. IUSM-BL had approximately 36 first medical students in it classes.

Qualitative methodology. Qualitative analysis represents the second type of method used in this mixed method study and was necessary to analyze non-statistical data collected. **Grounded theory (GT)** was the method selected to best analyze the qualitative data. In this section I discuss the history of GT, different types of GT, the rationale for using GT in this study, and finally the specific details of population, sample, recruitment, data collection and data analysis.

History of grounded theory. GT is a qualitative research method that "enables the identification and description of phenomena, their main attributes, and the core, social or social psychological process, as well as their interaction in the trajectory of change" (Morse, 2009, pp. 13-14). Therefore, grounded theory can be a powerful qualitative research method. GT is a relatively young qualitative approach. GT was first used in Glaser and Strauss in *Awareness of Dying* (1966) followed shortly by their introduction of the theory in *The Discovery of Grounded Theory: Strategies for Qualitative Research* (1967). The two authors developed the method in conjunction with each other as they recognized the approach they were using in *Awareness of Dying* (1966) was different than previously established qualitative research models (Bryant & Charmaz, 2007b). The research backgrounds of each author played a key role in his contributions to the developing grounded theory method. Strauss, who's early work in symbolic interactionism and pragmatism at the University of Chicago is recognized as one of his key contributions to the development of the GT method and Glaser in quantitative methods and mid-range theory development positivistic background from Columbia University (Bryant & Charmaz, 2007a; Charmaz, 2014). The introduction of GT by Glaser and Strauss provided a qualitative approach making qualitative investigation visible and verifiable (Bryant & Charmaz, 2007a). Early GT emphasized data and the role of the researcher as an outside observer. It also emphasized the inductive approach of GT. Stauss and Corbin (1994) acknowledged the overemphasis of inductive approach and it is now recognized that deduction and abductive reasoning both play a role in GT (Bryant & Charmaz, 2007a).

While GT has seen a variety of changes and newly proposed methods over the years, there are several core aspects of it maintained throughout the various iterations: data guides theory development, theory is emergent and not predefined, constant comparison during data collection and analysis is vital. Additionally, GT from its start has been associated with developing practical and practice-oriented research that has real world ramifications (Bryant & Charmaz, 2007b).

Initial GT as presented by Glaser and Strauss. Differences between these two are seen in later publications. Glaser's publication of both *Theoretical Sensitivity* (1978) and *Emergence versus Forcing: The Basics of Grounded Theory Analysis* (1992) marked his divergence from Strauss. While Strauss's publication of *Qualitative Data Analysis* (A. L. Strauss, 1987) and Strauss's later publication with Julie Corbin of *Basics of Qualitative Research* (1990) and *Grounded Theory Methodology: an Overview* (1994). The two distinct methods were labeled Glaserian grounded theory and Straussian grounded theory (Stern, 1994). While Glaser and Strauss both follow the same basic tenants, both fall under an objectivist grounded theory umbrella, each has published extensively on the differences between their approaches to grounded theory.

Objectivist grounded theory and constructivist grounded theory. In the 1990s in addition to the divergence of Struass and Glaser, GT methods have also expanded to include **constructivist grounded theory (CGT)** (Charmaz, 2000, 2009, 2010, 2014). It is the divergence the created two dominant camps in grounded theory methodology. The objectivist camp, including both the Glaserian GT and Straussian GT comprise **objectivist grounded theory (OGT)**, and the constructivist camp identified with Charmaz (Bryant & Charmaz, 2007b). This discussion will primarily focus on the differences between the OGT method best exemplified by the early works of Strauss, Corbin, and Glaser from the late 1960s through the 1990s (Corbin & Strauss, 1990, 2014; Glaser, 1978; Glaser & Strauss, 1967; A. L. Strauss, 1987) and the CGT methods of Charmaz (2000, 2009, 2014).

OGT works from a positivist epistemology in which knowledge exists in the world waiting to be found by the researcher. The researcher is neutral observer that examines the process of study with no preconceived notions and theories can be generalized (Charmaz, 2009). The pragmatic and symbolic interactionist underpinnings are not fully identified in this camp until the publishing of the 3rd edition of *Basics of Qualitative* Research (Corbin & Strauss, 2008). This is important in that it helps to distinguish the objectivist epistemology from the constructivist epistemology. (Corbin &

Strauss, 2014). In OGT, there is a single knowledge that can be identified and discovered.

CGT emerged in response to the prescriptive method that had become known in GT in the early 1990s. It reengages the from a pragmatist tradition that was present in the early iterations of GT (Charmaz, 2014). CGT recognizes that the researcher is part of the construction of the data through interactions with participants in interviews and other data sources used in GT (Clarke, 2012). Charmaz identifies the strong ties to social constructivists in that the social context, the interactions, are key to constructivist grounded theory (Charmaz, 2014). Charmaz best describes how constructivism is critical to understanding the development of a grounded theory:

> Glaser and Strauss talk about discovering theory as emerging from the data separate from the scientific observer. Unlike their position, I assume that neither data nor theories are discovered either as given in the data or the analysis. Rather, we are part of the world we study, the data we collect, and the analyses we produce. We construct our grounded theories through our past and present involvements and interactions with people, perspectives, and research practices (Charmaz, 2014, p. 17).

Rationale for grounded theory: examining peer teaching and self-directed learning in anatomy. SDL and peer teaching have been explored through a variety of research lenses, both quantitative and qualitative, but most often as an exploration of a teaching innovation and the subsequent impact on students. The use of grounded theory in my research allows for a new approach at examining these topics that may be able to better inform and identify the impacts of the process.

How peer teaching and SDL impact the process of learning is challenging to identify and measure. By using an approach that is iterative and based in the data, a GT analysis can provide new understanding and yield a theoretical lens through which to view the peer teaching process in A550-551. I see CGT as the approach that best fits my perspective as a researcher. I know that I fall in a unique position as having been both and instructor and student in this class. By identifying my previous knowledge and assumptions coming into the field and through detailed memoing and consultation with others, I attempted to limit my personal bias and impact on the research (Birks & Mills, 2015; Charmaz, 2014).

The following sections address the specific methods of GT conducted in this study. The terminology used to identify the methods used in the GT analysis were taken from Charmaz (2014). Table 3.X provides a summary of the GT terms used by Glaser and Strauss (1967), Glaser (1978), Corbin and Strauss (1990, 2008), and Charmaz (2014) so that the terms used in this research based on Charmaz (2014) can be understood in the broader landscape of GT.

Table 3.9

Grounded Theory Coding Terminology

	Initial coding	**Intermediate coding**	**Advanced coding**
Glaser & Strauss (1967)	Coding and comparing incidents	Integrating categories and properties	Delimiting the theory
Glaser (1978)	Open coding	Selective coding	Theoretical coding
Corbin & Strauss (1990, 1998)	Open coding	Axial coding	Selective coding
Charmaz (2014)	Initial coding	Focused coding	Theoretical coding

Note. Reprinted from *Grounded Theory: A Practical Guide, 2ed.* Birks and Mills (2015), p. 91.

Population. The individuals of interest in this study were first-year medical students enrolled in Human Gross Anatomy at IUSM-BL between August of 2012 and

May of 2016. These are the students who experienced the alternating lab approach and peer teaching experiences. Instructors involved in the course for those same years, including any TAs, were included in the study as their experiences in the lab can provide an additional point of view.

Sample. In grounded theory methodology, it is necessary that the sample subjects have experience with the question of interest. For this reason, grounded theory does not use a random sample. Rather, the recruitment is designed to select individuals that will best be able to address the research question. Rather than random sampling, I used convenience sampling and theoretical sampling as is required by grounded theory following the approach described by Charmaz (2014).

Purposeful sampling. Purposeful sampling involves identifying the group of interest and selecting subjects from within that group. In this study, the group of interest is defined as individuals who had experiences with the alternating lab approach and peer teaching. Purposeful sampling was done by recruiting students and instructors that participated in the course between the fall of 2012 and the spring of 2016. Course documents were also collected from specific student groups. These documents included laboratory exams from IUSM-BL students enrolled in Anatomy A550-551 during the 2015-2016 school year and VoiceThreads© from students enrolled in the 2014-2015 and 2015-2016 school year. VoiceThread© is an application that was used by students to generate an annotated, narrated slide show of each dissection that was then shared with group members. These VoiceThreads© assignments provide documented evidence of the peer teaching that happened between students for each dissection. These will be used as point-in-time data to enhance the data generated in end of course interviews with the students themselves.

Theoretical sampling. For this study, the LEQs from the 2015-2016 students provided a theoretic sample that was used to confirm and refine theoretical categories developed in the GT analysis. Theoretical sampling was done to fully complete the analytical process. Categories were identified that needed more data to expand and explain emerging theories. Examining the data for incomplete categories was necessary in grounded theory to ensure data saturation is reached, the point at which codes being identified in the analysis have reached saturation and have fully been developed from the data. (Charmaz, 2014).

There is no set sample size required for a grounded theory study, but I believed the saturation point was reached. Refer to Table 3.2 for specific numbers of interviews, VTs, structure lists, and LEQs per school year.

Recruitment. All student participants enrolled in A550-551 during the 2013-2016 school years were invited to participate in this study. Recruitment was done through in class recruitment. Students had the option to consent to allowing their course work to be used in the study, to participate in an interview, both, or neither. Students indicated their preferences on the informed consent document. Those agreeing to participate in an interview were contacted and a mutually agreed time was set to complete the interview. IRB consent (IRB Study #1404683093) was obtained for the outlined procedure and the finalized documents are included in Appendix F and G.

Data collection. Data collected included student interviews, instructor interviews, student grades, student exams, and VoiceThreads© slideshows, and LEQs. All collected data were stored in a password protected computer connecting to the university computing system. All individuals that participated in the study were identified by a numeric system. These numbers were used to deidentify all stored data.

Interviews were conducted using an intensive interview approach (Charmaz, 2014). This means they were guided interviews that attempted to bring out and explore the subject's experiences, in this case with the laboratory process. Interview questions are found in Appendices A-D. Each interview was recorded using a digital recording device and then transcribed for use in the study. Microsoft Word and Microsoft Excel were used to manage and store interview data rather than a qualitative data analysis computer program.

Coding. The coding of the data followed the process outlined by Charmaz (2014). Coding is the method of analysis used in GT and it begins before date collection is even complete. Charmaz (2014) explains that GT involves

> Involves the researcher in data analysis while collecting data. Data analysis and collection inform and shape each other in an iterative process. Thus, sharp distinctions between data collection and analysis phases of traditional research are intentionally blurred in GT studies (Charmaz, 2014, p. 343).

Each phrase of all interviews and all related LEQ answers were transcribe and coded in the process of GT data collection and analysis. The methods used to collect the data were describe in the previous section. In this section I will define and describe the coding process and explain my unique role as the researcher in this dissertation.

Initial coding. Initial coding was the first interaction with the data. Codes were assigned using gerunds to maintain an active voice in the coding process and to attempt to best capture the experiences in the PTL and PTL+ labs.

Focused coding. Focused coding began upon completion of the initial coding of the instructor interviews and continued throughout the GT analysis. Focused coding merges frequent and significant initial codes. Focused codes continue to become more refined as additional data is analyzed and incorporated into the growing body of data contributing to the GT analysis. Focused coding continues through multiple iterations of constant comparison between data, development of focused codes, back to comparisons between data, comparisons between focused codes, until finally the final refined sets of are assigned.

Theoretical coding. Theoretical coding is the process of abstracting the final codes to identify the theoretical categories that explain the process being studied, in this research that was the impact of peer teaching and SDL in the gross anatomy laboratory classroom. Theoretical categories explain the phenomenon of interest and are the result of the GT analysis.

Initial coding began with the interviews. Instructor interviews were coded first, followed by the interviews with the 3 students with experiences in the TL and PTL. Then the 5 interviews with students in the PTL from 2013-2014 were coded and finally the 10 interviews with students in the PTL+ from 2014-2015. All interviews went through a process of initial coding, focused coding, and finally theoretical coding. Then codes were confirmed, modified, and finalized by coding the LEQs from the 2015-2016 school year. This ensured that the theoretical codes developed using the interviews were verified when applied to a new data set from a related sample. Figure 3.4 demonstrates the process of coding used in this research. For PTL, theoretical categories were used to present a single theory describing the impacts. PTL+, there was less data and due to uncertainty presented a theoretical category but not abstracted to the level of theory.

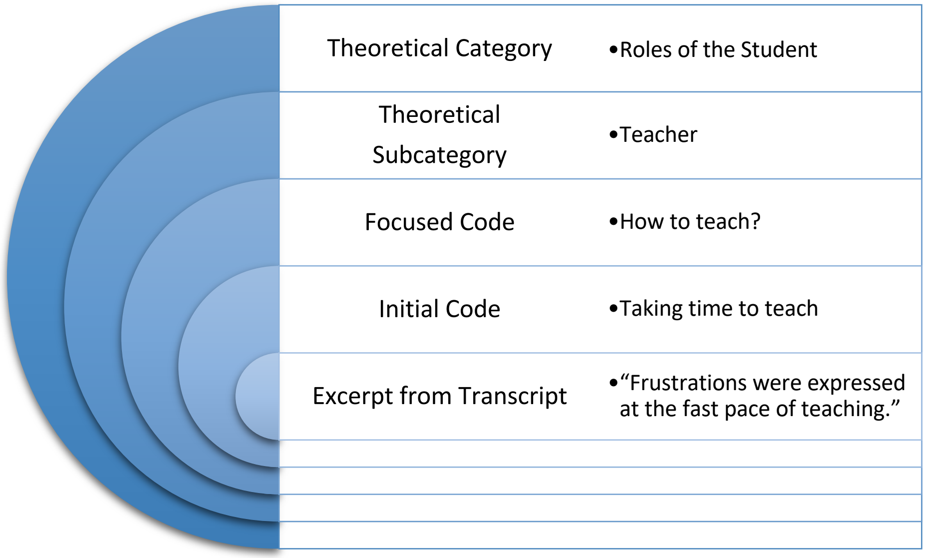


Figure 3.4. Illustration of Grounded Theory Coding Process. Coding begins at the center and works up the list going from concreate (closely tied to the transcript) to more abstract and theoretical.

Role of the researcher. My experience brings a unique perspective to this research. In the fall of 2010 I enrolled at IUSM-BL seeking a PhD in Anatomy and Cell Biology with a minor in Education. For the 2010-2011, I was enrolled as a student in A550/551 in the TL format. In the 2011-2012 (TL) and 2013-2014 (PTL) school years I was a TA for A550/551. My degree involved coursework in anatomical sciences and coursework related to educational research. This positioned to explore the topic of peer teaching in the anatomy laboratory from the multiple perspectives: student, instructor, and researcher.

In the spring of 2014, I began some preliminary research to explore the impact of peer teaching in A550/551. Based on my observations of students in the 2013-2014 PTL, I was concerned with the lack of teaching occurring during the peer teaching time.

During the summer of 2014, I developed the SDL activities discussed in this research to complement the PTL format being used in A550/551. I state this information to indicate my awareness of the potential for researcher bias. In order to minimize bias I used memoing (Charmaz, 2014; Corbin & Strauss, 1990, 2014) record my thoughts, justifications, and rationale throughout the process. Additionally, my process of initial coding was completed phrase by phrase by followed by additional levels of coding that used constant comparison to refine and check emerging categories and not force preconceived meanings to fit the data collected. Finally, my unique position as a previous student and instructor now turned research gives the added benefit of potentially increased sensitivity (Corbin & Strauss, 2014). Sensitivity is defined by Corbin and Strauss (2014) as "having insight as well as being tuned in to and being able to pick up on relevant issues, events, and happenings during collection and analysis of the data."

In the next chapter I will discuss the results and analysis of the quantitative methods used in this research. This will be followed by a separate chapter addressing the results and analysis of the qualitative methods. Finally, the discussion will merge the results and analyses and from both methods to address the 3 research questions posed by this dissertation.

CHAPTER 4: QUANTITATIVE RESULTS AND ANALYSIS

This chapter will discuss the results obtained through quantitative analysis of the data collected for this dissertation. The first section will focus on the results obtained related to the impact of dissection on student laboratory exam performance in Gross Human Anatomy (A550-551) for the 2015-2016 school year at Indiana University School of Medicine – Bloomington (IUSM-BL). Statistical guidance and consultations were provided by Michael Frisby, M.S., at the Indiana Statistical Consulting Center at Indiana University Bloomington (IUB). The data was analyzed using a generalized estimating equation (*GEE*) to determine if the act of dissection had an impact on a student's ability to correctly answer related practical laboratory questions. The second section will discuss the results of analysis of variance (*ANOVA*) of the final course grades, lecture exam averages, and laboratory exam averages for students enrolled in A550-551 from fall 2010 through spring 2016. These 6 year-long classes are subdivided into 3 groups based on their gross anatomy laboratory format: tradition laboratory (TL) in 2010-2011 and 2011-2012, peer teaching laboratory (PTL) in 2012-2013 and 2013-2014, and peer teaching plus laboratory (PTL+) in 2014-2015 and 2015-2106. Together these two quantitative sections address research question 1 identifying the impact of peer teaching and self-directed learning on student grades in human gross anatomy.

Quantitative Results and Analysis of Laboratory Exams From the 2015-2016 Class Only.

Method summary. Analysis was performed using a **Generalized Estimating Equation (*GEE*).** The recurring nature of the data requires an analysis method that can address the fact that data was repeatedly gathered from the same students, in the same course, for 5 separate block laboratory exams in a single school year. The *GEE* accounts for the repeated nature of the data in the modeling and eliminates statistical concerns related to the homogeneity of the data. Additionally, the *GEE* accommodates the binary data used as well (Liang & Zeger, 1986). The binary data used here was whether a student answered a question or incorrectly and if a student actively dissected of was peer taught. Table 4.1 summarizes the benefits of GEE statistical analysis.

Table 4.1

Benefits of Generalized Estimating Equations

Good for repeated measures
Tolerant to some missing data
Works with binary measures
Robust to misspecification of correlation structure

Refer back to Table 3.6 for details concerning the block exams collected, the number of students, and the number of questions per exam. Available laboratory exams were collected and examined to determine if there was a difference in student ability to answer questions on the lab exam if they actively dissected the content for the basis of the question, rather than exposure to the information through peer teaching from classmates. Table 4.2 indicates the 36 students comprised the sample for this study and that a minimum of 51 and maximum number of 276 questions were analyzed for each student the study sample. The exams were retrieved from the student folders at the end of the 2015 – 2016 school year. Unfortunately, several students had removed exams, and these were not able to be retrieved thus, some exam samples were incomplete. Refer back to table 3.7 for the number of exams collected and the number missing for each block.

Table 4.2

Data Collected for the GEE Analysis

Correlated Data Summary		
Number of Subjects		36
Number of Measurements	Minimum	51
	Maximum	276

The distribution of the outcome variable needs to be assessed. Laboratory exams were separated and exams 1, 2, 4, 5, and 6 were coded using binary notation to indicate if a question was dissected or not by a student and if the question was answered correctly or not; refer back to Table 3.8 for coding methods. Recall question related to lecture material, general bone question, surface anatomy questions, and radiology questions were excluded as these questions were covered in multiple lab sections and were not part of the dissections sessions.

The dependent variable for the *GEE* model was the correctness of the answer on the exam. The 3 factors analyzed were **Lab Exam**, **Question Dissected**, and **Lab Exam*Question Dissected.** Statistically significant factors in the *GEE* in model indicate that there is a relationship between the factor and the dependent variable. The Lab Exam factor is representative individual block exams, which cover different content, and indicates if the exam content effects a student's ability to correctly answer an exam question. The Question Dissected factor is assessing if active dissection effects student's ability to correctly answer an exam question. Finally, the Lab Exam*Question Dissected factor is an interaction factor. It is an indication that active dissection impacted a student's ability to correctly answer an exam question differently dependent upon the exam content. Therefore, does the act of dissection impact each exam block similarly or differently? Table 4.3 identifies the dependent variable and factors included in the *GEE* model.

Table 4.3

Variables and Factors for GEE Analysis

Variable Information			N	Percent
Dependent Variable	Answer Correct	Incorrect Answer Given	1904	23.3
		Correct Answer Given	6636	77.7
Factor	Lab exam*	1 -BKTK	1372	16.1
		2 – TACAV	1798	21.1
		4 – HDNK1	1736	20.3
		5 – HDNK2	1798	21.1
		6 – LIMBS	1836	21.3
	Question Dissected**	Dissected by Student	3638	42.6
		Not Dissected by Student	4902	57.4

*Exam 3 was not included in the GEE analysis as there are too many confounding factors in that exam. See Table 3.1 for Block Exam descriptions.
**Some structures were dissected and identified in more than one exam so this factor is not 50/50.

Results. The *GEE* model found that all 3 factors, Lab Exam, Question Dissected, and Lab Exam*Question Dissected, were statistically significant ($p<0.05$) factors that impacted a student's likelihood of correctly answering individual questions on the laboratory exam. Table 4.4 summarizes the *GEE* model. The model indicates that lab exam content (i.e. whether a lab exam covered thorax, head and neck, or limbs) has the greatest impact on the likelihood of correctly answering a question (Wald χ^2 45.31(4) $p <$ .0001). The higher the value of the Wald χ^2, the more the factor accounts for the

Table 4.4

Generalized Estimating Equation (GEE) Model Effect

	Type III		
Source	Wald χ^2	*df*	*p*
Lab Exam	45.309	4	.000*
Question Dissected	10.941	1	.001*
Lab Exam * Question Dissected	13.540	4	.009*

Dependent Variable: Answer Correct
Model: Lab Exam, Question Dissected, Lab Exam * Question Dissected
**Significant at p<0.05.*

likelihood of increasing a student's ability to correctly answer a question on the exam. The *GEE* model also indicated the act of dissection contributes to the probability of a correct answer (Wald χ^2 10.94(1) $p < 0.001$) as well as the interaction factor Lab Exam*Question Dissected (Wald χ^2 13.54(4) p=0.00). In other words, the content of the exam, active dissection, and active dissection of specific content all were all statistically significant factors that contributed to a student's ability to correctly answer questions on laboratory practical exams.

Table 4.5 identifies the parameters measured in the *GEE* model. Exp(B) is the exponentiated parameter estimate, and when statistically significant it refers to multiplicative increase in odds of answering a question correctly. For example, students were 1.31 times more likely to correctly answer a question on Lab Exam 2 than on baseline set as Lab Exam 6. The baseline simple serves to provide a measure for the development of the model. The model also indicates that active dissection increases the

Table 4.5

Parameter Estimates for GEE Model

Parameter	*B*	95% Wald CI		Hypothesis Test			**Exp (*B*)**	95% Wald CI for Exp (*B*)	
		Lower	Upper	Wald χ^2	*df*	*p*		Lower	Upper
Lab Exam 1	0.16	-0.06	0.37	2.06	1	0.15	1.17	0.95	1.44
Lab Exam 2	**0.27**	**0.05**	**0.50**	**5.65**	**1**	**0.01**	**1.31**	**1.05**	**1.64**
Lab Exam 4	0.16	-0.05	0.37	2.16	1	0.14	1.17	0.95	1.45
Lab Exam 5	**0.59**	**0.40**	**0.79**	**35.16**	**1**	**0.00**	**1.81**	**1.49**	**2.20**
Lab Exam 6	0	.	.	.	.	.	.	.	.
Question Not Dissected	**-0.26**	**-0.47**	**-0.50**	**6.00**	**1**	**0.01**	**0.77**	**0.63**	**0.95**
Question Dissected	0	.	.	.	.	.	.	.	.
Question Not Dissected*Lab Exam 1	0.15	-0.09	0.39	1.44	1	0.23	1.16	0.91	1.47
Question Not Dissected*Lab Exam 2	**0.28**	**0.006**	**0.56**	**4.02**	**1**	**0.05**	**1.33**	**1.01**	**1.75**
Question Not Dissected*Lab Exam 4	0.11	-0.12	0.34	0.93	1	0.34	1.12	0.90	1.41
Question Not Dissected*Lab Exam 5	-0.13	-0.35	0.09	1.40	1	0.23	0.88	0.70	1.09
Question Not Dissected*Lab Exam 6	0	.	.	.	.1	.	.	.	.

Statistically significant factors are in bold ($p<0.05$). Explain table and what parameters mean. Bold for stat sig results.

odds of correctly answering a question by 1.29 times. While this is statistically significant, practically it only results in students having about a 3% increase in the average number of correct answers when dissecting. Additionally, students that actively dissected structures also peer taught the same information to their team members. Therefore, it is not possible from this research to determine if it was the active dissection or the peer teaching that increased the likelihood of correctly answering a question.

A graph the *GEE* model better illustrates the impact of exam content and active dissection, see Figure 4.1. There is an increase in mean number of correct answers from not dissected to dissected for every exam except TACAV. For TACAV, the slope is flat and so there was no change based on dissection. Additionally, the fact that each block exam has a different mean number of correct answers, indicates that students performed at different levels on different exams. For example, HDNK 2 had higher mean answer correct (~.78) when not dissected than LIMBS (~.70) when not dissected. Finally, the interaction between the two factors is demonstrated in that the slope of the line for each exam is not identical; therefore, the act of dissection impacted each block exam differently.

Interpretation. As the *GEE* model shows, the likelihood that a student will correctly answer a question, when the student actively dissected a structure, is slightly improved but the improvement is limited as a practical measure of improved performance. However, the slightly positive benefit to active dissection does demonstrate the value of maintaining dissection opportunities for students as opposed to the results indicated by Wilson et al. (2018) in which there was no difference in student

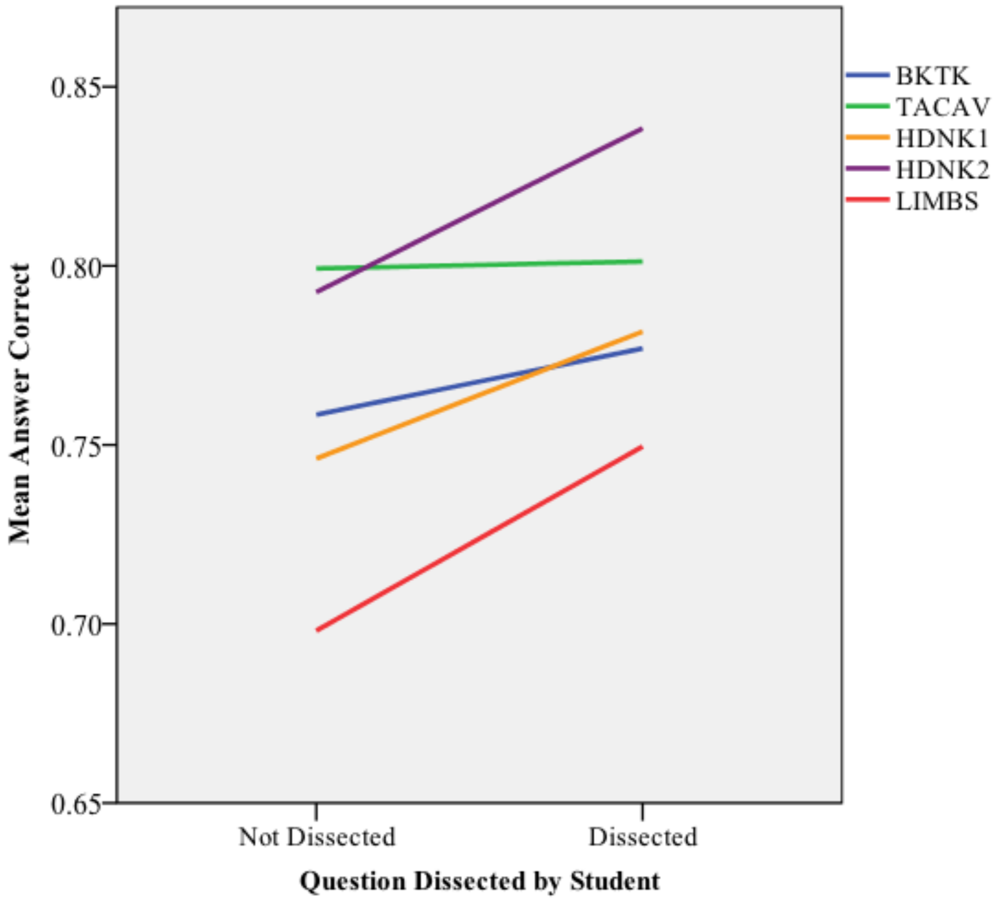


Figure 4.1. Graph of GEE Model. This is a graph of the generated GEE model. The Y axis indicates the average number of correct answers. The X axis indicates if the question was or was not dissected by the student. Each block exam is represented by an individual line on the graph. With the exception of one block exam (thorax and abdomen), in all other exams student answered more question correctly when they actively dissected a structure.

exam scores based on active dissection. In this research, active dissection was also tied to peer teaching. The structures that a student dissected were the same structures the student had to peer teach to team members. Because the two activities are paired it is impossible to state specifically if it was the active dissection, the peer teaching, or both that were responsible for the increase in correct answers. Yet, no matter the specific cause, these results advocate for the use of dissection and indicate that peer teaching appears to have either a neutral or positive effect on a student's ability to correctly identify structures. This supports previous research related to peer teaching in anatomy laboratories that indicate either no impact or a slightly positive impact on student grades when incorporating peer teaching (Abedini et al., 2013; Hendelman & Boss, 1986; Krych et al., 2005; Lazarus et al., 2016; Marshak et al., 2015; Adam B Wilson et al., 2011) Therefore, whenever possible dissection time should be maintained in anatomy. Also, alternating dissections and PTL are an approach that limit contact hours while providing the benefits of active dissection.

The increased slopes of the lines seen on Figure 4.1 for exam HDNK1, HDNK2, LIMBS indicate a increase in the correct number of answers when the student had dissected for those 3 exams. These exams all occurred in the second half of the course. One potential explanation might be that the impact of dissection may increase as students dissect more. Potentially as their dissection skills improved, the benefit of dissection increases. Thus, there is an increased impact due to dissection in the second semester of the class.

Finally, there was very little difference in student's correct answers on both the BKTK and TACAV. The back, thorax, thoracic cavity, and abdominal cavities are all areas of the body that student may have had more exposure in previous biology and health classes. Potentially the effect of dissection is limited by previous knowledge, or because the exams are the first two in the class, lack of dissection skills could limit the benefits gained through active dissection.

Limitations. There are several limitations for this analysis. First, it is limited to a small number of students from a single class year. Therefore, the generalizability to a broader population is limited. Second, the analysis did not account for the fact that the student doing the dissection is also the student that does the peer teaching. Possibly it is the act of teaching rather than the act of dissection that increases the likelihood of correctly answering a question. Third is unknown if dissection skill level contributes or detracts from learning anatomical structures.

Next, I will discuss the results and analysis of the quantitative analysis of the course grades, lecture grades, and laboratory grades of students enrolled in A550-551 from 2010 – 2016.

Quantitative Results and Analysis Comparing Traditional, Peer Teaching, and Peer Teaching Plus Laboratory Formats Using Student Course Grades

This section discusses the results of the quantitative analysis of course grades for A550-551 medical students from fall 2010 through spring 2016. It was hypothesized that the laboratory format employed in the A550-551 course would not impact student grades based on previous research (Granger & Calleson, 2007; Krych et al., 2005; Marshak et al., 2015; Adam B. Wilson et al., 2011). Refer to table 3.5 for a breakdown of the laboratory formats, school years, and the number of students in each group. Graduate students were not included in the analysis because the student group of interest was only the medical students; graduate students involved in A550/551 come from a variety of programs and backgrounds that may not be similar to the medical student population of interest. First, I will discuss the three laboratory format groups and the equality of those groups, next I will discuss the descriptive statistics, finally I will present the results of the grade analysis.

From fall 2010 through spring 2016, three laboratory formats were employed in the year-long A551-551 gross anatomy course at IUSM-BL. Groups used for this research included medical students enrolled from fall 2010 through spring 2016. The 2010-2011 and 2011-2012 school years employed peer teaching lab (PTL) format; and the 2014-2015 and 2015-2016 school years employed the enhance peer teaching lab format (PTL+), which included the use of VoiceThread© (VT) slideshows and a self-directed learning (SDL) exercise of prioritizing lab items to be dissected.

Prior to comparing the 3 lab formats, statistical analysis was done to determine that there was no statistically significant difference between the 2 years comprising each laboratory format group: TL, PTL, and PTL+. *ANOVA* was completed for final course averages, lecture exam averages, and laboratory exam averages. All assumptions of normality and homogeneity were met. *ANOVA* determined there were no statistically significant differences between the mean final percentages ($F(2,202) = 1.95$, $p = 0.09$) between the years comprising the paired laboratory formats groups. Table 4.6 provides n, mean, and standard deviation for each school year. Following the table, figure 4.2 displays the mean and the range of final grades for each school year. Thus, the 2 classes in each two-year block could be treated as a single cohort.

ANOVA determined there was no statistically significant differences between the mean lecture exam averages ($F(5,202) = 1.99$, p =0 .08) within the TL, PTL, and PTL+ groups. Table 4.7 provides n, mean, and standard deviation of lecture exam averages for each school year. Following the table, figure 4.3 displays the mean and the range of lecture exam averages for each school year. On figure 4.3, there are 3 student outliers were identified. These were left in the data as each year there are occasions when a

Table 4.6

Descriptive Statistics for Final Grades From Fall 2010 – Spring 2016.

School Year	N	Mean	Std. Deviation
2010-2011	34	81.14	6.94
2011-2012	32	79.18	6.06
2012-2013	35	81.95	6.19
2013-2014	35	79.65	5.70
2014-2015	36	81.94	8.41
2015-2016	36	83.69	5.60
Total	208	81.30	6.66

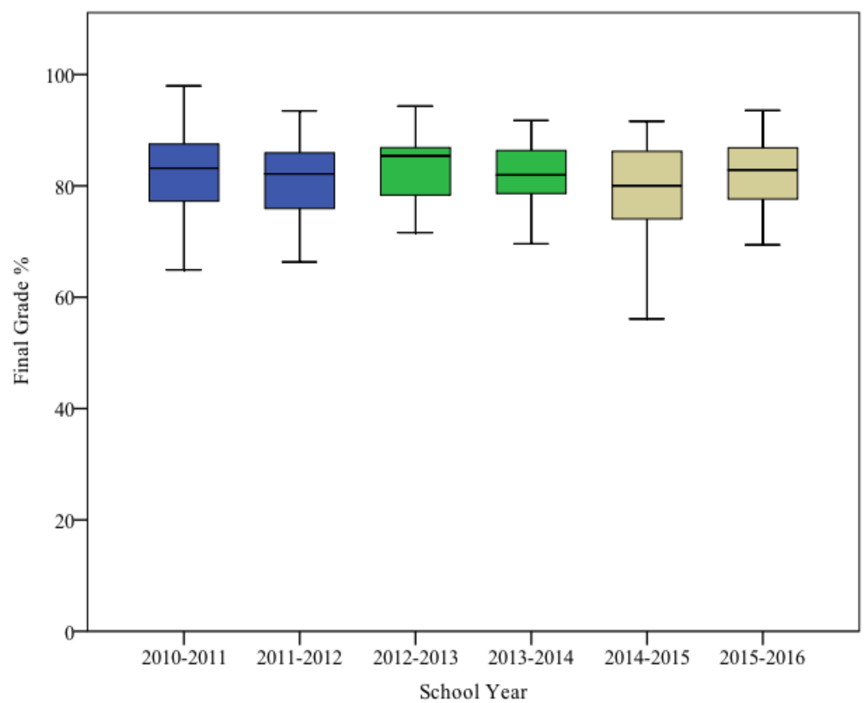


Figure 4.2. Final Grade Average Score Ranges. Display of final grades and ranges for all school years of study. Each color represents 1 of 3 laboratory formats used from 2010 through 2016.

Table 4.7

Descriptive Statistics for Lecture Exam Averages

School Year	N	Mean	Std. Deviation
2010-2011	34	82.78	7.81
2011-2012	32	84.22	6.28
2012-2013	35	86.02	5.47
2013-2014	35	84.84	5.35
2014-2015	36	82.01	8.01
2015-2016	36	85.53	6.29
Total	208	84.24	6.70

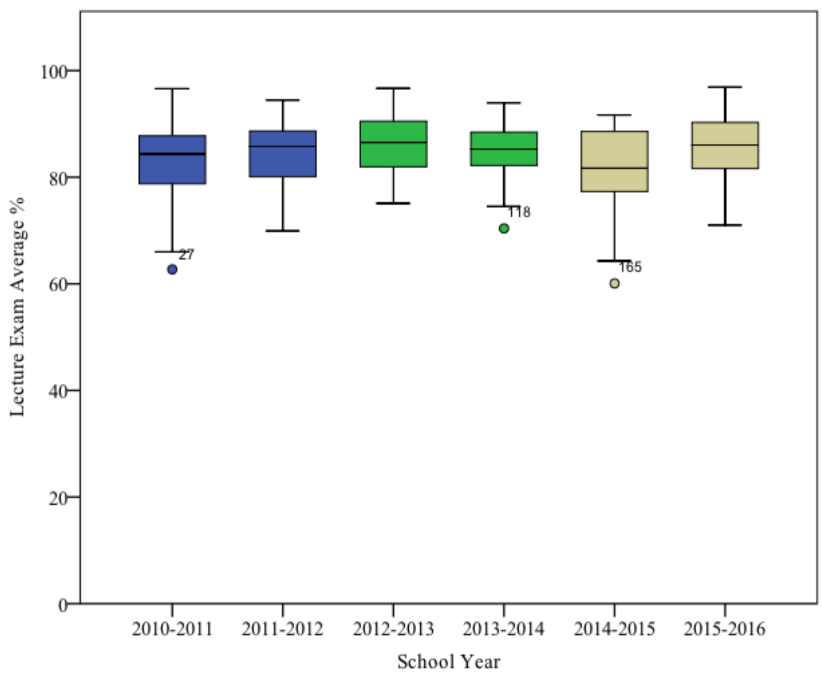


Figure 4.3. Lecture Exam Average Score Ranges. Display of final grades and ranges for all school years of study. Each color represents 1 of 3 laboratory formats used from 2010 through 2016.

student scores lower the cohort and it is not unusual. Also, the 3 outliers are distributed across the 3 laboratory formats and are not concentrated in a single course year. Additional outliers are identified on relation to the laboratory exam averages in the next section. Again, based on the results, the 2 classes in each two-year block could be treated as a single cohort.

Finally, *ANOVA* was used to compare the mean laboratory exam averages, but the assumption of homogeneity of variance was not met in the analysis of mean laboratory exam averages. Therefore a Welch's test was used to determine statistical significance ($F(5, 93.82) = 2.52$, $p = 0.092$). The test indicated there was no statistically significant difference in the mean lab exam averages within the three laboratory format groups of interest. Table 4.8 displays n, mean, and standard deviation for each year. Figure 4.4 shows the distribution of student laboratory exam averages.

Table 4.8

Descriptive Statistics for Laboratory Exam Averages

School Year	N	Mean	Std. Deviation
2010-2011	34	81.91	7.74
2011-2012	32	78.87	7.49
2012-2013	35	80.77	8.32
2013-2014	35	80.45	6.54
2014-2015	36	75.86	10.09
2015-2016	36	78.77	6.78
Total	208	79.41	8.07

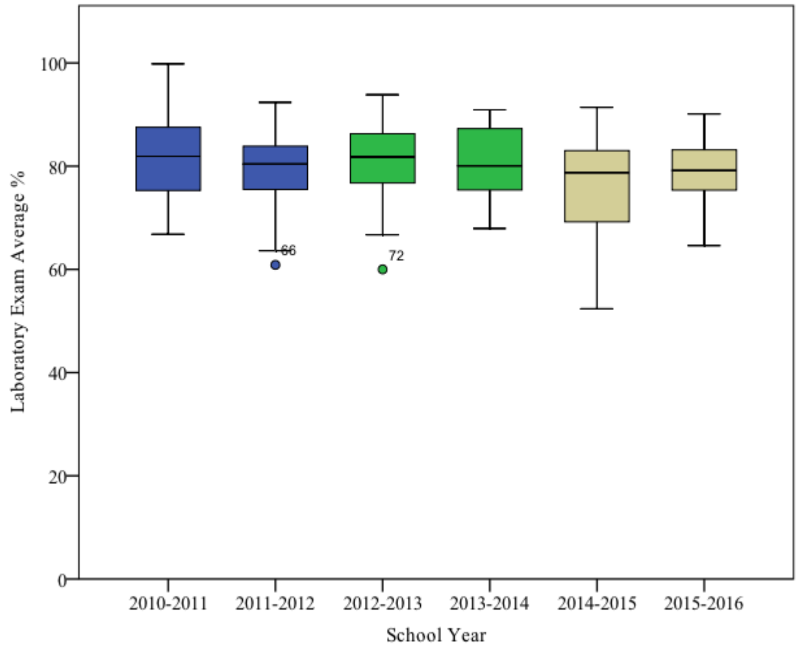


Figure 4.4. Laboratory Exam Average Score Ranges. Graph of the laboratory exam averages and ranges of student averages from fall 2010 through spring 2016. Explain outliers

Based on the *ANOVA* analysis, it was determined that there were no statistically significant differences in the average final course grades, lecture exam averages, or laboratory exam averages between any of the paired course years that comprise the 3 laboratory formats. Based on these results, the following classes were grouped appropriately in cohorts and used further analysis. The 2010-2011 and 2011-2012 school years form the TL cohort. The 2012-2013 and 2013-2014 form the PTL. Finally, the 2014-2015 and 2015-2016 school years form the PTL+ cohorts.

Descriptive statistics. Next, I will provide the basic descriptive statistics obtained concerning the 3 laboratory format groups: TL, PTL, and PTL+. Demographic information was not collected for the students due to the Family Educational Rights and Privacy Act (FERPA) concerns. Descriptive statistics are shown in Table 4.9 and include

Table 4.9

Descriptive Statistics for Students in Three Laboratory Formats

Lab Format	N	Laboratory Exam Average %		Lecture Exam Average %		Final Grade %	
		Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
TL	66	80.44	7.72	81.85	6.98	83.48	7.09
PTL	70	80.61	7.43	82.96	6.02	85.43	5.51
PTL+	72	77.32	8.66	80.57	7.69	83.77	7.36
Total	208	79.41	8.07	81.78	6.97	84.24	6.70

the number of students in each group, and the mean and standard deviation for student final course grades, laboratory exam averages, and lecture exam averages.

***ANOVA* results**. Statistical testing using analysis of variance (*ANOVA*) was used to compare the grades of students among the 3 laboratory formats to determine if there were statistically significant differences. Assumptions of normality were met for all data. Grades compared included: final course grades, lecture exam averages, and laboratory exam averages. Final course grades are specifically the final grade at the end of the school year given as a percentage. Lecture exam averages are the average of a student's six block lecture exam given as a percentage. Laboratory exam averages are the average of a student's 6 block lab exams given as a percentage. All scores were converted to percentage from points due to small differences in point totals each year; refer to Table 3.4 for specific point totals.

First, I will present a summary of the findings followed by specific details about each analysis. For all statistical analysis, $p < 0.05$ is determinative for significance.

Figure 4.5 displays the 3 laboratory formats and the final, lecture exam averages, and laboratory exam averages.

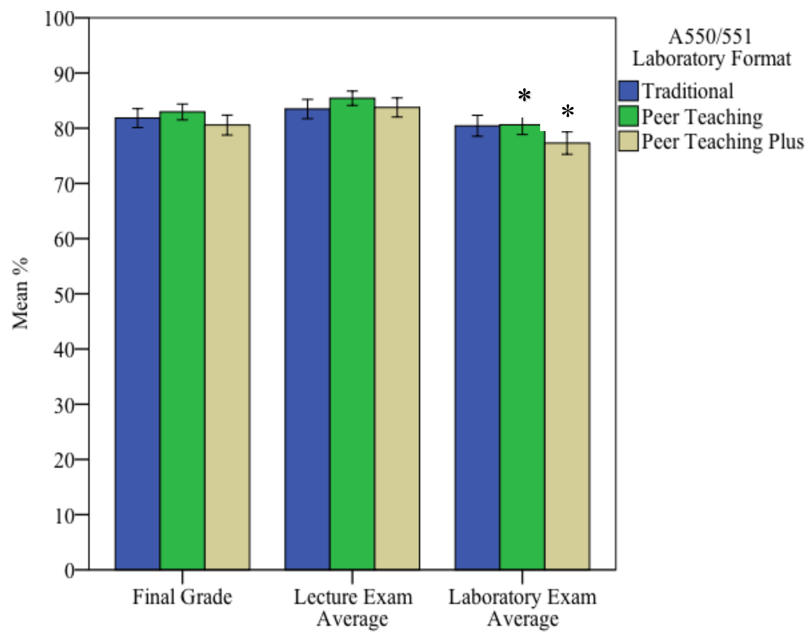


Figure 4.5. *ANOVA* Results for Course Grades. Student Final Grade, Block Lecture Exam, and Block Laboratory Exams Averages for 3 Laboratory Formats from 2010 – 2016 in A550-551. The only statistically significant difference was between the laboratory exam averages of the PTL and PTL+ formats.
* Indicates $p < 0.05$.

ANOVA of final course grades. No statistically significant differences were found between the mean final grades between the TL, PTL, or PTL+ ($F(2, 205) = 2.10$, $p = 0.13$) and the assumption of homogeneity of variance was met indicating the groups exhibit equivalent levels of error.

ANOVA of lecture exam averages. The *ANOVA* of lecture exam averages indicated the assumption of homogeneity of variance was not met in the analysis of mean lecture exam averages ($F(2, 205) = 3.15$, $p = 0.045$). An adjusted F was obtained with a Welch's test ($F(2, 133.13) = 2.07$, $p = 0.131$), indicating there was no statistical difference between the mean lecture exam averages of the 3 laboratory formats.

ANOVA of laboratory exam averages. The *ANOVA* of mean laboratory exam averages indicated a statistically significant difference (F(2, 205) = 3.83, p = 0.023) and the assumption of homogeneity of variance was met. A Tukey post hoc test was performed to follow up the *ANOVA*. Based on Tukey, the PTL+ averaged a statistically significant lower mean (p = 0.042) on laboratory exam scores than the PTL, but not significantly lower than the TL (p = 0.068).

Further analysis was then completed to determine if any one exam or more was the primary cause of the diference between the laboratory exam averages. *ANOVA* found that there was a statistically significant difference in 2 exam averages, Block Exam 2 and Block Exam 3, between the TL, PTL, and PTL+ formats. Table 4.10 provides the descriptive statistics for Block 2 and 3.

Table 4.10

Descriptive Staticstics for Laboratory Block Exams 2 and 3

Lab Format	N	Block Exam #2 (%)		Block Exam #3 (%)	
		Mean	Std. Deviation	Mean	Std. Deviation
TL	66	84.42	9.23	83.88	8.64
PTL	70	84.76	7.96	80.08	8.78
PTL+	72	79.54	11.58	74.49	9.46
Total	208	82.84	9.98	79.35	9.74

ANOVA of Block Exam 2 averages indicated the assumption of homogeneity of variance was not met (F(2, 205) = 5.47, p = 0.005). An adjusted F was obtained with a Welch's test (F(2, 134.06) = 5.38, p = 0.006), A Games-Howell post hoc test was performed to follow up the *ANOVA*. Based on Games-Howell, the PTL+ averaged lower mean for Block Lab Exam 2 than the TL ($p < 0.001$) and the PTL ($p < 0.001$).

ANOVA of Block Exam 3 found a statistically significant difference ($F(2, 205) = 19.16$, $p < 0.001$ and the assumption of homogeneity of variance was met. A Tukey post hoc test was performed to follow up the ANOVA. Based on Tukey, the TL averaged a higher mean than the PTL group ($p = 0.038$). The TL also averaged a higher mean than PTL+ ($p < 0.001$). Finally, the Tukey test indicated the PTL averaged a higher mean percent than the PTL+ ($p = 0.001$).

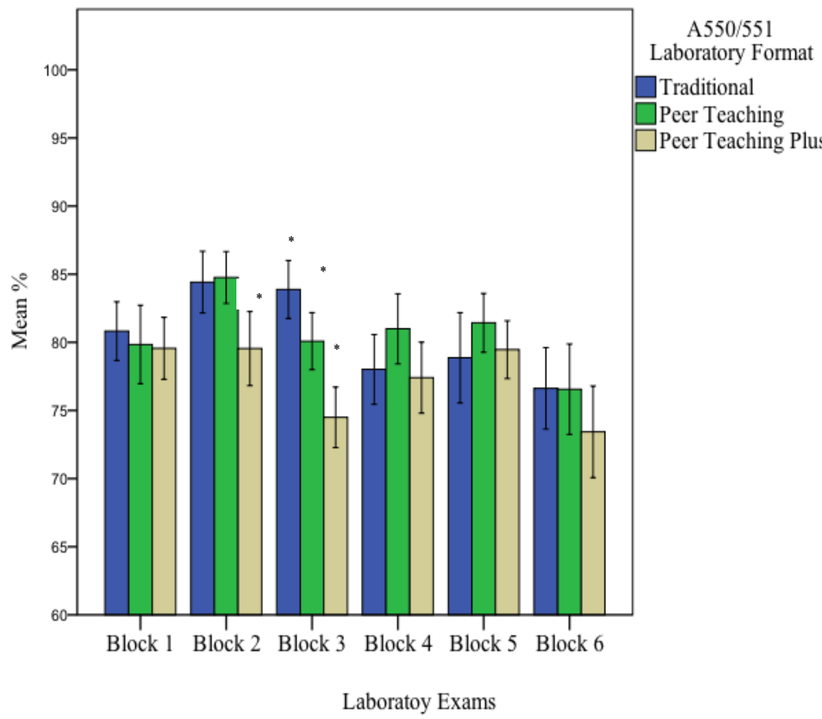


Figure 4.6. ANOVA Results for Laboratory Black Exams. Laboratory Block Exams for 3 Lab Formats. Graph of mean lab exam scores for each lab format in each block. * Indicates $p < 0.05$.

Implications. No statistically significant differences were found between the final grades or lecture grade averages in any of the laboratory formats. There was a statistically significant difference in the laboratory exam averages of the PTL and PTL+.

Further analysis indicated the PTL+ scored statistically significantly lower on block exam 2 and 3. These were thoracic and abdominal cavity (TACAV) and pelvis and perineum (PELVIS). Based on the data available, it is not possible to state why this occurred. Perhaps the increased cognitive load related to the creation of the SDL activities in the PTL+ detracted from the learning opportunities in the gross anatomy lab (Jamniczky et al., 2015; McCutchen, 2000). Also, because block 3 has so many variables related to the dissection pelvic dissection, perhaps the reduction of time in lab might limit the opportunity to interact with the variation across the donors, and students in the PTL+ cohort had to complete VT© assignments which could further limit available time.

Another possibility is related to the overall scores in the 2014-2015 school year. While not statistically significantly lower, the course director indicated the class seem to struggle more with content in that particular class. This outlier year could be the cause of the reducing in scores seen in the PTL+ group. Finally, it is important to note that the overall course grades were not statistically different so even though lab scores were lower, lecture scores were high enough to balance out the difference.

Limitations. As with the GEE analysis, these tests are performed with a limited number of students and has limited generalizability to a broader population. Also, because this data spans a 6-year period there were different instructors teaching the course in different years. While teaching very similar content, their styles may differ and impact student performance.

Based on the quantitative analysis in this research, dissection and peer teaching were found to have a positive impact on students' abilities to answer exam questions. Overall, peer teaching appears to have neither a positive or negative impact on course grades. However, the incorporation of SDL activities in the PTL+ did result in a small, statistically significant decrease in laboratory exam averages for the PTL+ cohort.

CHAPTER 5: QUALITATIVE RESULTS AND ANALYSIS

This chapter will present the results and analysis of the grounded theory analysis of student and instructor interviews, laboratory experience questionnaires (LEQ), anatomy dissection structure lists, and VoiceThreads© (VT©). First, I will review the data sources used in the grounded theory analysis. Next, I will discuss the positive and negative attributes of a traditional laboratory (TL) and compare those to the positive and negative attributes of a peer teaching laboratory (PTL). Then, I will discuss the theoretical categories developed through a grounded theory analysis to explain the underlying impacts of implementing alternating dissections and peer teaching in Human Gross Anatomy (A550-550) at Indiana University School of Medicine – Bloomington (IUSM-BL). Finally, I will explain the results of the grounded theory analysis of interview data, laboratory experience questionnaires, VTs©, structure lists to explore how self-directed learning (SDL) can be incorporated in gross anatomy laboratory sessions.

Reviewing the Data Sources for Grounded Theory Analysis

For the qualitative methods of this research, data was collected using interviews, LEQs, and by reviewing student generated coursework (i.e. Structure Lists and VTs©). Refer back to Chapter 3 for a specific discussion of the method for interviews and the process of grounded theory (GT) coding. For reference, Table 5.1 provides details about the data sources used for the grounded theory analysis that comprises the qualitative component of this dissertation. In the following sections I will identify how each data source contributed was used in the GT analysis for this research.

Table 5.1

Review of Data Sources Used in the Grounded Theory Analysis

Data Source	*n*	Description
Instructor Interviews	5	Interviews with instructors that taught in the A550-551 laboratory from 2010 – 2016.
Student Interviews (Students with TL and PTL experiences)	3	Interviews conducted with students that had experience in both a TL and the A550/551 PTL. TL experience may have been at IU or other institution but was defined as a dissection-based anatomy laboratory in which the student attended every dissection session.
Student Interviews (Students with the PTL experience)	5	Interviews conducted with students enrolled in the 2013-2014 A550/551 course at IUSM-BL.
Student Interviews (Students with PTL+ experience)	10	Interviews with students enrolled in the 2014-2015 A550/551 course at IUSM-BL. This was the Peer Teaching + (PTL+) Laboratory format. Students attended alternating dissection sessions and used peer teaching. Additionally, they completed structure list and VT© assignments.
Gross Anatomy LEQs	36	An end of course self-evaluation questionnaire. Questions addressed student behaviors and experiences in A550/551. Only from 2015-2016 school year.
Anatomy Dissection Structure Lists	764	Student created structure lists created by each group for each dissection. Lists had to identify the classification scheme the students used to organize the list of structures to be dissected for the day.
VoiceThreads©	784	Digital slideshows that student narrated and annotated to provide team members the opportunity to review the dissection prior to attending the peer teaching session at the next class.

Comparing Traditional Laboratory Formats and Peer Teaching Laboratory Formats: Viewpoints of Instructors and Select Students

GT is a process of constant comparison between data as well between the emerging analysis and data. While reviewing and coding interview data from the instructors and students in A550-551, it became apparent that two specific interview groups offered unique perspectives. These two groups were the 5 instructors that had taught in both a TL and PTL and the 3 students that had the unique experience of having taken gross anatomy in both a TL and PTL format. Specifically, 4 questions asked only in the interviews of these individuals provided information that the rest of the sample of study were unable to address. The interview questions were

1. Describe the positive and negative aspects of the non-peer teaching lab (TL).
2. Describe the positive and negative aspects of the peer teaching lab (PTL).
3. Which class style do you prefer and why? Example?
4. Which lab provides the best experience for students and why?

In order to develop the best analysis, the transcripts related to these 4 questions were coded and analyzed independently to develop a comparison between a TL and PTL from two perspectives, that of the instructor and the student. This resulted in comparison of lab formats and recommendations for specific laboratory formats in A550-551. While a GT method was employed to analyze this data, I specifically chose not to proceed toward theory development and present this data adhering closely to the transcripts to allow the specific thoughts, suggestions, and recommendations identified in interviews to be presented as given by the individuals. Also, due to the limited number of individuals in this study that had experience in both TL and PTL, I believe that theory development was not possible due to the limited sample size. The next several sections present the information learned from the 5 instructors involved in A550/551 in both its TL and PTL formats and 3 students with experiences in both a TL and a PTL.

Instructor comparisons of a traditional laboratory and a peer teaching laboratory. In comparing TL and PTL, instructors noted how the increased space in the lab and the reduction of students created a better classroom environment, one where students were more actively engaged in the dissection process. One instructor stated, "With PT, at least from my perspective, it was much less crowded, and more people were on task." Another noted, "Fewer people working at one time makes everyone more productive." Yet another stated, "They (students) may be physically in the laboratory, but they are not actively engaged, this (peer teaching) has increased the active engagement." From the point-of-view of the instructor, even though students are in the lab less, the decreased number of students working on a dissection requires everyone to be actively engaged in the dissection to complete the session in a timely fashion.

Instructors also noted that students have to be prepared and participate due to the obligation to teach their peers in upcoming sessions. With peer teaching, "students have to teach each other, and they can no longer fall into earned helplessness because they have to show some classmates what is going on." The increased need for preparation and the obligation to teaching may have other benefits as well. One instructor stated the following related to students understanding, "I think they had a deeper understanding of things because they could quickly correct each other's misconceptions."

The primary concerns related to moving away from the TL format included (1) recognizing some students might miss an explanation if an anomaly or other detailed description was provided by an instructor in a dissection session, (2) the challenges of working in a group of 4-5 may require more conflict management and work on the students' part, so PTL may reduce what students learn about working together, and (3) PT requires students to rely on each other for knowledge and answers; unequal partnerships may negatively impact the PT experience. Table 5.2 summarizes the positive and negative aspects identified by the instructor for both the TL and PTL formats.

Table 5.2

Comparing Positive and Negative Attributes of TL and PTL: Instructor Viewpoint

Traditional Lab Positive Attributes	Traditional Lab Negative Attributes	Alternating Dissection/Peer Teaching Lab Positive Attributes	Alternating Dissection/Peer Teaching Lab Negative Attributes
No one is "missing out" on lab experiences and explanations given in a specific session.	Unequal sharing of dissecting experience and instructors observe "hording" and "avoiding" of active dissection.	Increased responsibility and accountability for preparation and participation in dissection sessions.	Students may not appreciate the entirety of a dissection because they do not see it from start to finish.
Students have to collaborate with 4 or 5 partners, which may require more cooperation.	The space around the tables and in the room is crowded and noisy.	Increased efficacy because the students that are present are on task.	There may be a lack of trust between students to inaccurate teaching.
Students attend all dissection sessions and have the traditional anatomy lab experience.	Individual accountability is decreased and instead distributed across the group.	Easier to move around the room and address student questions.	The potential for information to be lost in the relay between students.
Dissecting skills are reinforced though attendance.		Decreased complaints of intragroup conflict.	

Student comparisons of a traditional laboratory and a peer teaching laboratory. While the instructors were able to offer valuable insight into how TL and PTL impact A550/551, the 3 students that had experience in both TL and PTL formats were able to address issues from a student point-of-view. Some attributes were similar to those identified by instructors, yet there were also unique attributes identified by the students. Specifically, students noted that in an ideal setting, TL is an opportunity to view and participate in all dissections and that time in lab can be used to review both lecture and laboratory content. In the PTL, students identified concerns with relying on other students and questioned the potential skill level of some partners. Students were also concerned with the possibility of being "stuck" with a challenging partner in the PTL format. Table 5.3 summarizes the attributes of TL and PTL from the student viewpoint.

Traditional laboratories or peer teaching laboratories: what was recommended? During the interviews with the 5 instructors and the 3 students that had experiences in both a TL and PTL, these individuals were asked to identify a laboratory format preference. With the exception of one student, 7 of the 8 individuals that had experiences in both TL and PTL indicated a preference for the PTL format. All 5 instructors indicated they preferred the PTL format for themselves and indicated that they felt PTL was the best experience for the students too. One instructor stated, "In this day and age in healthcare with individuals working in shifts and replacing each other, communication is vital and that is essentially what we are doing here in the lab setting." Another instructor, based on the positive changes observed in the PTL and after many years of instruction in a gross anatomy laboratory, stated "I would strongly recommend this form of dissection for other institutions."

Table 5.3

Comparing Positive and Negative Attributes of TL and PTL: Student Viewpoint

Traditional Lab Positive Attributes	Traditional Lab Negative Attributes	Alternating Dissection/Peer Teaching Lab Positive Attributes	Alternating Dissection/Peer Teaching Lab Negative Attributes
Participation in all dissections	Unequal distribution of dissection time between students	More individual time to actively participate in dissection	Some students lack confidence or possibly the skills to teach each other.
Time for learning in lab with group review.	Inefficient when students are not equally distributing tasks and time is wasted.	Access to dissection, while allowing students efficiently use time both in and out of class.	Not all group members may have the same level of knowledge.
Development of strong relationships with other students.	Lack of space surrounding the dissection for all to see and participate	Opportunity to teach and develop positive commun-ication skills.	If you have a bad partner, working in pairs may be more difficult.

Two students that had both TL and PTL experiences, indicated they preferred the PTL format for themselves and thought it was the best format for students generally. The third student preferred the TL but felt that most students would be better served in a PTL. The student that preferred TL, indicated that was a preference because the experience in the TL had included an ideal group that cooperated and learned well together. However, that student stated a belief that PTL would be better for most students because, unless an ideal situation was created, the PTL offered more benefits in general. Additionally, the student believed her TL experience was unique and therefore could not be expected to happen in most gross anatomy laboratories.

> What is unique in my case, my group would study at the same time (as dissecting). Not every table did this, but we utilized our time well. Even

> when not dissecting I was observing and studying with them. To just stand there and if you did not have a great group it could be a waste of time. I would say efficiency is key and I think that PT is more efficient in the long-run.

Another student described the differences between the TL and PTL as related to preparation and the social experience. This student found the TL offered more time for socializing but that distracted from the purpose of the lab. In addition to more focus on the dissection in the PTL format, the student also indicated an increased need to prepare in the PTL.

> Our dynamics and personalities worked out really well (TL). Everyone getting an equal share and no one getting left out. It did feel very crowded for a number of dissections where you are looking at a small region. But, with my group of four, I knew I could get away with not reading my dissector or not preparing and just showing up. When it was just two (PTL), I knew I had to read the dissector and come in prepared and do my background work. Also, we would be more efficient with time because there was only those two hours and then you would have to teach it to the other group the next time.

To summarize, all 8 individuals with experience in both a TL and PTL recommended the PTL format as the best option for students. These individuals felt the PTL improved efficacy, increased hands-on dissection time, alleviated crowding, and offered a better learning environment. Additionally, the 5 instructors preferred teaching in the PTL rather than the TL because it allowed for more interaction with individual students, improved student preparation, and seemed to decrease intragroup conflict. I recognize this is derived from a small sample of individuals, and therefore a grounded theory method was used to code the data and identify emerging categories, but no theoretical categories were proposed due to the very limited sample size. However, I felt inclusion of these results was important because but of the insights provided into the PTL format.

Grounded Theory Results and Analysis of Peer Teaching and Alternating Dissections

GT methods were used to develop a theory to explain the impact of peer teaching and alternating dissections on the student experience in A550/551. This section will discuss the theory developed and the data that led to its development. Note that the term theory indicates a substantive theory that explains the observations made in this research and provides insight and limited generalizability to other similar classroom situation (Glaser & Strauss, 1967, pp. 32-34). GT was selected for this dissertation to provide a deeper understanding of the impacts of peer teaching and alternating dissections than is possible through an analysis that simply examining themes or common terms in interview transcripts

This research developed a theory using GT methods to analyze 18 student interviews and 35 LEQs. Refer back to Table 5.1 for information about these data sources. Only interview and LEQ questions related to peer teaching and alternating dissections were used for the analysis in this section. Interview questions, LEQ questions, anatomy dissection structure lists, and VTs© related to SDL will be discussed in a separate analysis later in this chapter.

GT led to the development of a theory that explains the impact to the student experience that occurs with the incorporation of peer teaching and alternating dissections in the gross anatomy laboratory for A550-551 at IUSM-BL. The proposed theory states that **peer teaching and alternating dissections altered the roles of students in A550/551 and contributed to challenges within dissection groups.** The next several sections will describe how GT was used to identify the theoretical categories and subcategories that led to the development of the theory.

Theoretical categories used to form the theory. The proposed theory was developed using the constant comparative method specified for grounded theory methodology (Charmaz, 2014; Corbin & Strauss, 1990, 2014; Glaser & Strauss, 1967). As discussed in Chapter 3, a series of codes were developed to move analysis from interview transcripts to the final proposed theory. Coding began by breaking transcribed interviews into short segments of related text. Then, initial codes were assigned to each segment. Next focused codes were identified that grouped together similar initial codes. The constant, comparative method was used to refine focused codes. Then, theoretical subcategories were identified that clustered the focused codes. Finally, the subcategories were organized into 2 distinct theoretical categories that formed the backbone of the proposed theory. Refer to Chapter 3 for the specific methods used in this research. The theory indicates that there were 2 distinct impacts to the student experience when incorporating peer teaching and alternating dissections in A550/551.

1. **Student roles in the class were altered.**
2. **Impacts contributed challenges within dissection groups.**

Within each theoretical category there were theoretical subcategories identified that best explained how students understood the experience of A550-551 in a PTL format. Figure 5.1 diagrams the two theoretical categories and the 5 subcategories that emerged through the GT analysis of the interview and LEQ data related to peer teaching and alternating dissections in A550/551. The next section will describe the evidence that led to the development of the first theoretical category, **roles of the student**.

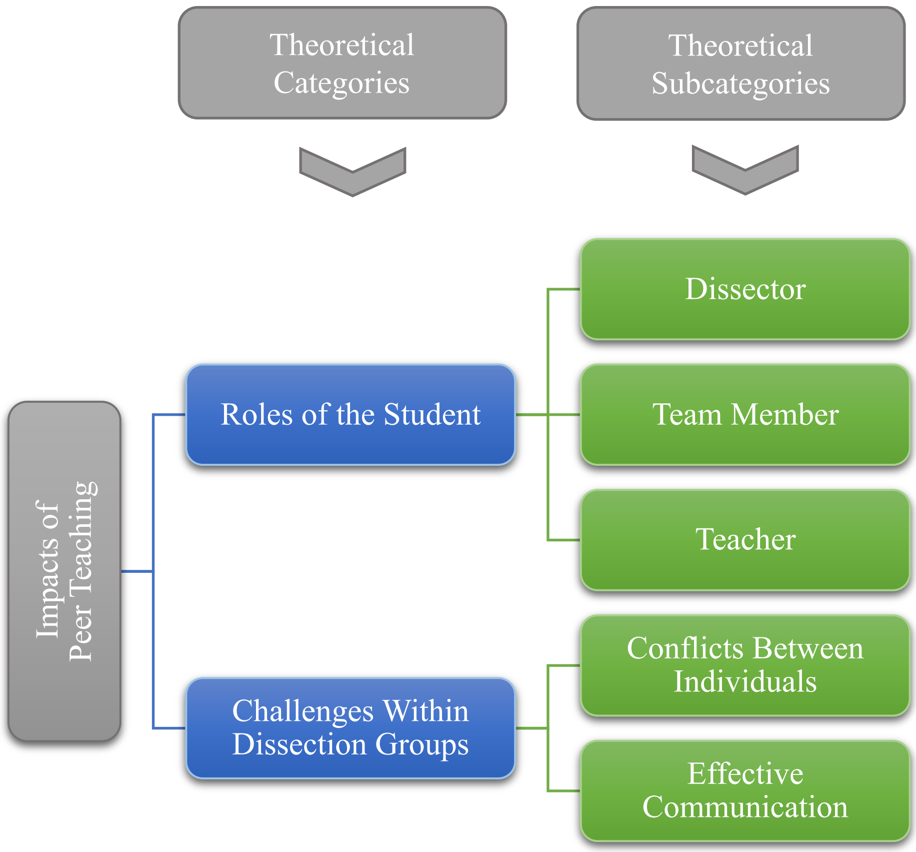


Figure 5.1. Diagram of Impacts Developed Through Grounded Theory Analysis of Peer Teaching and Alternating Dissections. Theoretical Categories and subcategories of the impacts of peer teaching on the experiences in Human Gross Anatomy Laboratory

Roles of the student. Students in a PTL must fill various roles in order to participate in all aspects of the class. The 3 roles that students undertook in A550/551 were the role of a dissector, a teacher, and a team member. Based on the analysis no one role was more important than another, as each was necessary to complete course content and assignments. However, based on the observations of the students, individuals exhibited varying degrees of success in each role. Students could be successful or deficient in any or all of the 3 roles. Some students excelled at managing the dissections and working with efficacy. Other students were excellent teachers and devoted extra time to ensure that all questions were answered for team members during the peer teaching time in the lab. Finally, some students shone as team members by always coming prepared and ready to complete the assigned dissection. There were also students that did not meet peer or personal expectation and students noted these deficiencies in interviews or on the LEQs. It was through these positive and negative discussions about the roles students filled in the lab that the GT analysis led to the identification of the 3 subcategories: dissector, teacher, and team member. Table 5.4 provides exemplar quotations from interviews, initial codes, and focused codes that led to the development of each subcategory. This is a small sample of the data and more will be discussed in the following sections that discuss the development of each subcategory individually.

Dissector. The central aspect of most gross anatomy laboratories is the dissection process and that was true of A550-551 and dissection is the backbone of A550/551 laboratory sessions. The role the student readily identifies as part of the anatomy laboratory class, even before attending the first session, is the role of the dissector. Students actively dissect anatomical structures following a series of directions provided in a dissector and guided by the instructors in the laboratory. With only 2 students dissecting in the PTL format, each individual had to participate and actively dissect in order to complete the daily dissection sessions in a timely fashion. One student said, "delegation and teamwork also became vital skills in divvying up the workload between people to maximize our efforts." Students also discussed that each lab session was an opportunity for "tons of hands on experience with the donor."

Table 5.4

Roles of the Student: Theoretical Category Development

Theoretical Subcategory	**Focused Code**	**Initial Code**	**Exemplar Quotes from Interview Transcripts**
Dissector	Hands-on dissection	Increasing dissection experience	"I felt like I got tons of hands on experience with our donor."
	On task of dissection	Being on task	"With PT, at least from my perspective, it was much less crowded, and more people were on task."
Team Member	Be prepared	Preparing so you can support your lab partner	"I think often times we let each other down by not coming to lab as prepared as possible."
	Be dedicated	Letting the team down	"I think the major obstacle we faced was that some group members were a little annoyed to have to come into lab on the days they were not dissecting."
Teacher	How to teach?	Thinking about how to teach	"We have to focus, not just on a list of items in the lab manual, so we can take the time and explain where this thing comes from."
	Issues when students teach students.	Failing in teaching role	"Whenever people wanted to get out of the lab as quick as possibly, they quickly showed us stuff and didn't go through the dissection."
	Learn as you teach	Learning through teaching	"Not only did I do the dissection and I learned it, but then I explained it to someone else and that also helps with that learning process."

Whereas in TL, there may be 4 or 5 people working on a single dissection and if one person is off task, the day's assignment likely would get done. It was stated by one student that "fewer people working at one time makes everyone more productive." In the PTL, even though the student is attending less dissections sessions, there is evidence that students, as a whole group, take on a greater responsibility for dissection. The need to take on this greater role did present an issue related to learning. For some students the dissection requirements made it more difficult to learn about the anatomical structures being dissected in the lab. One student stated,

> The one complaint I did have was since we were only two people, and there were often many structures to find, we spent most of the time digging things out rather than learning structures.

The increased role of dissector forced students to use time wisely in the lab in order to complete required tasks. Preparation for lab was noted to be critical in being able to complete dissections. The need for preparation will be discussed further in the role of a team member.

Team member. Being part of a team means taking on specific responsibilities in order to ensure team success. Students identified 2 responsibilities that were necessary to be an effective team member. The responsibilities were to be prepared and to be dedicated. Two-person dissection teams were dependent on each other working in the lab and teams depended on each other to teach the dissections sessions through the peer teaching process. Therefore, the success or failure of the team was dependent on the actions of each member. In a PTL, as compared to a TL, the role of team member took on increased importance.

Be prepared. As noted in the in the role of dissector, preparation impacted the ability of students to complete dissection assignments and impacted the learning opportunities. Students in the PTL were very aware of the need to do the reading assignments before coming to class in order to maximize dissection time in class. One student described the need to be prepared as follows:

> I knew I had to read the dissector and come in prepared and do my background work. Also, we would be more efficient with our time because there was only those 2 hours and then you would have to teach it to the other group.

Students also indicted that being unprepared meant not supporting your partner. One said, "I think often times we let each other down by not coming to lab as prepared as possible." So, in a PTL, students recognized the need to prepare prior to class and identified that failing to prepare impacted the entire team. In addition to preparation, dedication was identified as critical component of being part of the team.

Be dedicated. To be dedicated was to recognize that you had a role and your team counted on your fulfilling the duties of that role so that the entire team did not suffer. Poor attitudes could undermine the team. One student discussed the importance of the team in a PTL in following:

> Some people, if they had a lazy lab partner that didn't prepare before going in or other group members that didn't get the lab done, I could see that being frustrating. You really have to rely on the other half of your team to get everything done.

When one or two individuals in a team do not carry out their responsibilities, the team cannot function as necessary. In a PTL, lack of dedication to the team undermines the purpose of peer teaching. One particularly bad experience was summarized by a student:

> We started doing that (peer teaching) at the beginning of the year, but we stopped toward the end of the year. We would set one day side the week before the exam and show them (our team members) what we had done. They don't want to sit there and memorize all kinds of things when they have their whole lab section. We just kind of blazed through it and said the words for the sake of it and got out.

Based on the experiences described by the students, this was not common in A550/551. However, instructors need to be aware of the potential and know that students may be hesitant to bring it to their attention without prompting. In A550/551 instructors were unaware that a group was only 'going thought the motions' and occasionally skipping the peer teaching portion of the gross lab session. The final role that the student fills in the PTL is the role of teach.

Teacher. The biggest change to the role of the individual in A550-551 is the need for the student to take on the role of teacher. In PTL, students act as instructors to their peers. This changes the dynamics between students and increases the responsibilities of each individual student. Within the subcategory, teacher, there were several themes related to teaching the emerged from the data. Students were concerned with how to teach, lacked confidence in the skills of their peer teachers, and identified that teaching could serve as a learning opportunity.

How to teach? Students possess varying degrees of ability to teach and many have had no formal instruction on theories of learning or methods for teaching, so there was significant variability across the groups related to ability. One student simply summarized the issues by stating the following:

> I don't think (it was) dissecting or not dissecting that really determined if we learned something, it was more the time for the education. I think more time spent developing that (time) could work out better for the students' learning.

In moving from a TL to a PTL, IUSM-BL did not provide specific instruction for students enrolled in A550/551 for how to teach. This was an unfortunate oversight. Students need direction related to teaching and best practices. Based on this research, it was apparent there were different approach and levels of ability. One student said,

> Some people were really careful and showed everything and if they didn't find something on our body they would take us to a different body and show us there.

Other students expressed concern with the fast pace of the teaching. Students identified methods they used for peer teaching: summarization, demonstration of structures, and quizzing. Again, students would benefit from direction in methods for teaching. Students in the PTL also were concerned with the ability and knowledge level of their peer teachers.

Issues when students teach students. When students teach each other they sometimes question the knowledge of their partners and of themselves. One student described concerns generated when team members tried to identify structures after a challenging lab, but the team members were unable to identify all of the structures. Another student discussed asking an instructor to review structures after the peer teaching time elapsed, because the lack confidence in what had been identified by fellow team members. Students need to be aware that instructors are there to help, but prior to teaching students need to take the time to ensure they are prepared to teach team members. On student described the difficulty as "sometimes it felt like we were just trying to keep our heads above water."

What happens when a student does not want to teach? This was an unforeseen issue in that it was expected students would at least try and give it theory best effort to participate in dissections and peer teaching. But when a student or team fails to take responsibility, someone has to step in to change the process. One student described advocating and said,

> When you come in on the day the other group is teach you, I had to be a little more assertive sometimes. If I wasn't assertive, they might move on, talk to a neighbor, or do something else without showing us everything. I did not feel bad to be like, 'no, you need to show us.'

Students need to be empowered to speak up when necessary. Many may do this on their own, but the instructor needs to ensure that all students are aware that if help is needed to deal with a more challenging situation, the instructor is available for consultation and aid. Finally, in discussing peer teaching, students noted there was value in teaching others.

*Learn as you teach***.** Many students noted that the value of teaching others lies in the fact that as you teach them, you are reinforcing the information for yourself. One student described teaching as a "tool for success" stating,

> I learned that teamwork is a great tool for success in anatomy. By having information explained to you and also explaining it yourself, you are better able to master the material.

Given the opportunity to reflect, many students recognized the value gained in teaching others. In order to help students, understand the benefits of PTL, it may be necessary to explicitly how teaching others can help with learning. While this may seem intuitive, student may more quickly adopt and be inclined to improve their teaching in a PTL. The need for explaining the benefits of PTL are clear in the following:

> Some students don't really give it (peer teaching) a chance and think 'why am I doing the teachers job; this is not my responsibility.' But once they give it some thought, they come around to it and recognize that it is important.

If an instructor can help a student recognize the value of peer teaching from the start of the class, it is worth the time to explicitly tell students why the PTL format is used and what value it has for them in learning anatomy.

In the next section, I will discuss the development of the second theoretical category, **challenges within dissection groups**, that was developed through the GT analysis of interviews and LEQ questions related to peer teaching and alternating dissections in A550/551. Like the role of the student, the theoretical category of challenges within groups has subcategories that emerged based on the analysis that support the theoretical category.

Challenges within dissection groups. The PTL format required students to function differently in a group and presented different challenges than in a TL. Based on the GT analysis 2 subcategories emerged that frame the challenges within dissection groups. First, there were issues with conflicts between individuals. Second, groups had to determine a means for effective communication. Table 5.5 provides examples of how the data led to the formation of the theoretical category of challenges within groups and its 2 subcategories: conflicts between individuals and effective communication.

Conflicts between individuals. Conflicts in PTL are different than in TL. Instructors in A550-551 discussed the fact that they believed there was less intragroup conflict in PTL based on observations and a decreased number of students seeking help dealing with intragroup conflicts. However, the GT analysis revealed that students do have concerns with conflict in the PTL format and that intragroup conflict continued to exist but in a different form that was less visible to the instructors.

Table 5.5

Challenges Within Groups: Theoretical Category Development

Theoretical Subcategory	Focused Code	Initial Code	Exemplar Quote Interview Transcripts
Conflicts between individuals	Difficult partners	Challenging personalities a likely possibility	"I think in medical students there are a lot of chiefs in the room."
	Difficult partners	Finding ways to work with difficult people	"The most glaring lesson was how to work constantly with someone you do not get along with and still have a thorough dissection. My patience was tested."
	Reducing conflict	Changing partners should be required	"I think maybe it would be nice halfway through if people switch partners. If you are one of the 4 that might not be as easy to work with you could swap. A forced change so everyone has to work together."
Effective communication	Problems in PTL	Communication issues between A & B teams	The lab partner I dissected with and I had really great communication, both during dissection and between dissection days. That being, our communication between lab partners on different days (between teams) could have been improved.
	Better communication	Teaching Communication skills	This encourages more active communication and clearer communication. If someone has not been physically present in the room they need to be absolutely clear.

Dealing with difficult partners presented differently in PTL from the challenges in the TL. Whereas in TL, there are more people in a group to diffuse the situation if one person is not contributing or generating conflict through words or actions. Students working in pairs have to deal with difficult partners because it is the only individual they work with in the dissecting sessions. One students explained that in medical education, conflicts are likely to be a reoccurring issue because with "medical students there are a lot of chiefs in the room." This was recognized as an issue and multiple individuals suggested a forced change in partners, as one student said,

> I think maybe it would be nice halfway through if people switch partners. If you are one of the 4 that might not be as easy to work with you could swap. A forced change so everyone has to work together.

Not only does this potentially alleviate conflict, it gives everyone in the group a chance to work together. Students also identified they felt there was an unequal distribution of longer, challenging dissections. While this might have simply been perception, instructors teaching in a PTL need to be aware of how dissection sessions and the complexity of each session are distributed across the teams. Changing the order of dissections or decreasing the workload of specific dissection sessions may be necessary to prevent unequal distribution of long, difficult dissections.

Effective communication. Effective communication was the second theoretical subcategory identified in the GT analysis of the challenges within groups theoretical category. In a PTL communication between team members is vital because each team is only present for every other dissection session due to the alternating dissection schedule. In order to ensure both teams are aware of all necessary information, effective communication must occur between the teams in the transition process that occurs during the peer teaching time when teams meet. Student interviews and LEQs revealed there were concerns about communication specifically related to PTL.

In the PTL format, communication between teams dissecting on different days is critical and requires some coordination. Communication was especially important if a group was unable to finish a dissection.

> I think one area that could have been improved was between the 2 teams. The communication between the 2 could have been a bit better as far as coordinating this completed in different dissection sessions.

Students recognized the need for good communication, but no one had specific suggestions to improve the process. Since the analysis revealed an awareness of a communication issue, but a lack of ideas for improvement, this is an area that the instructors could provide guidance and suggestions to improve students' communication abilities. This would be advantageous as one student noted, "In this day and age in healthcare, with individuals working in shifts and replacing each other, communication is vital." Not only does teaching communication skills have the potential to improve communication between teams in the PTL, it also teaches essential skills students will need in the future.

PTLs are different from the TL counterpart. Through GT analysis, I was able to propose a theory that explains the changes to the student expedient in A550/551 with the incorporation of peer teaching and alternating dissections. I identified two theoretical categories, the role of the student and challenges within groups, that emerged through a GT analysis of PTL related interview questions and LEQ questions. This information can be used to inform instructors as they look to improve the PTL experience for students. The next section will discuss the results of the grounded theory analysis of interview questions, LEQ questions, anatomy dissection structure lists and VTs© related to the incorporation of SDL in the gross anatomy laboratory.

Results and Analysis of Self-Directed Learning in PTL+

At IUSM-BL during the 2014-2015 and 2015-2016 school years, students were required to complete 2 additional assignments in A550-551 laboratory beyond just the dissection. These additional assignments were intended to (1) improve the PT process and (2) incorporate SDL in the laboratory setting. Students created anatomy dissection structure lists that classified the structures to be identified into primary, secondary, and tertiary structures using any classification scheme they choose, but students had to explain the scheme at the bottom of the list in a short paragraph. Students were also required to create VT© slideshows. These slideshows could include images and videos that the students narrated and annotated so that their team members could review the dissection prior to coming to the peer teaching session in the next class meeting. The following section is a grounded theory analysis of the following data:

- Interviews conducted with students in the PTL+ (n = 10)
- LEQs completed by students in PTL+ (n = 36)
- Digital copies of student structure lists (n = 767)
- Digital recordings of VT© slideshows (n = 784)

Prior to discussing the results of the GT analysis, I will discuss how the structure lists and the VTs© were analyzed because the processes were different than the analysis of the interview and LEQs, which took statements given by students and coded those statements to develop theoretical codes.

Anatomy dissection structure lists. Students enrolled in A550/551 in 2014-2015 and 2015-2016 were required to create a list of anatomic structures to be dissected during the laboratory session. These structure lists were not discussed in the interviews, but the lists were shown in each VT© slideshow. Thus, the author was able to analyze these lists by viewing the VTs©. GT analysis was used to explore the organizing themes students used to order structures in primary, secondary, and tertiary groups for just the 2015-2016 year. After analysis of the 331 structure lists created by the 2015-2016 class, I believed saturation levels were met and analysis of the 2014-2015 class was deemed unnecessary. Based on the analysis, 7 classification schemes were identified that students used to organize the structures to be dissected in the dissection session. Table 5.6 indicates the frequency of each classification scheme. The most commonly used classification was based on body system (e.g. nervous, cardiovascular, musculoskeletal) followed by regional classification (e.g. mediastinum). The third most common scheme was based on layers (primarily going from superficial to deep). The use of layers to discuss classification decreased after the first several dissections sessions of the year and was rarely used in the second half of the class. It was noted that 27 times students failed to include a structure list; however, there was no grade penalty for students not completing a list.

While students did provide a rationale for the selection of their classification scheme, it was very general and directly related to the dissection session assigned for the day. It was also noted that students never related dissections to clinical relevance. While, clinical relevance is incorporated routinely in the lecture portion of the class and laboratory exams include questions related to clinical concepts, students did not classify

Table 5.6

Classification Schemes Used by Students on Structure Lists

Classification Scheme	*n*
Systemic	
Regional	73
Layers	56
None	27
Size	22
Relevance	14
Other	3

based on clinical relevance. Perhaps the focus on the dissection procedures and structures naturally guided students towards classifications based on system, region, and layer. This indicates that instructors may need to emphasize clinical relevance in lab or require specifically using clinical relevance as a classification scheme if the instructor is interested in having students consider the clinical implications of a particular dissection session or dissection of a particular region.

VoiceThread©

Similar to the structure lists, I watched and recorded notes about how the students created the VTs© slideshows. For the first few labs in the first semester, students primarily used still images dictated the process of the dissection. However, due to the difficulty students had in visualizing images, students transitioned to making short videos. Several short videos were then compiled to demonstrate a complete dissection. In videos, students were able to hold probes to point and demonstrate structures;

therefore, annotations were generally not used after the transition to short videos. Next, I will discuss the results of the GT analysis of the interview questions and LEQ questions related to SDL.

Grounded theory results and analysis of SDL. Ten interviews with students from the 2014-2015 school year and 36 LEQs from the 2015-2016 were used in a grounded theory analysis of SDL from the PTL+. From the data, the theoretical category identified is that the implementation of SDL was **"good in thought but not in practice"**. Incorporation of SDL aided student preparation, but the specific assignments and platforms used need to be modified improve the experience. While there were significant amounts of data in the form of structure lists, VTs©, interviews, and LEQs, the structure lists VTs© contributed a limited amount of data due to the repetitive nature of the assignments and therefore no theory fully emerged through the GT analysis. However, using the GT methodology, the results and analysis of the interview data, anatomy dissection structure lists, and VTs© provided insight as to what happened in the PTL+ format and can inform future incorporations of SDL activities in the gross anatomy laboratory.

The theoretical category of "good in thought but not in practice" was a quote from a student interview and appropriately encompasses the results of incorporating SDL activities into A550/551 in the PTL+ format. Based on the data, students identified a general benefit from the incorporation of SDL, the SDL activities improved student **preparation** to both perform the dissection and to thoughtfully engage in peer teaching when team mates arrived for the peer teaching session. Creation of anatomy dissection structures lists prior to lab provided an additional incentive to read through the assigned dissection prior to attending the lab session. VT© assignments ensured students reviewed the dissection immediately after finishing the lab.

Most students created VTs© either immediately after or shortly after finishing the A550/551 dissection session. Students recognized the value of summarizing and presenting the information to their team members. I student said,

> I thought it (making VT) was beneficial looking back. I appreciated, it was helpful because it's so easy to fly through a dissection not really knowing what you are seeing. 'Okay cool, there it is.' But not really putting it in context. So, the beneficial thing was having to synthesize what you did for those 2 hours.

Other students explained that being forced to review the information at the end of a dissection session helped with learning the material. This review helped to prepare students to teach team members during the peer teaching session held at the start of the next lab. A student stated the following:

> It made me study the material a little more. It definitely made me know what I was looking at in the lab, because it would be really easy to dissect a whole area and just leave without really knowing what we dissected."

Additionally, students discussed importance of clear communication when making a VT©. In order to describe and explain a dissection to a student not in the classroom, communication was critical. One student described "thinking of ways you can be more engaging, clear, and direct." Yet another student discussed thinking about "How can I frame this in a way that is more helpful and add something that is going to help them remember?" The SDL activities definitely had value in the classroom.

While students recognized the value, the VT© platform was not sufficient to allow students who had not been in the lab to become oriented. The problem was described by a student who said, "it was tough to watch a VT and get the level of detail we needed and the spatial orientation needed." Thus, the VTs© offered little value to students that were not in the laboratory. Watching these VTs© from home, without also examining the structures in the lab, simply resulted in confusion. Therefore, in the future a different platform or activity would be needed to ensure a benefit for those that were not present for the dissection.

While not accomplishing its intended goal, the results provided important information related to how incorporate SDL and to improve the format of the PTL+. It identified that creating a structure list and a review at the end of lab aided preparation for dissection and peer teaching.

This chapter described the results and analyses obtained based on the qualitative analysis of data in this dissertation. First, I described the positive and negative attributes of a TL and compared that to the positive and negate attributes of a PTL from the perspective of instructors and select students involved in A550/551. Then, I proposed a theory to explain that peer teaching and alternating dissections impact the student experience in A550/551 by altering student roles in the lab and creating challenges within dissection groups. Finally, I proposed the impact of implementing SDL activities in A550/551, was good in thought but not in practice. SDL activities improved student preparation, but the platform and assignments need modification implementing again any time in the future. The next chapter will synthesis the results obtained in both the quantitative and qualitative portions of this study into a single discussion to address the specific research questions put forth in this dissertation, discuss limitations of this study, explore future directions, and, in conclusion, summarize the findings of this study.

CHAPTER 6: DISCUSSION AND CONCLUSIONS

In this chapter, I will first integrate the results and implications from the quantitative and qualitative chapters into a single discussion to address the answers to the 3 research questions proposed by this dissertation. Second, I will and situate the findings in the current environment of anatomy educational research for 3 groups of stakeholders: (1) local stakeholders at Indiana University School of Medicine – Bloomington (IUSM-BL), (2) regional stakeholders at Indiana University School of Medicine (IUSM), and (3) national stakeholders engaged in anatomy education and medical education. Next, I will characterize the limitations of this study. Then, I will discuss future directions of research related to this dissertation. Finally, I will conclude by summarizing what was learned in answering my three questions to explore impacts of peer teaching and self-directed learning (SDL) on student learning and the gross anatomy experience in medical education.

Discussion

This dissertation used a mixed method approach to answer 3 primary research questions related to the incorporation of peer teaching and SDL into the gross anatomy lab at IUSM-BL. Previous research related to peer teaching primarily focused on course performance as measured by student grades (Abedini et al., 2013; Amorosa, Mellman, & Graham, 2011; Krych et al., 2005; Manyama et al., 2016; Marshak et al., 2015; Adam B Wilson et al., 2011), but this research supplemented the understanding gained through quantitative analysis of course grades with a detailed qualitative analysis of student interviews additional data to expand the understanding of the impact of peer teaching in anatomy. This research also developed SDL activities and analyzed their use in

A550/551 to inform other anatomy educators about strategies, concerns, and best practices for including SDL in the curriculum. With the incorporation of SDL in the LCME (2015) standards, it is necessary for instructors in medical education to understand what SDL is and how it can be included in the classroom

The subjects for this research were primarily students enrolled Gross Human Anatomy (A550/551) from the fall of 2010 – spring of 2016. Additionally, 5 instructors for the class in that same span were subjects of the study as well. In the 2010 – 2011 and 2011-2012 school years a traditional laboratory (TL) format was used in gross anatomy and all students addended and participated in all dissections session. IUSM-BL, like many anatomy programs in medical education (Drake, 1998, 2014; Drake et al., 2009; Drake et al., 2014; McBride & Drake, 2018), was required to reduce student contact hours in the fall of 2012. IUSM-BL transitioned to an anatomy laboratory format that utilized an alternating laboratory format and peer teaching. During the 2012-2013 and 2013-2014 school years the peer teaching laboratory (PTL) was used. Finally, in the 2014-2015 and 2015-2016, SDL activities were incorporated into the anatomy laboratory curriculum. This laboratory format was identified as the peer teaching laboratory plus (PTL+) in reference to the SDL activities. Using these subjects and the data collected, this research addressed the following 3 questions.

Research question 1. What is the impact of peer teaching on student exam grades in A550/551 at IUSM-BL?

Based on the quantitative analysis of student grades, the results of this dissertation support the current literature (Abedini et al., 2013; Amorosa et al., 2011; Krych et al., 2005; Manyama et al., 2016; Marshak et al., 2015; Adam B Wilson et al., 2011) that indicates implementation of alternating dissections and peer teaching had no negative impact on student learning as measured by course and exam grades. Using *ANOVA,* this research found that student grades were not statistically different between the TL and the PTL formats. Additionally, the results of the *GEE* analysis of laboratory exam answers found a positive association of with active dissection with an increased likelihood to correctly identify structures on laboratory examinations. This supports the benefits of learning anatomy through dissection (Dinsmore et al., 1999; Flack & Nicholson, 2018; J. H. Johnson, 2002; Marshak et al., 2015; Nwachukwu et al., 2015; Pawlina & Lachman, 2004).

While the exam analysis did indicate that students dissecting a structure had a statistically increased likelihood of correctly answering related exam questions, the design of this study is not able to tease apart if it was the role of the dissector or the role of the teacher that creates that increased likelihood. The subjects used for the *GEE* analysis first dissected and then peer taught the information to team members. This means that the positive impact of dissection could also be related to the act of peer teaching. However, this does not call into question the value of dissection as has been suggested by some recent research (Rizzolo & Stewart, 2006; Topp, 2004; Wilson et al., 2018). Improved knowledge of the structures may have resulted from the combination of active dissection and peer teaching. It is also possible that the improved identification of structures was due to the time and effort the student put in to ensure correctly teaching the dissected structure to teammates at the next session.

Peer teaching offers students an excellent review of the dissection, echoing the findings related to retrieval practice (Karpicke & Roediger, 2008; Karpicke & Roediger III, 2007). The grounded theory (GT) analysis of peer teaching in this study identified that students found teaching a valuable approach to learning. In preparing to teach team members, students would review and prepare material in practice for the teaching session. As one student said,

> I learned that teamwork is a great tool for success in anatomy. By having information explained to you and also explaining it yourself, you are better able to master the material.

This research supports the use of dissection whenever possible in an anatomy laboratory and indicates that the use of PT is not detrimental to student learning of the course content. McBride and Drake (2018) noted an additional decrease in hours allocated to gross anatomy laboratory class time. Based on this research, supported by other studies (Dunham, 2014; Manyama et al., 2016; Muñoz-García, Moreda, Hernández-Sánchez, & Valiño, 2013; Rhodes et al.), peer teaching and alternating dissections are an ideal means to reducing contact hours while still maintaining dissection, the backbone of human anatomy education.

Additionally, while this research question was specifically concerned with impacts to grades, if we expand the definition of assessment to include the skills and benefits that the GT analysis indicates are part of a peer teaching laboratory (PTL), then it could be argued that the PTL format may provide a better laboratory learning experience for students than a traditional laboratory (TL) experience.

Research question 2. What were the underlying impacts of alternating dissections and peer teaching gross anatomy laboratory formats that were not easily identified simply by examining exam grades and course performance?

This research used grounded theory (GT) to identify changes, specifically not grade based measurements, that impacted the student experience in an anatomy lab with the implementation of PT in A550/551 at IUSM-BL. The theory developed through the GT analysis highlight the how the experience of A550-551 changed with the introduction of PTL. The proposed theory stated that peer teaching and alternating dissections altered the roles of students in A550/551 and contribute to challenges within dissection groups. Chapter 5 provides a very detailed description of the identified changes to the student experience with the incorporation of alternating dissections and peer teaching.

Learning was likely impacted by many of these changes, but as indicated by the quantitative analysis, quantifiable changes to grades were very limited. However, that does not mean that there were no changes to learning. Through teaching, students may have had better reinforcement and repetitive practice for better recall for long-term learning (Blunt & Blizard, 1975; Karpicke, 2012; Pyc & Rawson, 2009; Ward & Walker, 2008). Attendance at only a single dissection, reduced the time in the laboratory and gave students an opportunity to have additional time during the week. This time could be used as needed, potentially reducing some of the stress associated with the first year of medical school.

In general, this research identified many positive aspects in moving to the PTL, but what was lost in moving away from the TL? Is there a reason to advocate maintaining the TL experience? While the switch to PTL at IUSM-BL was primarily related to the need to reduce contact hours, there were many benefits to the change that had not necessarily been anticipated. Our lab is limited in space and so there was significant benefit to reducing the number of individuals in the classroom at any given time. A peer teaching laboratory potentially offers a better learning environment with increased access to instructors and more hands-on dissection time, similar to benefits identified in peer teaching research outside of medical education (Campolo, Maritz, Thielman, & Packel, 2013; Topping, 1996, 2005).

Finally, in the PTL students developed skills that may not as easily find themselves in the curriculum of a TL. Developing and improving new skills in communication and teaching are an excellent addition to the anatomy curriculum. The lab itself had an increase in available space and students were able to have increased access to dissection experiences and instructors for help. While the instructors noted an overall decrease in intragroup conflict, if you were one of the few students that discussed working with a difficult partner, the amount of time spent negotiating with the partner in the laboratory may have outweighed any benefits acquired in the PTL. However, teamwork and communication are essential skills in medicine and therefore learning to deal with a difficult partner, teaches valuable lessons (Aspegren, 1999; Hulsman, Ros, Winnubst, & Bensing, 1999; Kurtz, Silverman, Draper, van Dalen, & Platt, 2005; Wittert & Nelson, 2009). In medicine, these are critical skills a physician needs and competency assessments is increasingly being measured in classes across the medical curriculum (McBride & Drake, 2015).

Research question 3. How can a gross anatomy course, specifically the laboratory component of A550-551 at IUSM-BL, effectively contribute to the accreditation process and directive to use SDL required by Standard 6.3 from the LCME (LCME, 2015)?

SDL and lifelong learning have long been identified as important aspects for physicians to begin to develop or hone while in medical school (Ainoda, Onishi, & Yasuda, 2005; Brydges & Butler, 2012; Harvey, Rothman, & Frecker, 2003; Murad, Coto-Yglesias, Varkey, Prokop, & Murad, 2010). The goal to integrate SDL was ambitious and it proved challenging. In order to meet the LCME definition of SDL, students would need to be doing more independent work (LCME, 2015). However, many first year medical students may not be prepared for non-scaffolded SDL and would benefit from a scaffolded learning experience that introduced and guided SDL activities before moving students to more independent SDL (Dornan, Hadfield, Brown, Boshuizen, & Scherpbier, 2005; Keator et al., 2016). The model set forth to have VT was a start to bringing SDL to the gross anatomy lab, but the delivery needs substantial modification.

Even with its flaws, students identified the process of preparing the VoiceThread (VT©) as beneficial because it forced them to review and the end of each lab. However, the platform limitations made watching the videos less useful. Modification to the SDL proposed in this study could involve creating a single digital project in which students create a detailed review of a dissection, integrate the lecture and laboratory material, and provide clinical correlations. In doing this, the student would generate a lasting digital project that meets the LCME requirements for SDL. The addition of a hand-off protocol such as the one developed by Lazarus et al. (2016) could maintain the requirements that forced students to review a the end of teach lab session. The hand-off protocol aided in the peer teaching process and transitioned dissection session between team members. It also offered an opportunity to practice hand-off skills that will be needed in clinical practice when transitioning between shifts.

There is an opportunity to address some of the skills needed do develop SDL without completely putting students in completely independent situations. Students cannot make the jump on their own and as anatomy laboratories are often offered, even in integrated curricula, early in the medical education program, and thus provides an opportunity to introduce SDL and lay the ground work for additional follow-up later in the medical education curriculum (Candy, 1991). The idea that simply telling students to be self-directed will result in lifelong learning is false. Students activity and participation is often best when support and gently directed early in the process (Dorhan 2005).
SDL has a role in medical education but it fits best with more advanced learners (Murad et al., 2010). Getting younger learners there means helping them understand SDL and begin to incorporate the techniques and components of SDL.

Finally, it is important to note that in this research the only slight decrease in grades was noted in the lab exam averages of the PTL+. These were students that completed SDL activities in A550/551. There was not an obvious reason that this group scored slightly lower, but it is worth noting that the increased focus on assignments might have taken away for the focus on learning structures.

Implications for Stakeholders

Local stakeholders: IUSM-BL. For instructors incorporating peer teaching and alternating dissections, this research suggests that the PTL is the best option for A550/551 at IUSM-BL. It makes the best use of the laboratory space, reduces student contact hours as necessary in the curriculum, and based on the grade data and GT analysis it offers the best possible learning experience in the anatomy laboratory

Regional stakeholders: IUSM. While VT© was not the ideal platform for a SDL activity, students appreciated the forced review that was required in order to complete the assignment. A modified SDL activity could incorporate the review opportunity but eliminate the additional unnecessary work that was generated due to the challenges with the VT© platform.

National stakeholders: individuals engaged in anatomy education and/or medical education. With the ongoing reductions in to anatomy laboratory course hours (McBride & Drake, 2018), it is necessary for anatomy educators to make the best use of the hours that are available. As more digital options are released, some have medical schools have chosen to eliminate dissection. This research supports maintaining dissection in the anatomy lab. If hours do need to be cut, alternating dissections and peer teaching are an approach to limiting hours while still maintaining dissection in the class.

Limitations

This study had several limitations that impacted the effectiveness of the research. The limitations included the following: single institution study, limited participation in interviews, overlapping variables, and multiple instructors in a single course.

This study was conducted in its entirety at IUSM-BL. Each year the location has approximately 36 students enrolled in the first year of medical education. The population of the study was limited; therefore, the generalizability of the findings is limited. While adding knowledge, this study does not create a generic formula that can be prescribed at all medical schools. Only 18 student interviews were able to be conducted. Inteviews were only able to be and students that did volunteer self-selected and that could impact the data that was used for the GT analysis. Limited participation was balanced with theoretical coding done using that LEQ was retuned by all 36 medical students in the 2015 – 2016 class. Student responses on the LEQ were used to refine the categories generated in the grounded theory analysis of PT and of SDL in the PTL+.

While the study did examine 6 years of data, there were multiple changes made to the gross anatomy curriculum in that time that increase the complexity of the analysis and make it more difficult to determine the cause of any specific change in learning or the student experience.

Finally, in the six years that this study was conducted there were three faculty involved in teaching the course. While the content remains similar across all years the mode of delivery and slight variation in content did exist. This was another variable that could not be controlled in this study.

Future Directions

There are several future directions for this research. Teasing apart the impacts of peer teaching and active dissection on performance in anatomy help to better explain how each of those variables is independently impacting performance and has not been addressed in current literature. In order to do this, a study would need to be designed such that the information that was taught using peer teaching was different than the information being learned in the dissection process.

Focusing on the development on SDL opportunities in the laboratory could further the benefits of SDL for students, while providing documentable evidence of SDL in the medical curriculum. This research showed some initial positive impacts of working to bring SDL into the anatomy laboratory. Continued refinement could make this possible and with further testing be a product that could be used in multiple institutions.

If SDL is going to be a prominent feature of medical education, it is necessary to development of an instruments that could measure SDL. There are several instruments currently, but these would likely need to be evaluated and modified to best measure SDL skills for medical students.

Conclusions

Taken together, the answers to the 3 research questions posed in this dissertation indicate that there are both positive and negative impacts to student learning and the experience in the gross anatomy lab when peer teaching and SDL are implemented in the curriculum. Implementing a peer teaching and self-directed learning in the Gross Human Anatomy course at IUSM-BL impacts the experience the experience students have in the course. PTL student grades were similar to those achieved by students in the TL, but a *GEE* model indicated that both students that dissected a structure and peer taught that same structure to team mates did have an increased likelihood of correctly identifying those structures on laboratory practical exams.

In-depth interviews with students and instructors involved in A550-551 provided the evidence necessary to explore how PT changed the student experience in the lab. These individuals noted that the PTL format was now considered the preferred curricular choice by students, instructors, and based on the research, myself for the laboratory because it increases the hands-on dissection time for students, provides an efficient and effective process for learning and participating in dissection sessions, increases student access to instructors in the laboratory setting, and generally creates a better environment for both students and instructors in the lab.

While VT© were not entirely effective at implementing SDL in the anatomy laboratory, in reflecting back, students recognized the value of teaching others and the impact of an immediate review upon completion of a dissection session. Additional the lessons learned in this research can be used to inform the design of future SDL interventions to build on the positive aspects identified in this research but eliminating the technical challenges of VT© and working to proactively scaffold student experiences to build SLD skills that will enable those same medical students to continue practicing SDL and hopefully develop into physicians that practice lifelong learning.

Appendix A

Gross Anatomy Instructor Interview Protocol

Date:_______________

Place:_______________

Evaluator Name:____

Start:__________ Finish: ___________

Introduce yourself (if applicable)

Read the following statement:
Thank you for agreeing to speak with me today. You may already know about the purpose of this interview, but I just want to make sure we are all on the same page as far as the purpose of this evaluation goes, so I'm going to read you the following paragraph that explains a bit more about our goals. Please feel free to ask any questions about the evaluation or your participation in the evaluation. I will also provide you with my own and the lead evaluator's contact information. If you have any questions or concerns after the interview please do not hesitate to contact me.
The main purpose of this interview is to develop a better understanding of the differences between the traditional lab and the new peer teaching approach in gross anatomy. We hope to better understand perceptions of peer teaching, its value in the classroom, and any concerns you may have with the approach.
The interview will take between twenty and thirty minutes. All responses given during this interview will be kept confidential and your name will not be identified with the interview.

Do you have any questions?

Do you mind if I record this interview

Faculty Participation

1. What is your role in the gross anatomy lab?

    - Can you provide examples of what you do?

2. How long have you instructed in a non-peer teaching lab?

3. How long have you instructed in a non-peer teaching lab?

4. Describe your interactions with the students?

    - Is this different in either lab instruction style.

Perceptions of Learning

5. Do you perceive any changes in student learning based on lab style?

    - Do you remember any changes in grades based on lab style?

6. Do you think one style is more conducive for student learning?

Overall Opinion

7. Which class style do you prefer and why?

    - Examples

8. Describe the positive and negative aspects of the non-peer teaching lab.

9. Describe the positive and negative aspects of the peer teaching lab.

10. Which lab provides the best experience for students and why?

11. How could the current peer teaching lab program be improved? Examples.

Appendix B

Gross Anatomy Traditional Lab & Peer Teaching Lab Student Interview Protocol

Date:_______________

Place:_______________

Evaluator Names:____

Start:__________ Finish: ___________

Introduce yourself (if applicable)

Read the following statement:
Thank you for agreeing to speak with me today. You may already know about the purpose of this interview, but I just want to make sure we are all on the same page as far as the purpose of this evaluation goes, so I'm going to read you the following paragraph that explains a bit more about our goals. Please feel free to ask any questions about the evaluation or your participation in the evaluation. I will also provide you with my own and the lead evaluator's contact information. If you have any questions or concerns after the interview, please do not hesitate to contact me.
The main purpose of this interview is to develop a better understanding of the differences between the traditional lab and the new peer teaching approach in gross anatomy. We hope to better understand your perceptions of the differences between the approaches, the value of each approach and any concerns you may have for either approach.

The interview will take between twenty and thirty minutes. All responses given during this interview will be kept confidential and your name will not be identified with the interview.

Do you have any questions?

Do you mind if I record this interview?

Gross Anatomy Lab Background

1. Describe the gross anatomy lab courses you have participated in.

    - Can you provide examples of your dissection roles?

    - What was the duration of the course? How many hours per week?

2. Non-Peer teaching Lab Experience:

    - What was your role in the lab? How much time were you required to be present?

    - Describe the in-class experience.

    - Describe additional time spent in lab outside of classroom hours.

3. Peer Teaching Lab Experience:

    - What was your role in the lab? How much time were you required to be present?

    - Describe the in-class experience.

    - Describe additional time spent in lab outside of classroom hours.

Perceptions of Learning

4. How would you compare your study habits between the two class styles?

5. Is one class style more conducive to your learning?

6. How did you perceive the learning of your classmates? Was one style more effective?

Overall Opinion

7. Which class style do you prefer and why?
    - Examples

8. Describe the positive and negative aspects of the non-peer teaching lab.

9. Describe the positive and negative aspects of the peer teaching lab.

10. Which lab provides the best experience for students and why?

11. How could the current peer teaching lab program be improved? Examples.

Appendix C

Gross Anatomy Peer Teaching Student Interview Protocol

Date:_______________

Place:_______________

Evaluator Name:____

Start:__________ Finish: ___________

Introduce yourself (if applicable)

Read the following statement:
Thank you for agreeing to speak with me today. You may already know about the purpose of this interview, but I just want to make sure we are all on the same page as far as the purpose of this evaluation goes, so I'm going to read you the following paragraph that explains a bit more about our goals. Please feel free to ask any questions about the evaluation or your participation in the evaluation. I will also provide you with my own and the lead evaluator's contact information. If you have any questions or concerns after the interview, please do not hesitate to contact me.
The main purpose of this interview is to better understand of the differences between the traditional lab and the new peer teaching approach in gross anatomy. We hope to learn about your experience in the lab and about any concerns or suggestions you may have about the class.

The interview will take about 15 – 20 minutes. All responses given will be kept confidential and your name will not be identified with your responses.

Do you have any questions?

Do you mind if I record this interview?

Gross Anatomy Lab Background

1. Peer Teaching Lab Experience:

    - What was your role in the lab? How much time were you required to be present?

    - Describe the in class experience.

    - Describe additional time spent in lab outside of classroom hours.

Perceptions of Learning

2. Describe your study habits for gross anatomy lab.

3. Was the style more conducive to your learning? Explain.

4. How did you perceive the learning of your classmates?

Overall Opinion

5. Describe the positive and negative aspects of the non-peer teaching lab.

6. Have you discussed different lab styles with individuals at other campuses? How would you compare your experience to theirs?

7. How could the current peer teaching lab program be improved? Examples.

8. If you did not like your lab experience, how would you prefer it to be taught?

Appendix D

Gross Anatomy Peer Teaching and VoiceThread© Student Interview Protocol

Date:_______________

Place:_______________

Evaluator Name:____

Start:__________ Finish: ___________

Introduce yourself (if applicable)

Read the following statement:

Thank you for agreeing to speak with me today. You may already know about the purpose of this interview, but I just want to make sure we are all on the same page as far as the purpose of this evaluation goes, so I'm going to read you the following paragraph that explains a bit more about our goals. Please feel free to ask any questions about the evaluation or your participation in the evaluation. I will also provide you with my own and the lead evaluator's contact information. If you have any questions or concerns after the interview, please do not hesitate to contact me.

The main purpose of this interview is to better understand the activities and learning that occurs in the gross anatomy lab. We hope to learn about your experience in the lab and about any concerns or suggestions you may have about the class.

The interview will take approximately 20 – 30 minutes. All responses given will be kept confidential.

Do you have any questions?

Do you mind if I record this interview?

Gross Anatomy Lab Background

Peer Teaching Lab Experience:

1. What was your role in the lab? How much time were you required to be present?

2. Describe the in class experience.

3. Describe additional time spent in lab outside of classroom hours.

Perceptions of Learning

4. Describe your study habits for gross anatomy lab.

5. Was the style more conducive to your learning? Explain.

6. How did you perceive the learning of your *classmates*?

Overall Opinion

7. Describe the positive and negative aspects of using VoiceThread in the lab?

8. Have you discussed different lab styles with individuals at other campuses? How would you compare your experience to theirs?

9. Tell me about any technical challenges you experienced? How did these impact the experience and learning.

10. Do you think the use of VoiceThread could be improved or done differently? Please describe your ideas in detail if possible.

Appendix E

LEQ - Anatomy A550/A551

<u>Laboratory Experience Questionnaire</u>

Competency V – Self-Awareness, Self-Care and Personal Growth

1. What did you learn about yourself during this lab? What potential strengths or weaknesses about yourself became evident as you dissected in lab?

2. What are some ways that enabled you to cope with the fact that you were dissecting a former living, breathing human being?

3. After observing your classmates, what comments/behaviors did you find that would be disturbing to the donor and family?

4. After considering these behaviors in others, what are some behaviors that you perceive in yourself that might require modification?

5. Has your lab group worked well together? Describe some specific instances where there was good teamwork, and not-so-good teamwork.

6. What are some ways that teamwork could have been improved?

7. What are some ways that would enhance the dissection experience and/or enhance respect for the donor?

Appendix F

IRB Study #1404683093

INDIANA UNIVERSITY INFORMED CONSENT STATEMENT
REVIEW OF PEER TEACHING IN GROSS ANATOMY

You are invited to participate in a research study concerning the use of peer teaching in the gross anatomy lab. You were selected as a possible subject because you are either currently enrolled in gross anatomy. We ask that you read this form and ask any questions you may have before agreeing to be in the study. The study is being conducted by Dr. Mark Braun and Stacey Dunham from the Medical Science Department at Indiana University. There is no funding or sponsor for this study.

STUDY PURPOSE
The purpose of this study is to examine the effectiveness of peer teaching in the gross anatomy lab. Interviews are to be conducted with instructors and students involved in Human Gross Anatomy (A550/A551) to better understand how the structural change in lab instruction to include peer teaching has changed the course. The goal of the study is to better understand how peer teaching impacts teaching and learning in the gross anatomy lab. It also seeks to identify specific aspects of the peer teaching model that may need further development.

NUMBER OF PEOPLE TAKING PART IN THE STUDY:

All students enrolled in A550/A551 will be asked to participate in this study.

PROCEDURES FOR THE STUDY:
If you agree to be in the study, you will do the following things:

- Provide contact information to schedule your participation in an interview.
- Participate in an interview last approximately 20 to 30 minutes.
- Allow digital voice recording of the interview, but no personal data will be collected (i.e. name, demographic data).

RISKS OF TAKING PART IN THE STUDY:

No risks are anticipated, but you can withdraw from the study at any time.

BENEFITS OF TAKING PART IN THE STUDY:
The benefits to participation that are reasonable to expect are to improve instruction and learning in the gross anatomy lab. There is no direct benefit to subjects participating

ALTERNATIVES TO TAKING PART IN THE STUDY:
Instead of being in the study, you have these options: to decline your participation in the study. There is no penalty for not participating.

CONFIDENTIALITY
Efforts will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be published and databases where the information will be stored.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees.

COSTS
You will not incur any costs as a participant in this study.

PAYMENT
There is no payment for participation.

CONTACTS FOR QUESTIONS OR PROBLEMS
For questions about the study, contact the researcher Mark Braun, M.D. at (XXX) XXX-XXXX or Stacey Dunham at (XXX) XXX-XXXX.

For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Subjects Office at (812) 856-4242 or (800) 696-2949 or by email at irb@iu.edu.

VOLUNTARY NATURE OF STUDY

Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with Indiana University or the School of Medicine.

SUBJECT'S CONSENT

(***This section should be in first person)*** In consideration of all of the above, I give my consent to participate in this research study.

I will be given a copy of this informed consent document to keep for my records. I agree to take part in this study.

Subject's Printed Name:____

Subject's Signature:_____________________________________**Date**:___________
(must be dated by the subject)

Email Contact: ____

Printed Name of Person Obtaining Consent:_________________________________

Signature of Person Obtaining Consent:____________________**Date**:___________

Appendix G

IRB Study #1404683093

INDIANA UNIVERSITY INFORMED CONSENT STATEMENT

MEDICAL STUDENTS ENROLLED A550/551 FALL 2014 – SPRING 2016

Review of Peer Teaching and VoiceThread© in Gross Anatomy

You are invited to participate in a research study concerning the use of peer teaching and VoiceThread©. You were selected as a possible subject because you are either currently enrolled in gross anatomy or have taken the course in the past. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

The study is being conducted by Dr. Mark Braun and Stacey Dunham from the Medical Science Department at Indiana University. There is no funding or sponsor for this study.

STUDY PURPOSE

The purpose of this study is to examine the effectiveness of peer teaching and VoiceThread. Interviews and focus groups will be conducted with instructors and students involved in Human Gross Anatomy (A550/A551) to better understand how structural changes in lab instruction to include have changed the impact of these programs in the lab. Researchers will review course content from to further understand the impact of the programs in the lab. Researchers may review VoiceThread videos, course exams, and course grades. All data will be deidentified by the researchers to protect anonymity. The goal of the study is to better understand how peer teaching, VoiceThread, and prosections impact teaching and learning in the gross anatomy lab. It also seeks to identify specific aspects of the laboratory experience that need further development.

NUMBER OF PEOPLE TAKING PART IN THE STUDY:

All students enrolled in A550/A551 from 2013-2016 will be asked to participate in this study.

PROCEDURES FOR THE STUDY:

If you agree to be in the study, you will do the following things:

- Participate in a focus group or interview that will last approximately 1 hour or less.
- Allow digital recording of the focus group or interview.
- Allow researchers to contact you at a later date to clarify statements or ask for additional information.
- Allow researchers to have access to VoiceThread videos, course exams, and course grades.

RISKS OF TAKING PART IN THE STUDY:
No risks are anticipated, but you can withdraw from the study at any time.

BENEFITS OF TAKING PART IN THE STUDY:
The benefits to participation that are reasonable to expect are to improve instruction and learning in the gross anatomy lab. There is no direct benefit to subjects participating in the study.

ALTERNATIVES TO TAKING PART IN THE STUDY:
Instead of being in the study, you have these options:

- Decline participation in the focus group/interview and only allow researchers access to course materials.
- Decline participation in the study completely. There is no penalty for not participating.

CONFIDENTIALITY
Efforts will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be published and databases where the information will be stored.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees.

COSTS
You will not incur any costs as a participant in this study.

PAYMENT
During the focus groups and interviews, light refreshments will be provided.

CONTACTS FOR QUESTIONS OR PROBLEMS
For questions about the study, contact the researcher Mark Braun, M.D. at (XXX) XXX-XXX or Stacey Dunham at (XXX) XXX-XXXX.

For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Subjects Office at (812) 856-4242 or (800) 696-2949 or by email at irb@iu.edu.

VOLUNTARY NATURE OF STUDY
Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with Indiana University or the School of Medicine.

SUBJECT'S CONSENT

	Yes	No
I have read this form and received a copy of it. I have had all my questions answered to my satisfaction. I agree to take part in a focus group or interview.	☐	☐
I agree to be contacted at a later date to verify interview information or answer additional questions.	☐	☐
I agree to allow researchers access to course materials (VoiceThreads©, A550/A551 Exams, Course Grades).	☐	☐

Subject's Printed Name:____

Subject's Signature:____**Date**:_______

(must be dated by subject)

Subject's email address: ____

(if you agreed to be contacted for transcript clarification or possible follow-up questions)

Printed Name of Person Obtaining Consent:____________________________________

Signature of Person Obtaining Consent:___________________________**Date:**_______

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Curriculum Vitae

Stacey Marie Dunham

Education

- **Ph.D.** in Anatomy and Cell Biology, Indiana University-Purdue University Indianapolis, August 2018.
- **M.S.** in Secondary Education, Indiana University, December 2003.
- **B.S.** in Biology, Indiana University, May 2002.

Professional Organization Memberships

- American Association of Anatomists (AAA)
- Human Anatomy and Physiology Society (HAPS)

Teaching Experience

- **Disease & The Human Body** (M131), Spring 2015. Taught 25% of an introductory course for approximately 80 undergraduates. Created lectures, notes, in-class activities, and a multiple-choice exam for my quarter of the class. Employed active learning activities to increase student engagement in lecture setting.
- **Basic Human Anatomy** (A215) Lecture, Summer 2014 & Fall 2014. Taught 50% of an undergraduate lecture and laboratory anatomy course for approximately 80 students in the summer and 350 in the fall. Created course content such as notes, multiple choice exams, and in class activities. Received positive evaluations from students for enthusiasm, content knowledge, and engagement during lectures.

Teaching Experience (cont.)

- **Improving Learning Skills in Anatomy** (M100), 3 Semesters from Fall 2012 – Spring 2013. Taught a 1-credit course for undergraduates designed as a supplement to the 200 level Basic Human Anatomy course. Instructed students about metacognitive and study strategies to improve class performance. Used various teaching strategies to review difficult anatomical content related to the Human Anatomy course.
- **Basic Human Anatomy** (A215) Laboratory, 9 Semesters from 2010 – 2018. Taught 2 laboratory sections of approximately 36 students with a fellow teaching assistant. Led daily introductions to content. Assisted students in learning anatomical structures, working with models, and using virtual microscope slides for histology study. Demonstrated prosected cadavers to student groups. Supervised and mentored the Undergraduate Teaching Assistants assigned to the lab sections. Set-up and graded laboratory exams.
- **Basic Human Physiology (**P215), 4 Semesters from 2015 – 2016. Taught laboratory sections of 24 students. Guided students through laboratory sessions reviewing physiology principles covered in lecture. Led post-lab discussions reviewing physiology. Graded weekly short answer quizzes. Introduced scientific writing and graded student reports related to a topic in physiology.

Teaching Experience (cont.)

- **Anatomy for Medical Imaging** (A480/A580), 2 Semesters 2014 & 2018. Worked with the course director in a combined lecture and laboratory course of 40 students. Evaluated and interacted with students through class blogs. Assisted with lab and worked with students in the anatomy laboratory examining models and images. Demonstrated basic Ultrasound techniques.
- **Gross Human Anatomy** (A550 – A551), 2 Years in 2011 – 2012 & 2013 – 2014. Taught in the gross anatomy laboratory with medical and graduate students. Circulated among students aiding dissections and answering question. Enhance the laboratory curriculum by designing and implementing self-directed learning activities to improve the peer teaching process for students. Develop a process, adopted by the department, to include prosected donors in a small gross anatomy lab.
- **Medical Neuroscience** (M555), 1 Semester in 2013. Led small group demonstrations of neurological structures on preserved brains and brain sections. Assisted with laboratory set-up and class procedures. Graded laboratory exams and assisted in exam set-up. Answered student questions related to both lecture and lab.
- **Cell Biology and Histology** (A560), 1 Semester in 2012. Presented introductions for each lab session to guide student activity for laboratory portion of the class. Implemented the use of digital laboratory exams using virtual microscope slides and electron microscope images. Provided extra review sessions to address both lecture and laboratory content.

Teaching Experience (cont.)

- **Human Parasitology** (M375/M575), 1 Semester in 2003. Worked with the instructor to set-up and run the laboratory portion of the class. Supervised independent graduate projects. Graded student quizzes and tests.
- **Biology Laboratory** (L113), 1 Semester Fall 2002. Taught a laboratory section and corresponding discussion for 25 students. Prepared lectures, provided directions, demonstrated techniques, and encouraged students to consider the biological principals during the lab. Planned activities to enhance student knowledge, created quizzes, and graded all lab reports and assignments

Related Experience

- **Prosection**. Independent dissection and preparation of donor for demonstration in undergraduate human anatomy. Three complete dissections; 2 females, 1 male.
- **HAPS Communication Committee Member.** Shared responsibility to disseminate society information through Twitter and Facebook.
- **High School Visits.** Lead educational tours for visiting high school student groups. Demonstrate donors to students.

Guest Lectures

Cell Biology and Histology (A560)

- Female Reproductive System

Medical Neuroscience (M555)

- Autonomic Nervous System
- Basal Ganglia

Guest Lectures (cont.)

Human Gross Anatomy (A550/551)

- Embryology: Fetal Period (weeks 3-8) & Labor
- Embryology of Head & Neck
- Oral Region: Tongue & Sublingual Region
- Team-Based Learning Exercise: Thoracic Region
- Ultrasound of Gastrointestinal Tract & Urinary System

Biochemistry

- Team-Based Learning Exercise: Collagen & Bone Fractures

Awards & Honors

- Associate Instructor Award ($1000), Indiana University School of Medicine (IUSM), 2018.
- Student Travel Award ($350) & Platform Finalist, American Association of Anatomists (AAA), 2018.
- Student Travel Award ($350), AAA, 2017.
- School of Medicine Travel Award ($500), IUSM, 2015
- Student Travel Award ($350), AAA, 2015
- Student Travel Award ($400), Human Anatomy & Physiology Society (HAPS), 2014.
- Women in College of Arts and Sciences Travel Award ($400), IU, 2014.
- Student Travel Award ($350), AAA, 2014.
- Student Travel Award ($350), AAA, 2013.
- Student Travel Award and Poster Finalist ($250), AAA, 2012.

Publications - Peer-Reviewed Research

- Collier, L., Dunham, S., Braun, M. W., & O'Loughlin, V. D. (2012). Optical versus virtual: Teaching assistant perceptions of the use of virtual microscopy in an undergraduate human anatomy course. Anatomical Sciences Education, 5:10-19.

Presentations

Research Posters – External

- Dunham, S. M. (2017). Student Generated Structure Lists: Bringing Self-Directed Learning into the Anatomy Laboratory. *The FASEB Journal*, *31*(1 Supplement), 582-5.
- Dunham, S. (2015). Developing lifelong learning skills through self-directed learning in the gross anatomy laboratory using narrated digital slideshows. *The FASEB Journal*, *29*(1 Supplement), 551-8.
- Dunham, S. (2014). Peer teaching in gross anatomy: reducing contact hours while maintaining student learning (721.12). *The FASEB Journal*, *28*(1 Supplement), 721-12.
- Dunham, S. (2013). Comparison between Student Desired Grades and Actual Final Grades in Undergraduate Human Anatomy. *The FASEB Journal*, *27*(1 Supplement), 956-2.
- Dunham, S., & Notebaert, A. J. (2012). Undergraduate study approaches to anatomy, using surface or deep approaches. *The FASEB Journal*, *26*(1 Supplement), 531-4.

Seminar Presentation - External

- Human Anatomy and Physiology Society Annual Conference, Salt Lake City, Utah, May 2017. *Using Grounded Theory to Explore Research Questions in Anatomical and Physiological Education.*
- Human Anatomy and Physiology Society Annual Conference, Jacksonville, Florida, May 2014. *Introduction to Comparative Anatomy of Humans and Other Vertebrate Animals.*
- Human Anatomy and Physiology Society Annual Conference, Las Vegas, Nevada, May 2013. *Transforming Review Sessions: Interactive Use of Practice Exams for Effective Student Review in Class Settings.*