2014

A mixed methods investigation of post-secondary students' long bone anatomy knowledge retention through constructivism and the works of Vesalius

Jennifer F. Tynes
Louisiana State University and Agricultural and Mechanical College, jennifer.tynes@selu.edu

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A MIXED METHODS INVESTIGATION OF POST-SECONDARY STUDENTS’ LONG BONE ANATOMY KNOWLEDGE RETENTION THROUGH CONSTRUCTIVISM AND THE WORKS OF VESALIUS

A Dissertation

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Doctor of Philosophy

in

The School of Education

by

Jennifer F. Tynes
B.S., Southeastern Louisiana University, 2003
M.S., Southeastern Louisiana University, 2005
Ed. S., Louisiana State University, 2013
May 2014
“Exploration is in our nature. We began as wanderers, and we are wanderers still. We have lingered long enough on the shores of the cosmic ocean. We are ready at last to set sail for the stars.”
— Carl Sagan, *Cosmos*

This work is dedicated to my family, for aiding in my exploration and helping me reach the stars.

To my parents and siblings for always encouraging me to do my very best and aiding in the person I have become. Dad, for a strong work ethic and instilling in me to always do what is noble. Mom, for your endless devotion… not only as a mother and friend but a wonderful educator; for you have touched many lives and continue to positively influence those around you. Matt and Leigh, thank you. You have always been there when I needed a helpful hand or ear to listen and I am proud of the educational quest you both are currently pursuing. Just remember, “A good time will be had by all!”

To my spouse, David, for standing beside me… always. You pick me up, yet keep my feet grounded, in touch with reality and focused. I am so thankful to have you and call you mine.

To my children… I am so blessed to be your mommy. I hope you become lifelong learners and enjoy the journey ahead of you because I know you are capable of a grand adventure! And when life gets tough, just remember the saying I’ve said time and time again, “Just keep swimming, swimming, swimming.” --Dory in *Finding Nemo*

I love all of you more than words could ever express and I dedicate this to you.

In Memory of Dr. James H. Wandersee
1946-2014
ACKNOWLEDGEMENTS

This dissertation could not have been completed had it not been for the support, guidance and encouragement of many people. First, I would like to offer sincere gratitude to my committee chair, Dr. Pamela Blanchard, for taking me and so many other doctoral students under her wing. I appreciate her pushing me to write more clearly, think more deeply, and constantly promoting me toward my best efforts. I would like to thank Dr. Krisanna Machtmes for offering her direction, patience, encouragement, time and insightful advice. I would like to thank Dr. Earl Cheek and Dr. Ed Bush for their time devoted to this study. And I would like to thank my mentor, Dr. Jim Wandersee. I started this journey under him, and after his retirement we continued to communicate via email. I am so appreciative of him believing in me through this endeavor even when I did not believe in myself, I will be forever grateful for the conversations, contributions, and inspiration. I am indebted for the many valuable learning experiences, advice and expertise offered by my entire committee as well as the Louisiana State University doctoral faculty.

To my colleagues, I appreciate the thoughts and words of encouragement you have provided. Rosemary Becker and Michaelyn Broussard, thank you for letting me join this expedition. You have helped me grow both professionally and personally.

My graduate student friends deserve my thanks for the conversations and companionship that made this journey bearable and enjoyable. I have become good friends with many of you and I truly appreciate the wisdom and feedback you provided. Bianca Deliberto, Jenna LaChenaye, and Serena Fisher I am especially appreciative of each of you!

Finally, I would be remiss to not acknowledge my family, friends, and loved ones whose words and support will be cherished. For enduring me throughout this process, you will always have my gratitude. Thank you.
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ABSTRACT

Understanding human long bone anatomy is an important concept to master for post-secondary students that major in medical fields since skeletal structures assist in locating a pulse, conducting clinical procedures, and identifying injection sites. Skeletal anatomy is also used to name structures associated with other organ systems like veins, arteries, and nerves. This explanatory mixed methods study explores post-secondary students’ knowledge retention and perception of various constructivist activities that utilize historical approaches based on the works of Vesalius, the Father of Modern Anatomy to teach long bone anatomy. Three treatment groups and one controlled comparison group (n= 92) were provided an online demographic survey, pre and posttests the day of the experimental lesson, a questionnaire regarding enjoyment and utilization of the activity, and two additional posttests given four and twelve weeks after the activity to gather knowledge retention data. Thirteen participants who fell within the quantitative tails of the first posttest assessment were interviewed regarding the activity. Coded interviews, field notes, observations and quantitative data were used for meta-inference. The data suggests that the osteology activities that incorporate historical and constructivist aspects increased students’ enjoyment, knowledge retention, and self-directed learning outside the classroom. The group that utilized multiple learning modalities through drawing and creating mental maps with blindfolds showed a positive significant difference (p < 0.05) among other treatments with respect to knowledge retention twelve weeks after the activity. Meta-inference of data suggests the utilization of constructivist activities that cater to several learning modalities will facilitate partner interaction, increase laboratory enjoyment, provide students with additional study techniques, and enhance knowledge retention the day of the activity and twelve weeks after the activity. This study fills a gap in the literature in which the incorporation of constructivist
activities designed using historicality of cognition, active and meaningful learning have not been explored with regards to knowledge retention within an osteology laboratory setting.

Additionally, this study could be used across disciplines and will be beneficial to educators, scientists, medical students and undergraduate students.
CHAPTER 1
INTRODUCTION

Statement of Problem

Human Anatomy and Physiology (A&P) is an undergraduate course. At the institute where I teach, the course consists of two lectures and two laboratories which are typically taken in sequence over two semesters. These are required course for students who major in nursing, kinesiology, and communication and science disorders (CSD) and are a prerequisite for courses within those majors. Undergraduates have stated that the A&P classes are “weed-out” courses for their discipline. The university views these classes as traditionally difficult courses for students; hence, free tutoring is offered every semester through the Office of Student Services at said institution.

From an instructor’s standpoint, these courses appear challenging for multiple reasons. First, there is a large amount of detailed information which the student is responsible for understanding. Secondly, the laboratories should help reinforce lecture material; however, the lack of active and constructive learning within the lecture hall and laboratory prevent students from gaining long-term knowledge. Additionally, students arrive with misconceptions about the human body and these mental models are not corrected; hence, building additional knowledge and more detailed information is difficult. Wandersee (1992) recommends the use of historicality. Knowing the history of a discipline and how that knowledge was gained is the definition of historicality. Making students aware of this history and how this knowledge was expanded by past scholars can help students understand their own misconceptions (Wandersee, 1985) and enhance their mental models, resulting in meaningful learning (Michael & Modell, 2003). The osteology lessons created for this study were designed based on the teachings of the Father of Modern Anatomy, Andreas Vesalius. Vesalius lived during the 1500s and
revolutionized the way the human body was taught by conducting hands-on examinations of cadavers and providing anatomically accurate drawings to his students. It has been said that he knew bone anatomy so well that he would describe bones while blindfolded (Ball, 1910).

Undergraduate Human Anatomy and Physiology laboratories are taught a variety of ways. In some colleges, the lecture focuses on anatomy or physiology and laboratory time is spent exploring the opposite field. Other institutions may teach a mixture A&P within the laboratory and lecture. The type of instruction also varies; which systems are covered, in what depth they are discussed and the methods used to teach the human body.

This study focused on the teaching of osteology; specifically, students’ understanding and knowledge retention of long bone anatomy when lessons derived from historical methods and the incorporation of constructivism were presented. With respect to long bones, this study examined the leg bones femur, tibia, and fibula; as well as, the arm bones humerus, radius, and ulna. Long bones were used in this study since they resemble each other and contain similar structures that students confuse. The focus on osteology, the study of bones, was chosen since the majority of the midterm exam in the first A&P laboratory consists of questions that test bone knowledge. Nearly 70 percent of the stations (18 of the 26 practicum locations) for the midterm exam contain one or more bones. The student withdraw date occurs after the midterm exam and the attrition or drop rate for lab is around 30 percent across fifteen to seventeen sections. Conversations with students regarding dropping the class often correlate withdrawing to their lack of understanding of the bones. Additionally, students in the second A&P lecture and laboratory display a lack of bone anatomy knowledge. Many other structures’ names correlate to the bone they are near; yet, students will question why a nerve, artery or vein has a certain name. As a prerequisite course these students should display knowledge retention throughout the first lab and in later courses.
Anatomy and physiology labs could provide an environment for active learning, lessons via constructivism, and incorporation of historical approaches and misconceptions; however, some instructors use direct teaching or expect students to learn via rote memory. Utilizing other teaching strategies would allow for more meaningful learning and could enhance long-term knowledge. This study was conducted to determine the effectiveness of incorporating constructive learning activities in Human Anatomy and Physiology laboratories to teach long bone anatomy and how undergraduate students benefit from these activities. Based on the data gathered, utilization of historical and constructivist approaches will benefit student retention of osteology knowledge and study habits.

**Purpose**

The purpose of this sequential explanatory mixed methods study was to examine the effectiveness of incorporating constructive learning activities of long bone anatomy in undergraduate Human Anatomy and Physiology (A&P) laboratories and explain how undergraduate students may benefit from these activities. Specifically, the question posed was:

How do historically based constructivist activities within a Human Anatomy and Physiology laboratory affect the retention of long bone anatomy knowledge?

A review of the literature showed limited studies examining long bone anatomy in face-to-face, hands-on, constructive laboratories. Many studies were located which explore the use of online or virtual laboratories verses hands-on (Hilbelink, 2009; Johnston & McAllister, 2008; O’Byrne, Patry, & Carnegie, 2008; Perez-Marcos, Sanchez-Vives, & Slater, 2012). The benefits and lack of natural specimens and cadavers was also seen in the literature (Bergman, Van Der Vleuten, & Scherbier, 2011; Bowsher, 1976; Collett & McLachlan, 2005; Dyer & Thorndike, 2000; Johnston, 2009; Nnodim, 1990; Pandey & Zimitat, 2007; Winkelmann, 2007).
The rationale for this study was that teaching lessons may benefit students by enhancing their knowledge retention of long bone anatomy. This study also fills a gap in the literature in which the combination of these sources has not previously been used to educate undergraduate students in the field of osteology.

**Research Method**

A mixed methods research approach was used in this explanatory study, which utilizes both qualitative and quantitative research methods in sequential order (Creswell & Clark, 2011; Tashakkori & Teddlie, 2003; Teddlie & Tashakkori, 2009). Understanding how students benefit from a variety of constructivist osteology activities is a complex question which will be best answered through a mixing of qualitative and quantitative methods. This type of methodology is a pragmatic approach (Creswell, 2003), as these methods complement one another when merged. A mixed methods approach makes up for the weaknesses of one method by incorporating the strengths of the two approaches (Creswell & Clark, 2011) and the combination allows for a more thorough analysis (Green, Caracelli, & Graham, 1989; Tashakkori & Teddlie, 1998). Menand (2002) explained in the *Metaphysical Club* that the term pragmatism was coined to explain what was practical and “what works.” Through this inquiry, one will identify truth as “what works.”

Creswell (2002, 2003) identifies the explanatory mixed methods approach as one of the most popular methods used in educational research. The design is divided into two phases. The first phase consists of collecting quantitative data through an online survey, pretests, and a series of posttests. The second phase is a qualitative phase in which outliers will be interviewed regarding the benefits and disadvantages of the activity lesson for which they participated. The results of the two phases will be integrated within the discussion section of the dissertation.
A pilot study was conducted in January and February 2013 across three laboratory sections. Two treatments were used and one control group; each section contained a sample of 20-24 students. This trial was used to test the online survey, pretest, posttest and classroom activities or treatments. Data gathered from qualitative posttest questions showed a split among participants and suggested a learning style assessment of the students in the Full Research Study may help to explain the findings.

There are three treatments and a control group in the Full Research Study. Each treatment consist of a different osteology activity including creating mental maps of the long bones through touch, utilizing kinesthetic and visual learning by drawing shapes associated with bones, and the final treatment is a combination of the two previous. The control group was given a typical lecture, which is also identified as a direct instruction, where the anatomical structures of the bones are identified and pointed out on each long bone but no constructivist activity was incorporated into the laboratory.

**Limitations**

This study, as with all research, does have limitations. First, the study was limited to one institution and all sections used were ones in which the researcher was listed as instructor of record. This may be viewed as problematic if one seeks to replicate this content elsewhere. However, there was also consistency in having the same individual instruct each treatment and this would reduce error. There was the potential for non-response error among the survey portion of the qualitative phase. The likelihood of this error was reduced since this segment was conducted during the laboratory; however, the researcher did note that this error could occur. There could be a lack of homogeneity of group variances and laboratory sections may not correlate to a random sample of the real population; therefore there is limited generalizability and
generalizing must occur among similar groups. Additionally, one must remember that qualitative data may be interpreted differently from one reader to the next. Finally, I refer the comparison group throughout this paper as the “control” or “control group” and it is not a true control group since direct instruction was provided. As an educator, I could not ethically justify having one laboratory section that was ignored; hence, the control was provided instruction that was not derived through the works of Vesalius to encourage constructive learning.

Summary

This study has been designed to narrow in on a specific problem among a certain population in hopes to benefit said population and two or more other audiences. As an educator, the primary goal of the researcher was to conduct a thorough investigation that results in future students gaining osteology knowledge easier and retain that knowledge. The researcher also hopes to merge anatomical information and educational theories so multiple audiences, including educators and anatomists can incorporate this into their classrooms. A mixed methodology was chosen because this method provides an ideal, pragmatic approach to examine the amount of knowledge retention and why did or did not this method work.

Definitions of Terms

Active Learning- “Broadly inclusive term, used to describe several models of instruction that hold learners responsible for their own learning” (Michel, Cater, & Varela, 2009, p398).

Constructivism- Theory of learning and understanding in which there is an external and knowable work and individuals actively construct knowledge of the world.

Gross Anatomy- Examining structures with the naked eye; topographical anatomy.

Histology- Study of tissues with the use of microscopy.
**Historicality** - The history of a discipline which includes how scholars gained knowledge about their field.

**Meaningful Learning** - Learning with understanding; learning by organize information into a mental model or conceptual framework which results in greater knowledge retention.

**Misconception** - Preconceptions, alternative conceptions, and naïve conceptions; a conception, view, or mental model which contains faulty knowledge.

**Osteology** - The scientific study of bones.
CHAPTER 2
REVIEW OF LITERATURE

The purpose of this study was to explore how Anatomy and Physiology laboratory activities based on historical works and constructivist theory improve students’ understanding and retention of long bone anatomy knowledge. James Vandersee introduced the term *historicality* in 1992. He stated that historicality of cognition is critical among scholars meaning that they must not only understand what others have provided to/within their discipline but also how those individuals gained that knowledge. The focus of this study was to examine how Andreas Vesalius learned and taught human anatomy in the 1500s. Then apply selected methods within a laboratory setting for students of the 21st century and through an explanatory mixed method study determine how this teaching style influenced their knowledge. This chapter will focus on the theoretical framework that supports this study.

**Inside the A&P Laboratory**

Human Anatomy and Physiology labs and lectures are taught a variety of ways across the country. Some institutions divide the course into two lectures in which one lecture focuses on certain systems and the other lecture addresses the rest of the body; other colleges divide the lecture into anatomy the first semester and physiology the second semester, lecture may cover either anatomy or physiology and the laboratory discusses the opposite, and sometimes the course is taught over one semester. With the emergence of virtual classes, laboratories are now offered online which adds to this complex dynamic. Additionally, the course or courses are offered by different departments from one local to another. Departments offering this type of class include Biology, Human Biology/Anatomy, Kinesiology, Nursing, etc. This section will discuss the laboratory and lecture setup at the institution in which I teach and compare it to other universities.
Current Course Topics and Offerings

The A&P lab at the university where I teach is offered as a prerequisite course for nursing, communication and science disorders, and kinesiology students. There are two labs that are supposed to be taken with the corresponding lecture over two semesters. In the A&P I lecture, students cover basic biology concepts (osmosis, diffusion, cell theory, etc), cytology (study of cells), histology (study of tissues), a brief history of A&P, integumentary system (skin), muscular system, skeletal system, and nervous system. The A&P I lab focuses on the anatomy of integumentary system, muscular system, skeletal system, and nervous system; as well as, the histology of muscles, bone, and hyaline cartilage (fibro-cartilage and elastic cartilage are not seen in lab but defined in the lab manual). The lab has three BioPac activities which focus on physiology of muscle contraction and the nervous system. BioPacs are hardware components that allow electrodes to be placed on the student and data can be gathered, displayed as a graph, and then analyzed. Students examine models and human bones to learn the anatomical structures. The models are constructed 3-D plastic specimens which have numbers placed on each structure. Students have an answer key within their lab manual which identifies each number. For exams, those numbers are replaced with letters. The skeletal system is taught using plastic and natural bones; hence, the only examination of real specimens would be the osteology labs. There are twelve stations or tables in the lab and students work in groups of two; hence the room holds a maximum of 24 students. Each station has a nearly complete skeleton that is taught over the course of several weeks. The nervous system is the only system discussed after the midterm exam in A&P I lab.

The second semester lecture focuses on all other systems of the body: circulatory, respiratory, digestion, urinary, lymphatic, reproductive, endocrine, etc. The A&P II lab covers
physiology of the respiratory system by using a BioPac activity and anatomy of all the other systems listed except lymphatic and endocrine. The anatomy within that lab is displayed only by models. There are six tables in the room that allow seating for four students each, a maximum of 24 students. “Models” are plastic representations of the organ or organ system. Some are life-like, like the heart model, but most are flat boards that represent a cross-section or longitudinal-section of the specimen. The models have numbers labeled throughout and the students are given an answer key within their lab manual. It is not uncommon for students to memorize the answer keys for the midterm and final exams for this lab, since most of the A&P II instructors do not re-label the models for tests.

**A&P at Other Universities**

A&P labs vary across the country. Many medical, pharmacy, dental, and professional schools recommend four to eight hours of anatomy and physiology courses; however, at my institution, the human A&P does not count towards the curriculum for pre-professional biology majors. Most students who are Pre-Professional will take Comparative Zoology at our institution because it counts towards their degree requirement. The Comparative Zoology course looks at many organisms but none are compared to humans. Within that course, students will dissect an amphioxus, shark, bird, and a cat. It may be a beneficial course for Pre-Veterinarian or animal science students but Human Anatomy and Physiology would be more beneficial for students interested in pursuing a career in human health disciplines.

The laboratories vary greatly from university to university. The institution where I teach is one of the largest in the state. Comparing it to the closest and larger university shows many differences. The larger university will be identified as OSU (Other State University) and the institute I currently work will be called MCU (My Current University). OSU offers this lab
within the Department of Kinesiology as opposed to the Department of Biological Sciences at MCU. It is listed as a junior level course at OSU and a sophomore level listing at MCU. According to universitytools.com, students of OSU state that almost everything is online and the course is basically an independent study. The university catalog states the lab uses interactive software and students will learn gross anatomy. There is no indication that histology or microscopy are taught in the OSU course.

Looking at universities not within the state, I explored University of California at Berkeley Extension and the University of Nebraska at Lincoln. University of California at Berkeley Extension offers two labs for A&P. The first lab does not have dissection and the second lab has dissections and basic microscopy. These are courses which are offered via distance. The University of Nebraska at Lincoln offers the lab as a twelve week course that meets for two hours and 50 minutes a week. MCU offers the class over sixteen weeks and meetings are held once a week for one hour and 50 minutes; therefore, MCU meets 4.67 hours less than University of Nebraska at Lincoln. At the University of Nebraska at Lincoln, a teaching assistant instructs the course and human cadavers and models are used. The website did not give details regarding how the cadavers were used within the lab or if students would conduct dissections.

Benefits of Laboratory Activities

Group work and interactions allow for “Peeragogy;” in which, students can learn from one another. This also enhances the likelihood that students will not memorize information but instead apply the knowledge they have gathered and construct a mental model. Experimentation and hands-on activities are higher levels of Bloom’s taxonomy (Figure 2.1). The original or old version of Bloom’s Taxonomy (Figure 2.1) was proposed in 1956 and
revised in 2001, converting the original terms, which were nouns, into verbs and swapping the top tiers. The lower level of knowledge is basic information recall (Remember) and being able to apply that knowledge, analyze and evaluate it are higher levels. The ability to create something from what you know is the highest level.

This also provides the students with an opportunity to move from abstract to concrete and discover something they may not have known (Apps, 1991). Laboratories create an environment for student centered and active learning which is supported by National Science Foundation (NSF), National Science Resources Center (NSRC), National Science Teachers Association (NSTA), and the National Institute of Health (NIH) (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012).

Labs have the ability to increase interest and mastery by allowing physical manipulation and interaction with simulations, data, and instruments (Singer, Hilton, & Schweingruber, 2005). Wandersee (1985) promoted the use of hands-on learning because this method helps to clear up misconceptions. This can be seen within the human A&P lab every semester. When we discuss the ribcage, I often ask my students if men and women have the same number of ribs. Every semester, I am told that men have fewer ribs than women. Students’ assume this to be true.

Figure 2.1. Bloom’s Taxonomy (Overbaugh & Schultz, 2008).
because of the biblical story: God took a rib from Adam and created Eve. I often explain this misconception but it is not until they examine a male and female skeleton and see that they both have twelve pairs of ribs that they realize their idea was flawed. Correcting metal maps and models through constructivism and hands-on learning is extremely beneficial (Wandersee, Mintzes, & Novak, 1994). This allows for meaningful learning which is easier to retain and should be a goal of all science educators (Michael & Modell, 2003). Additionally, Apps (1991) states that adults do not learn different than children and the use of drawing and creating 3-D models allow them to understand a concept.

**Osteology Lab Teaching**

Osteology, the study of bones, is often taught at the undergraduate level within Human Anatomy and Physiology (A&P) courses. Students who enroll in these classes are typically pursuing a degree in medicine/nursing, health education, or kinesiology. Osteology is an important sub-discipline in understanding the anatomy and physiology of other organ systems. It is a vast topic which includes bone composition, function, growth, and regulation of metabolism, as well as, diseases and disorders associated with the skeletal system (Saladin, 2012).

Osteology is often taught within the first few weeks of Anatomy and Physiology classes because it lends itself to understanding of other anatomical structures. Joints perform differently depending on the type of structures present and leverage created. Muscle attachment to the skeleton requires roughened ridges and these structures have anatomical names. Familiarity of bone and skeletal structure names will assist in naming nerves, muscles, veins, and other structures. The lobes of the brain correspond with the bone that covers said lobe: occipital, parietal, temporal, and frontal. Radiologists utilize knowledge derived from gross anatomy, what is seen with the naked eye, to examine X-rays; nurses and doctors feel for the rough ridges which
are known as processes to assist in locating a pulse, conducting clinical procedures, or to identify an injection site (Saladin, 2012). Hence, it is important to learn the skeletal structures before moving on to internal organ systems of the body.

Many A&P courses are divided into lecture and laboratory components. Sometimes lecture will focus primarily on physiological functions while lab sessions are designed for anatomical understanding. The lack of variety with instructional strategies is an issue within the education of osteology. Lectures often rely on direct instruction, which may be the result of larger numbers of students within the lecture hall, how the teacher was taught the material in the past, or lack of time or space. Direct teaching typically incorporates readings, and the instructor’s presentation may incorporate visuals through the use of projection equipment. This type of teaching is also known as expository teaching and is a teacher-centered approach (Cruickshank, Jenkins & Metcalf, 2006). It is also considered a traditional teaching technique, but as Brooks and Brooks (1999) point out, this type of instruction causes students to believe they are uninterested in certain subjects. Brooks and Brooks (1999) state that constructivist paradigm allows for information to be presented in a way that lessens the level of disinterest and the reason students are not interested is because of how the material was transferred to them.

Among laboratories, instruction of the skeletal system occurs via models, text or lab manual, and small groups. Laboratory instructors may also use the direct teaching method and then require students to memorize anatomical structures. There is an alternative to direct teaching that incorporates newly understood pathways of learning; an indirect method in which one teaches to both hemispheres of the brain and encourages student-centered learning would allow for meaningful learning.
Learning in the Brain

Memory formation begins with the detection of sensory information that is sent to the central nervous system. Sensory information is afferent input that ascends to the brain where it is processed. All sensory, except for smell, must first go to the thalamus (Lawson, 1995; Saladin, 2012; Sousa, 2001). The thalamus is located near the top of brain stem and medial in the cerebral cortex. It weeds through the sensory information and passes input to higher order sections. Those areas integrate the information through the utilization of neuronal pools or neuronal networks. Sousa (2001) and Zull (2002) identify touch, hearing, and vision as the three primary senses that provide individuals with the most cognitive information about their environment.

Sensory Pathways

Broadly speaking, the nervous system is divided into the Central Nervous System (CNS) and Peripheral Nervous System (PNS). The CNS is comprised of the brain and spinal cord; PNS is everything that branches from the CNS. The sense of touch is detected by corpuscles in the skin which connect to peripheral nerves that connect to the CNS. Sensory receptors in the dermal layer include: free nerve endings, Pacinian corpuscles, and hair follicle receptors. Free nerve endings are pain receptors that can also detect changes in temperature. Light touch is detected by Meissner’s corpuscle and Merkel’s cells. Pressure is registered by the Pacinian corpuscle. Hair follicles can detect if the hair shaft moves which aids in tactile perception. Basically, when the skin is touched impulses are generated by sensory receptors. Imagine you are wearing shorts and someone touches your leg. The sensory receptors discussed previously will create electrical impulses that are carried to nerves near said receptors. Those peripheral nerves could include the femoral nerve, sciatic nerve, common fibular nerve, superficial fibular
nerve, saphenous nerve, the deep and superficial peroneal nerves, and the tibial nerve, which connect to the sacral plexus and lumbar plexus near the spinal cord. That impulse then travels the nerve axon to the spinal cord; hence, arriving at the CNS.

Hearing and vision are explained as pathways. Understanding the anatomy of the ear will aid in understanding this pathway (Figure 2.2). The auditory pathway begins with the production of sound. That noise is funneled into the ear, through the external auditory meatus or auditory canal and then strikes the tympanic membrane. The tympanic membrane, also known as the ear drum, converts this sound into vibrations; those vibrations travel across three small bones: malleus, incus, and stapes. The vibrations now enter the labyrinth via the oval window and travel to basilar membrane. The vibrations are now converted to electrical nerve impulses within the Organ of Corti. Finally, the electrical impulses will travel by way of the cochlear nerve, a branch of Cranial Nerve VIII, to the brain.

Figure 2.2. Anatomy of the ear (Saladin, 2012, p. 597). Used with permission from Anatomy & physiology: The unity of form and function (6th ed.). Copyright by The McGraw-Hill Companies, Inc. (Appendix A).
Image formation and recognition is due to a visual pathway which begins because of light hitting an object. Visible light is the light humans can see and falls among the visible light spectrum of Red, Orange, Yellow, Green, Blue, Indigo, and Violet. An object appears a certain color because it is reflecting that color of light. An example is the chloroplasts of plants appear green because they absorb all other colors of the light spectrum and reflect green. On the ends of the spectrum is light that humans cannot see but other animals can; such as, Ultra Violet (UV) light and Infra-Red (IR) light. These have wavelengths that exceed what humans can detect.

Birds and insects can detect UV light and this is one feature among bees which allows them to locate abundant amounts of nectar in flowers. Bees have amazed philosophers for centuries, Descartes wrote of their dances in the 1600s (Weismann, 1996). Today we know they have polarized vision and the dance mathematically maps out where nectar is located. The ability to see UV light allows bees to locate flowers with darker centers in which there is more nectar.

IR light is at the opposite end of the spectrum and this type of light is detected by some snakes like the pit vipers (Roelke & Childress, 2007). This type of light is viewed as heat. Goggles and special lenses have been made to detect this type of light. It can be used for recreational hunting and also for scientific research. There are more types of light than what humans see but the visible light spectrum allows for an object to have color. The colors in italics are the ones in the visible light spectrum:

IR--- Red  Orange  Yellow  Green  Blue  Indigo  Violet ---UV

Once light is reflected from an item, it then can be registered by the brain if that images passes through the visual pathway. The visual pathway begins with the image passing through the eye (Figure 2.3) by the following: the image first goes through the cornea of the eye, then
through the anterior chamber which holds aqueous fluid (this is the chamber that causes glaucoma if pressure of the humor becomes too high), now the image will pass through the hole in the eye known as the pupil, it will then go across the lens which can shorten, thicken, and relax or become tighter and thinner depending on depth of the object, after the lens the image goes through the posterior chamber filled with vitreous humor (the pressure of this chamber keeps the retina attached), and finally the image is detected by photoreceptors on the retina.

These photoreceptors are bipolar cells, cones, rods, etc. Rods detect black and white, cones detect color, and the other cells within the retina assist in forming the image. Now the image gets transferred to the optic nerve and eventually to the back of the brain; the occipital lobe. The occipital lobe is the vision center and has primary and associated vision cortexes within it.
primary vision cortex determines what you see and the associated vision cortex identifies the purpose of that image. For example, if you walk up to a door, you don’t pause and wonder what the door handle is for because this area of your brain, the visual association cortex, has already merged that information. You know the door handle opens the door. It seems the brain was designed for humans to be extremely visual; of the twelve cranial nerves, six assist the eyes as seen identified in the table below (Table 1.1). These are the nerves on the base of the brain and along the brain stem.

The brain is divided into four lobes and named for the bone(s) that cover said lobe: frontal, parietal, temporal, and occipital (Figure 2.4). Each has its own major functions; however, they interact with one another and this assists with associated (long-term) memory. Starting anterior or at the forehead is the frontal lobe. It is responsible for personality, reasoning, memory formation, and the posterior aspects contain the somato-motor cortex which is specifically located on the pre-central gyrus. Behind the frontal lobe are the parietal lobes. This area contains the somato-sensory cortex on the post-central gyrus and aids in spatial orientation and navigation. Below the parietal lobes and just above the ears is the temporal lobe that assists with hearing, speech, and language production. The back of the cerebrum contains the occipital lobe which is the vision center of the brain. Below the occipital lobe is the cerebellum, which is the motor center of the brain but also plays a role in cognition (Leonard, 1999). So, although the temporal lobe is associated with hearing and language formation, the occipital with vision, the frontal with personality, motor function, and reasoning, and the parietals with space orientation, sensory, and navigation; these areas have a complex neural network that is woven together. Additionally, some regions of the brain contain areas that typically another part would be responsible for processing. For example, Broca’s area (Figure 2.4) is associated with speech but
<table>
<thead>
<tr>
<th>Cranial Nerve Number</th>
<th>Name</th>
<th>Type</th>
<th>Function</th>
<th>Assists with Eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Olfactory nerve</td>
<td>Sensory</td>
<td>Smell</td>
<td>No</td>
</tr>
<tr>
<td>II</td>
<td>Optic nerve</td>
<td>Sensory</td>
<td>Vision</td>
<td>Yes</td>
</tr>
<tr>
<td>III</td>
<td>Occulomotor nerve</td>
<td>Motor</td>
<td>4 of the 6 extra-ocular eye muscles</td>
<td>Yes</td>
</tr>
<tr>
<td>IV</td>
<td>Trochlear nerve</td>
<td>Motor</td>
<td>Innovates “Pulley-muscle” of eye (allows eye to roll up and back)</td>
<td>Yes</td>
</tr>
<tr>
<td>V</td>
<td>Trigeminal nerve</td>
<td>Motor and Sensory</td>
<td>Movement and sensory. Branches into Ophthalmic, Maxillary, and Mandibular branches</td>
<td>Yes</td>
</tr>
<tr>
<td>VI</td>
<td>Abducens nerve</td>
<td>Motor</td>
<td>Lateral eye movement</td>
<td>Yes</td>
</tr>
<tr>
<td>VII</td>
<td>Facial nerve</td>
<td>Motor and Sensory</td>
<td>Movement and sensory of the face</td>
<td>Yes</td>
</tr>
<tr>
<td>VIII</td>
<td>Vestibulocochlear nerve</td>
<td>Sensory</td>
<td>Equilibrium and hearing</td>
<td>No</td>
</tr>
<tr>
<td>IX</td>
<td>Glossopharyngeal nerve</td>
<td>Motor and Sensory</td>
<td>Taste and tongue/throat movement</td>
<td>No</td>
</tr>
<tr>
<td>X</td>
<td>Vegas nerve</td>
<td>Motor and Sensory</td>
<td>Thoracic sensory and motor function</td>
<td>No</td>
</tr>
<tr>
<td>XI</td>
<td>Spinal Accessory nerve</td>
<td>Motor</td>
<td>Neck movement</td>
<td>No</td>
</tr>
<tr>
<td>XII</td>
<td>Hypoglossal nerve</td>
<td>Motor</td>
<td>Tongue movement</td>
<td>No</td>
</tr>
</tbody>
</table>
located in the frontal lobe. The cerebellum aids in motor control; however, the frontal lobe contains the somato-motor cortex.

Sprenger (1999) discusses episodic, procedural, automatic, semantic, and emotional as the five memory routes. Episodic has to do with locations and is also known as spatial or contextual memory. She notes students score lower on exams when assessed in a room different from the room they were taught due to the creation of episodic memory or “invisible information” (Sprenger, 1999, p. 52). Procedural memory forms through motor function; therefore, repetitive movement and is also known as “muscle memory.” Automatic memory is a type of “conditioned response memory” that is aided by the cerebellum. Examples include singing songs and reading. Semantic memory deals with words and is learned through textbooks and lectures. This type of memory must be repeatedly processed or associated/compared to be stored as long-term memory. Emotional memory is a powerful type of memory that is stored as how one felt about or during an experience.

The idea behind understand that neuronal networks form in the brain; creating a variety of highways by which information can be retrieved, is that by using different teaching methods a teacher can assist the student in creating multiple routes to that information storage site. Students have networks when they arrive and teachers “cannot create new ones out of thin air or by putting them on a blackboard. And we cannot excise old ones. The only recourse we have is to begin with what the learner brings” (Zull, 2002, p 105). Although students may have similar cognitive abilities they could have different cognitive styles (Almeida & Tavares, 1998); hence the constructivist pedagogic methodology is ideal in Anatomy and Physiology courses (Mota, Mata, & Aversi-Ferreira, 2010).
Dunn and Dunn (1993) define learning style as the method by which a student begins to focus on, process, internalize, and remember new and challenging theoretical information. Huston and Cohen (1995) explain that learning style is a strategy or strategies that individuals prefer to use to process new information for effective learning. Learning styles, or the way people receive information, may also be referred to as learning modality. The use of sensory channels to receive and retain information is defined as learning modality (Barbe and Swassing, 1979). Sensation, perception and memory establish what those authors termed modality; hence,
the critical component of this definition is "receives and retains information.” There are three main categories or learning modalities: visual, auditory, and kinesthetic according to the VAK (visual, aural, and kinesthetic) Framework.

The discipline of cognitive psychology has explored the field of human learning styles for decades and many theories exist regarding how individuals learn. For this study, the VAK Framework was utilized when examining the learning style of students due to the simplicity of the framework and the availability of free online assessments that used this system. However, I would like to make the reader to be aware that other systems are available. VAK has been expanded to include an additional type of mixed-sensory learning modality that incorporates reading/writing; hence, the acronym used for this model is VARK and known as the VARK sensory modality model. Another model is derived from Howard Gardner’s Theory of Multiple Intelligences which was discussed in his 1983 book *Frames of Mind*. This model is called Gardner's Multiple Intelligences schema. Gardner’s belief was that individuals are typically only tested on about two levels of intelligent for most assessments including IQ tests (Tanner & Allen, 2004). However, there are eight types of intelligences explained within this schema including Bodily-kinesthetic, Interpersonal, Intrapersonal, Linguistic-verbal, Logical-mathematical, Musical-rhythmic, Naturalistic, and Visual-spatial. These intelligences are defined:

1. Bodily-kinesthetic requires the physical interaction and manipulation of objects
2. Interpersonal is the understanding and ability to work effectively with others
3. Intrapersonal is self-awareness
4. Linguistic-verbal utilizes words, language, writing, and reading
5. Logical-mathematical is quantifying information through mathematics or calculations
6. Musical-rhythmic knowledge of pitch, tone, and rhythm
7. Naturalistic is the recognition of patterns and ability to identify and classify
8. Visual-spatial is the ability to utilize imagery and 3-D or graphic information

The VARK sensory modality model and Gardner’s Multiple Intelligences schema discussed above are two of the many theoretical frameworks available for human learning styles. As stated previously, this study will use the VAK framework. VAK explains that individuals who remember best from what they see are often identified as visual learners. This type of learner will benefit from pictures, flow charts, time lines, diagrams, and demonstrations (Fedler and Silverman, 1988). Auditory learners remember information they hear or say better than information that is visually presented. Individuals whose preference is the auditory modality tend to benefit for dialog and verbal explanations. Kinesthetic learners remember information best while moving, doing, tasting, touching, and/or smelling (Fedler and Silverman, 1988.)

Many authors have stated that one’s learning style is determined by both biological and developmental influences; therefore, one type of instruction presented may benefit some students but be ineffective for others (Bracht, 1970; Dunn & Dunn, 1972, 1992, 1993; Dunn, Dunn, & Perrin, 1994; Restak, 1979; Thies, 1979, 1999/2000). Barbe and Milone (1981) state a modality shift typically occurs before adulthood and individuals are more likely to become visual learners. Barbe and Swassing (1979) believe one’s learning modality is key to understanding how an individual gains knowledge. It is beneficial for one to understand their primary learning style or modality to help enhance their ability to learn. Federico (2000) states, “Understanding styles can improve the planning, producing, and implementing of educational experiences, so they are more appropriately compatible with students’ desires, in order to enhance their learning, retention and retrieval” (p. 367).
Most students utilize all modalities while learning but retain information best when their primary or strongest mode is utilized. In 1988, Fedler and Silverman stated that college teaching is mismatched with learning modality of most college-age people. They explain that adults tend to be visual learners but the college classroom utilizes predominantly auditory information. This is still the case today since information typically is presented verbally through lecture format or via handouts and PowerPoints which contain written texts. The laboratory provides a setting where lessons can be created that utilize all three modalities.

**Importance of Meaningful and Active Learning**

“Active learning is a broadly inclusive term, used to describe several models of instruction that hold learners responsible for their own learning” (Michel, Cater, & Varela, 2009, p398). Bonwell and Eison (1991) identify several techniques that can be used instead of a traditional lecture. These techniques include: classroom discussions, fieldtrips, experiments, use of surveys or quizzes, and other methods which allow the student to be actively involved in the course. The traditional lecture would result in a passive learning environment. The active learning environment helps create a student that is more engaged, motivated and using higher order thinking skills (Bonwell & Eison, 1991).

Meaningful learning is facilitated through the articulation of explanations to peers, the instructor, or one’s self (Michael, 2006). Through this process, a student develops higher levels of learning by creating connections or links between new information and previous knowledge. Each learner’s knowledge may be different because of a previous situation, lesson, or activity that changed the knowledge base. Students do not enter a class room as a blank slate (*tabula rasa*) but instead have prior knowledge, misconceptions, and past experiences that influence how they interpret what is presented. Michael and Modell (2003) explain how the richness of the
learning context allows a learner more opportunity to create bonds and associate what he is currently learning with information he has already acquired and skills he currently possess.

In 2003 I entered a Master’s program in Biological Sciences and began teaching undergraduate labs as a Graduate Teaching Assistant. After receiving my Master’s degree, I became an instructor of freshman biology and of human anatomy and physiology. I have realized over the years that most students memorize information or learn via rote-memory. They often make flashcard or study guides, but this is not what I would consider to be “real learning.” It is not meaningful. The student often cannot “use” or apply what they have memorized. Rote learning is common because of how assessments test knowledge (Mintzes, Wandersee, and Novak, 2001) and how teachers present information. Declarative knowledge is often memorized; however, as teachers, we can help students organize this information into a mental model or conceptual framework to create meaningful learning (Michael & Modell, 2003). Rote-learned information is difficult to recapture; however, active involvement and learning something in a meaningful way can be recalled much quicker (Dodd, 1992). Dodd (1992) gives the example of riding a bike verses reciting state capitols. Repetition may help store information in the short-term; however, once you have actively participated in a lesson (e.g., riding a bike), you will always be able to do it. Meaningful learning leads to longer retention of recently learned information (Michael & Modell, 2003).

Although educational laboratories lend themselves to be an ideal environment for active learning, teachers do not always utilize this advantage. As stated previously, some instructors may provide a presentation and then allow students to observe models and memorize structures. Instead, students should build knowledge based on what they previously learned; hence, they should utilize constructivism.
Constructivists believe that new knowledge is constructed from prior intellect (Glasersfeld, 1989) and the instructor and the student both expend mental energies (Lord, 1998). Lord (1998) states that in a traditional classroom, energy is usually expended by the instructor for the duration of the class period and the students’ cognitive energy typically does not last but for 10 to 12 minutes. In the constructivist classroom, cognitive energy from the students’ remains high for most of the class, as well as the instructor’s energy and this creates an environment which promotes critical thinking, longer retention of knowledge and more engaged students. Good, Wandersee, and St. Julien (1993) identify 15 types of constructivism within the literature. Although the adjective, contextual, dialectical, empirical, humanistic, information-processing, methodological, moderate, Piagetian, post-epistemological, pragmatic, radical, rational, realist, social, and socio-historical are placed in front of constructivism to clarify its meaning (p. 74), all forms deal with a student or individual constructing knowledge.

Humans often build better understanding by combining previous knowledge with a new experience. For example, students may come to lab knowing the names of some bones or that ligaments and tendons attach to bones; however, they may lack the knowledge of how these tissues attach or that specific structures on bones have names as well. Exploring the anatomical structures of bones and combining these new experiences with previous knowledge would allow them to gain understanding of a complex situation, an example of constructivism. This makes the student “responsible for the learning that occurs” (Michael & Modell, 2003, p. 5). Knowledge cannot be transmitted from one person to another; instead, an individual will build his knowledge by creating mental models that evolve and are refined as new experiences occur (Michael & Modell, 2003).
As educators, one of our primary goals should be to help students correct their alternative conceptions by refining existing mental models. Wandersee et al. (1994) have identified terms used in the literature for faulty knowledge as misconceptions, preconceptions, alternative conceptions, and naïve conceptions. Assisting students in correcting the models which contain this faulty knowledge will allow them to enhance their understanding of the anatomy and physiology discipline. One must know what faulty knowledge exists before helping a learner to evolve her mental model, and a pretest could assist in gathering this information. Michael and Modell (2003) point out that providing the student with the right answer does not correct the mental model, but instead forces the learner to create two mental models to utilize depending on environment (school, home, etc.). Michael and Modell (2003) recommend the use of active learning and using multiple modalities (auditory, touch, vision) to provide students with the opportunity to identify their own misconceptions while preparing them to learn a correct mental model. Also, if the instructor knows the students’ past knowledge (via pretest) then new information can be delivered in a context that is easier for the students to link to previous knowledge. (Michael & Modell, 2003).

**Telling the History of Science**

Scientific knowledge has possibly accumulated since the times of *Homo erectus* creating controlled fires. Through observation, knowledge was passed from one individual to the next and later via oral tradition and writing. The first medical text could be Edwin Smith Papyrus from Ancient Egypt, which dates to the seventeenth century B. C. (Wilkins, 1992). Knowledge continued to grow during the times of Mesopotamian, Ancient Greece, the Middle Ages, and so forth.
History of Science as an academic field began in 1837 with Whewell’s publication of *History of the Inductive Sciences*. It turned into a more formal discipline with *Iris* Journal being founded in 1912, in 1927 Sarton’s publication of *Introduction to the History of Science*, and in 1945 history of science became a sub-discipline of history at Harvard under Cohen (Dauben, Gleason, Smith, 2009).

There are several reasons history can be beneficial to a course or science program. Matthews (1991) outlines seven reasons cited in the literature:

1. “History promotes the better comprehension of scientific concepts and methods.
2. “Historical approaches connect the development of individual thinking with the development of scientific ideas.
3. “History of science is intrinsically worthwhile. Important episodes in the history of science and culture—the Scientific Revolution, Darwinism, the discovery of penicillin and so on—should be familiar to all students.
4. “History is necessary to understand the nature of science.
5. “History counteracts the scientism and dogmatism that are commonly found in science texts and classes.
6. “History, by examining the life and times of individual scientists, humanizes the subject matter of science, making it less abstract and more engaging for students.
7. “History allows connections to be made within topics and disciplines of science, as well as with other academic disciplines; history displays the integrative and interdependent nature of human achievements.” (p. 50)
Misconceptions and Historicality

The educational effectiveness of a story format has also been documented (Wandersee, 1992). Matthews (1991) wrote about Ernst Mach and stated that Mach saw that the “recognition of the historicity of cognition promoted independence of mind, which for him was a cardinal virtue” (p. 13). The semantics of “historicity” did not seem to fit a constructivist view; hence, in a 1992 article by Wandersee, he recommends the term historicality be used instead of historicity. He states that historicality of cognition is vital in understanding how scholars within a discipline know their field but also how individuals gain that knowledge. The history of a discipline traces the growth of knowledge and gives a context for present knowledge. By teaching history of science, students gain knowledge about science. Without the incorporation of historical misconceptions, students will not be able to understand how today’s collective knowledge base of science was formed. Duschl (1990) warns that without this understanding of collective knowledge, students may assume that all claims within science have equal weight, that these claims do not interact with one another, and that scientific theories are stagnant and will not change.

Historical materials can also be used to create lessons or entice students. Teachers often rely on a single textbook to create a lesson or presentation. The downfall to this approach is that students will receive limited information or only one view of a complex situation (Brooks & Brooks, 1999). According to Conant (1951), incorporating history can increase laypersons’ understanding of science. James Bryant Conant was a chemist and in 1933 became president of Harvard University (Bartlett, 1983; Saltzman, 2003). He initiated the Harvard Case Studies, an historical approach to teaching science which was widely adopted (Matthews, 1992). Matthews
(1992) identifies seven reasons why contextualist tradition supports the teaching of the history of science within science classrooms. The assertions include:

1. Motivates and engages the student
2. Humanizes the topic
3. Shows development, and evolution enhancement allows for students to understand and comprehend concepts
4. Demonstrates that certain periods (ie: Scientific Revolution) within scientific history are vital and have fundamental worth
5. Shows that scientific knowledge evolves and current knowledge may change
6. “Combats scientistic ideology” (p 18)
7. Creates understanding which is richer today than in the past, and the breakdown of this history provides an acknowledged methodology

Wandersee (1985) contended that exposing students to historical misconceptions and then explaining the modern knowledge of said topic may allow them to discard their own misunderstandings and gain scientific knowledge. His recommendation was that teachers compare and contrast scientific explanations of the present with the misconceptions of past scientists. Wandersee concluded that this approach allows students to discard a flawed view and replace that model with a modern one. Matthews (2008) correlated current students’ naïve understanding of anatomical realities to those of people living in Ancient Greece, during the Renaissance, and in the nineteenth century. Therefore, if our students’ misconceptions are similar to those of historic times, it would be fruitful to explain why these naïve conceptions arose and how they have been refined over the years.
Within osteology, a common student misconception regards the number of female and male ribs. While presenting information about the axial skeleton, I will ask my class, “How many pairs of ribs do you have? How many pairs do women have? What about men?” Every semester a few students will answer that one sex has less than the other. They sometimes are confused if men “should” have less than women or if women have less than men; however, the misconception becomes apparent and can be addressed. My next line of questioning is “Why would men have fewer ribs than women?” Sometimes the students are not sure where their alternative conception arose and, at other times, I quickly get the reply that God took one of Adam’s ribs and made Eve; hence, men have one less rib. Males and females both possess 12 pairs of ribs. Even Galen, whose texts were taught from 200 AD until Vesalius corrected the knowledge in the 1500s, believed men had one less rib than women. This discussion allows students to understand their own misconceptions and why they hold that view. They also understand that knowledge evolves. Scientists of the past eras were also philosophers (Matthews, 2008) who laid the ground work for the knowledge we have today but did not have the access or tools necessary to thoroughly investigate their disciplines.

Michael and Modell (2003, p. 20) stated: “Learning with understanding (meaningful learning) is universally acknowledged to be one of the major, but not exclusive, goals of science education.” To impact student knowledge, a variety of teaching techniques should be utilized within the lesson. Exposing students to historical misconceptions allows them to refine or discard their own alternative conceptions. Research has shown that science education is often best taught by constructivism which allows students to revise their current mental models. Noll (2012) identifies readiness as the reason constructivism has not been widely implemented into schools. He identifies the three failures of readiness as teacher readiness, curricular readiness,
and societal readiness. As Tobin, Tippins, and Gallard (1994) point out, curriculum that has a constructivist perspective must be influenced by others such as parents, teachers, and school administrators. Those influences are also resources that can help address the readiness issues that Noll raised. Ultimately, as educators, we should cater each lesson to best serve our students as well as having an historical understanding of our discipline with a variety of teaching techniques to enhance their learning experiences.

**Milestones in Human Anatomy**

The study of Human Anatomy and Physiology (A&P) began as early as 2000 B.C.E. with perfected mummification practices in Egypt. This could be the beginning of A&P education since individuals had to train others regarding techniques for burial. The purpose or physiology of organs and organ systems may have been speculated during that time, but the main focus was removing organs for preparation for the afterlife. Knowledge of the body continued to expand with the assistance of several Greek scholars and, during the 2nd century, from the comparative anatomical works of Galen. There was limited growth during the Dark Ages; however, the Renaissance brought about a rebirth of this discipline. Since that time, human anatomy and physiology knowledge has exploded. This section will explore ten important events with respect to the history of Human Anatomy and Physiology and the influence those events have had on this discipline. The topics covered in this section are displayed in Table 2.1. Knowledge of this timeline will assist the reader in understanding why the researcher chose Vesalius and osteology as a specific focus for this study.

Mesopotamia and Egypt used herbal medications, physical therapy, and salts to help heal the body (Saladin, 2012). Due to mummification of the dead, Egyptians gathered knowledge
Table 2.1. Timeline of Ten Major Milestones within Human Anatomy

<table>
<thead>
<tr>
<th>Year</th>
<th>Individual or Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>1600 B.C.E.</td>
<td>Egyptian knowledge of the body</td>
</tr>
<tr>
<td>300 B.C.E.</td>
<td>Hippocrates</td>
</tr>
<tr>
<td>Circa 150</td>
<td>Galen and Previous Greek Anatomists</td>
</tr>
<tr>
<td>Late 1400-early 1500</td>
<td>Da Vinci</td>
</tr>
<tr>
<td>1514-1564</td>
<td>Vesalius</td>
</tr>
<tr>
<td>1500s-1832</td>
<td>Resurrectionists</td>
</tr>
<tr>
<td>1600-1657</td>
<td>William Harvey</td>
</tr>
<tr>
<td>1650-1720 &amp; continues</td>
<td>Microscopy, Histology, Hooke and Leeuwenhoek</td>
</tr>
<tr>
<td>1895</td>
<td>William Roentgen</td>
</tr>
<tr>
<td>1860s-present</td>
<td>Neurotransmitters</td>
</tr>
</tbody>
</table>

about the internal anatomy of the body. The general method for mummification consisted of removing all internal organs with the exception of the heart. The brain was extracted by forcing a rod into the cranial cavity via the nose and removing smaller sections of the organ through the nostrils. The body was then covered and filled with a mixture of salts called natron which help prevent bacterial growth and assisted in removing moisture from cavities and the skin surface. About a month and half later, the natron was removed, the cadaver was filled with cloth and resin and the body was wrapped in cloth (Embar-Seddon & Pass, 2009). Not only did the Egyptians initiate detailed explorations of the human body, but their preservation practices still intrigue scientists today, such as in the enhanced techniques that have been created to preserve the human body in such a way that it still appears life-like. One example is “Plastination” which
was created in 1977 by Gunther von Hagens which uses silicon to preserve tissues (von Hagens, 2002). Many of his specimens have been displayed on the Body Works tours. Preservation of specimens is important within science and provides educational benefits.

The “Father of Medicine” is the second influential aspect of this timeline. Hippocrates (c. 460- c. 375 B.C.E.) always comes to mind when one thinks of the medical field (Saladin, 2012). You probably recall that many medical doctorates must recite the Hippocratic Oath. This is an oath credited to this Greek physician because of the code of ethics he encouraged other physicians to follow. Hippocrates urged care givers to look for natural causes of illness instead of superstitious or mystical sources (Saladin, 2012). The idea of illness occurring because of a natural phenomenon verses that of a supernatural form split the worldview of that time. The epistemology was Metaphysical since Physical did not come about until Darwin’s Origin of Species in 1859. We now see this as a major branching from Gnosis (wisdom via religion/mysticism) to Episteme (knowledge via rationalism/empiricism). Of course, many other individuals were involved including Plato, and rationalism is correlated to Descartes, whereas empiricism is linked to Bacon (Davis, 2004).

Another major influence to the discipline of A&P was the Greek Galen (Aelius Galen also known as Claudius Galenus). During his time (c. 130- c. 200) human dissections and autopsies were not allowed. A ban had been placed on these activities because of previous issues, such as the public vivisections of prisoners (Saladin, 2012). Keep in mind that this is the time of the Gladiators, and public entertainment occurred at the town centers and arenas. Public dissections were another way of entertaining the masses. Vivisections are live dissections; the word is derived from Latin vivus, meaning "alive" and sectio, meaning "cutting" (Paixão & Schramm, 1999). Anatomists like Herophilus and Erasistratus (300 B.C.E.) performed
vivisections (Magner, 2005). Herophilus “has been hailed as one of the greatest anatomists that ever lived, rivaled only by Andreas Vesalius who is regarded as the founder of modern human anatomy” (Bay & Bay, 2010, p280). He and Erasistratus are said to have founded the anatomy school in Alexandria. So, while Galen was learning anatomy, he did not have human specimens to assist him in creating his theories. He had examined pigs, oxen, and goats; however, most of his assumptions regarding the human body were based on Barbary ape (monkey) and dog dissections (Vesalius, 1998). Unfortunately, some of his deductions were incorrect and, although he warned that his texts may be flawed, they became the primary source for medical students for the next 1,500 years.

The Renaissance marked a period of rebirth for art and science. Works published by da Vinci show superb anatomical drawings of the human body. He performed several dissections during his life and had notebooks filled with sketches of organs and organ systems. For the first time, we see the body divided into planes and drawn from angles not done before. Cross-sections and longitudinal sections of specimens give views that usually are not noticed by medical students. During that time, medical students did not perform dissections. They would watch an assistant (“barber-surgeon”) conduct the procedure; the professor often sat in an elevated chair directing the “barber-surgeon” while reading Galenic texts. Because of decay, these procedures occurred quickly over four days (Saladin, 2012).

Andreas Vesalius was another important anatomist of the Renaissance and is known as the “Father of Modern Anatomy” (Tarshis, 1969). I would argue that he is the most important milestone within the discipline. Vesalius revolutionized the teaching of anatomy. He created drawings of specimens and provided those to his students, allowed students to assist in dissections that he performed, and corrected Galenic errors within previous works. He was
denounced by his mentor and teacher for correcting traditional beliefs. Professors often taught students while seated above the class. They would read from the works of Galen which reinforced misconceptions (von Hagens, 2002). Vesalius performed these dissections with his students and noted the errors within Galen’s works. He eventually received word that Galen had not performed dissections on humans and, to understand why Galen’s works contained misinformation, Vesalius began to dissect other organisms. The drawings provided to his students and located in his texts may have been the work of his illustrator Kalkar (von Hagens, 2002). Vesalius launched anatomy into a new direction; the later works of William Harvey will send physiology in the same direction.

Now the sixth milestone would be “Resurrectionists.” Typically, medical schools were provided one cadaver a year for dissection. That cadaver was often an executed prisoner. But since the field was changing and professors were allowing students to assist in dissections, additional cadavers were needed… “Resurrectionists” were born. A “Resurrectionist” would locate a corpse and, for a fee, would provide it to an anatomist. This Black Market thrived as professors would pass the fee along to their students, and body snatching or grave robbing became somewhat common. Families would purchase coffins made with iron or heavy tops or have iron bars placed around the grave site to help prevent the theft of their loved ones. In 1832, the United Kingdom passed the Anatomy Act which allowed individuals to donate themselves or family member(s) to medical schools as anatomical specimens. There are several documented body snatchers but among the most famous are John Hunter, founder of The Hunterian Museum, and interestingly, Andreas Vesalius.

As previously mentioned, William Harvey did for physiology what Vesalius had done for anatomy (Saladin, 2012). And just as Vesalius was looked down upon for going against the
works of Galen, Harvey was also thought to be incorrect and was laughed at for his ideas of a closed circulatory system. He was respected by Descartes, which is why in Descartes’ *Discourse and Meditations*, he goes into great detail explaining the workings of the heart and correlating that Harvey’s deduction/logic (Weissman, 1996). Harvey’s idea that the heart pumps blood (not the liver as Galen thought) and that the circulatory system is closed is a major correction that is worth noting. Harvey’s basis for these theories was from his experimentations on snakes. Saladin (2012) states how Harvey was able to study the filling and emptying of the atriums and ventricles by tying off blood vessels superior and inferior to the heart. He then collected data to measure cardiac output and correlated that to humans to create an estimated cardiac output for our species. He determined that the heart pumps more blood within 30 minutes than the amount of blood within the body (even if food and fluids are kept from the species); hence, this must be a closed system in which blood returns to the heart. Galen’s idea that blood was consumed by other parts (peripheral organs) of the body was incorrect. Harvey was not sure how the blood reached all parts of the body but the invention of the microscope would allow Antony van Leeuwenhoek and Marcello Malpighi to the discovery of capillaries (Saladin, 2012).

The eighth most important event would be microscopy. The invention (and later perfection) of the microscope would lead to histology, the study of tissues. Prior to this invention, gross anatomy--only what one could see with the naked eye--was used to observe the body. Robert Hooke identified cells but Anton van Leeuwenhoek noted that cells are living and would continue to discover cells and microscopic organisms into his 80s. Some of the cells he identified include sperm, blood cells, muscle tissues, and bacteria. Not only did histology advance our knowledge of human anatomy and physiology, but cellular biology would give rise to the molecular and genetic fields.
The ninth event would be the X-ray. William Roentgen (Wilhelm Röntgen) created an image of the bones via “x-rays” in 1895. In 1901, he received the first Nobel Prize in Physics for this discovery and donated the money to the University of Würzburg. Although other names were recommended for this discovery, he liked the term “x-ray.” An interesting piece of trivia is that the “x” stands for an unknown, as in mathematics. He was not sure what type of radiation or rays were created and termed them “x-rays.” This discovery yielded the field of radiology.

Finally, the tenth milestone in my opinion is the identification of hormones and neurotransmitters. I lump these together because within the nervous system these chemicals are identified as neurotransmitters; however, within the blood stream we call them hormones. The roles that these substances play in our body continue being discovered. The fields of endocrinology and neurobiology are fascinating. There are so many players involved that have identified different hormones and neurotransmitters, and it all began in the late 1800s. Many hormones were first synthesized from other animals or plants and then identified within humans. Some have even been renamed, for example Vagusstoff is now Acetylcholine. Amazing things happen within the synaptic clefts of our nervous system. We are now realizing that not only does it depend on which neurotransmitter is present but also the structure of the receptor/binding site. This knowledge we gain about these compounds will drastically influence pharmacology, thus influencing many other disciplines.

As one can see, the teaching of Human Anatomy and Physiology has been influenced over thousands of years. Starting with the Egyptians, the knowledge of the body was mainly used in order to assist burial rituals. The Greeks explored the body but illness was thought to be caused by demons or wrath from upsetting the gods. Luckily, Hippocrates encouraged physicians to rationalize the ailments and look for a natural cause. Galen provided writings that
attempted to explain the body. Unfortunately, he was unable to perform human dissections and some of his misconceptions were viewed as accurate for the next 1,500 years. The first anatomically accurate drawings of the body at different angles were provided by Leonardo da Vinci. Vesalius reformed the field of anatomy and influenced how it was taught within France, Italy, and Spain. He focused on a hands-on approach and interacted with students. He was a “Resurrectionist” and this method of locating cadavers continued for several hundred years and changed the way anatomical specimens are collected today. Additional fields of study emerged because of the explosion of knowledge after Vesalius. Sub-disciplines arose including microscopy, cellular biology, physiology, radiology, endocrinology, neurobiology, etc. The influence of Andreas Vesalius has played a vital role in the field of human anatomy. Exploration in how he learned and taught and utilizing those techniques in today’s classrooms is one foundational stepping stone for this study.

History of Andreas Vesalius, Father of Modern Anatomy

On the 31st of December in the year 1514, Andreas Vesalius was born in Brussels, Belgium, which was part of the Habsburg Netherlands during that period (Edmundson, 1922). He may have been destined for greatness due to his genealogy—his great-great-grandfather, Peter, was a physician, and his great-grandfather, John, was the chosen physician of Brussels (Saunders & O’Malley, 1973). His grandfather, Everard van Wesel, was the Royal Physician of Emperor Maximilian (Saunders & O’Malley, 1973).

In 1528, Vesalius (also known as Vesal) would attend the University of Leuven (Belgium) and study arts. This was a common study for those seeking to become professionals. Within a few years he would transfer to the University of Paris where he studied medicine under Jacobus Sylvius who is also known as Jacques Dubois and Johann Guinther of Andernach who is
also known as Johann Winter (Saunders & O’Malley, 1973). Sylvius was an anatomist who became well known because he named muscles which were previously given numbers by various authors and those numbers were not always consistent. Johann Guinther was a physician who translated many of Galen’s texts and was also a writer and professor.

During this time period lecture was used to teach anatomy; however, this was not always the case and students were provided medical writings and told to read the text in order to learn the material (Vesalius, 1998), and the majority of knowledge regarding the human body was from the works of Aelius Galen (also known as Claudius Galenus). Galen was a Roman physician who lived around 200 A.D. Sylvius was a staunch Galenist and both he and Fernel encouraged Galenic supporters. Dissections were not performed at the school (Saunders and O’Malley, 1973) but, as Vesalius sought to understand the body, he would examine skeletal remains at Cemetery of the Innocents (Vesalius, 1998) and understood skeletal anatomy so well that he could identify and describe bones when blindfolded (Ball, 1910). This cemetery had dealt with overcrowding for many years. Mass burials to accommodate plague victims of the past and the working class residents of that time were common and could hold 1,500 individuals. This cemetery was removed during the 1700s because it exceeded capacity. At that point, the remains were moved and placed throughout the stone quarries under Paris. Today those stone quarries hold the skeletal remains of roughly six million people (Shea, 2011) in what is commonly called the Catacombs of Paris.

Vesalius returned to Leuven in 1537, probably because of the war between France and Holy Roman Empire, and completed a degree under Johann Winter von Andernach. On December 5th of that year he received his doctorate from University of Padua in Italy (Saunders & O’Malley, 1973; Vesalius, 1998) after completing two days of examinations (Vesalius, 2008).
Immediately he was offered a position of Lecturer of Surgery and Anatomy at that university and began his professional and teaching career.

Vesalius taught anatomy from a different angle. Most medical students were taught from the texts of Galen only via lecture or independent reading. Although Vesalius did not know this at the time, Galen’s works were misleading since he had never performed a human dissection. He had examined pigs, oxen, and goats; however, most of his assumptions regarding the human body were based on Barbary ape (monkey) and dog dissections (Vesalius, 1998) since human dissections were not allowed during Greek and Roman rule around 200 A.D. Vesalius believed that learning should occur through demonstrations and direct observation. Having his students surround the table, he would cut and explain the anatomical and physiological roles of structures himself rather than follow the usual custom of having a barber surgeon or surgeon perform the dissection. The medical profession was divided into three categories: physician, surgeon, and barber. Barbers or barber surgeons and surgeons were not medical doctors but performed surgeries, extracted teeth, and conducted procedures related to war injuries. Human dissections were allowed during the 1500s, and although cadavers were attained through the local prisons, many universities were only allowed one anatomical specimen per year. Since resources were limited, Vesalius would perform the dissections while students watched and he later created detailed and anatomically accurate drawings of the body so students could refer to the illustrations. Tablets were created by carving the images into wood blocks (Saunders & O’Malley, 1973). Soon, his illustrations became famous and a Paduan judge, Marcantonio Contarini, allowed Vesalius additional cadavers of executed prisoners. This provided him with repeated opportunities to examine the human body, compare and then challenge Galen’s descriptions.
The first set of Vesalius’ meticulous drawings was published in 1538, which included six tablets known as *Tabulae Anatomicae Sex* (Saunders & O’Malley, 1973). These were published because Vesalius feared plagiarism or theft of the works. The following year he updated Galen’s anatomy handbook *Institutiones Anatomicae*. When the work reached Paris, Sylvius denounced his previous student.

From examining gross anatomy, Vesalius began to realize errors in Galen’s works. Exploration of these errors led to additional animal dissections. Vesalius assumed Galen based his knowledge of human anatomy from that of animal dissections and publically proved these mistakes in Bologna in 1541 during a guest lecture. He showed the audience the variations of human and ape skeletal articulations and visually compared the differences to that of Galen’s work.

With solid evidence that Barbary apes were used as a comparative model for Galenic human anatomy, Vesalius assisted Giunta Press in publishing a corrected version of Galen’s *Opera Omnia* between the years of 1541 and 1542 and began writing his own texts to clarify assumptions which had been taught and published previously (O’Malley, 1964). In August 1543, *De humani corporis fabrica* (*On the fabric of the human body*) was published and provided corrections of the previously taught materials (Vesalius, 1998). This would be the first anatomy textbook with detailed illustrations and symbols within the text referencing the images (Vesalius, 1998).

A few weeks later, a student text, *De humani corporis fabrica librorum epitome*, commonly known as *Epitome* (*Abridgement of the Structure of the Human Body*) was published to include more visuals and less text. The first chapter discussed the skeletal system and displayed many strong claims against the anatomical works of Galen. It seemed fitting that this
system, the one that Vesalius felt was the framework of the human body, would be his opening section and would provide the initial foundation for his claims. The revisions of Galen’s works within this book corrected many body systems, but the first chapter examined human osteology and amended previous misconceptions such as the sternum having three and not seven parts as seen in true monkeys, the humerus being shorter than the femur, and the mandible having not two bones but one. This chapter ended with details regarding bone preparation, articulation of the skeleton, and how these resources should be available for future dissections.

Although his work contained some errors, he revolutionized the field of human anatomy and provided future generations with not only more accurate information but the premise that personal observation is critical for learning.

Recent Research in A&P Techniques

Many database and web searches were conducted regarding osteology and knowledge retention at the undergraduate level. “Retention refers to the process whereby long-term memory preserves a learning in such a way that it can locate, identify, and retrieve it accurately in the future” (Sousa, 2001, p 850). Several articles examined the retention of knowledge among anatomy students (Finn, White, & Abdelbagi, 2011; Hopper, 2011; Logan, Thompson, & Marshak, 2011). Some results dealt with the benefits of simulations and/or the controversy between hands-on laboratory and virtual or online labs (Hilbelink, 2009; Johnston & McAllister, 2008; O’Byrne, Patry, & Carnegie, 2008; Perez-Marcos, Sanchez-Vives, & Slater, 2012).

Articles regarding the lack of cadavers, natural anatomic specimens, and the lack of a national core curriculum were noted during the review of literature (Bergman, Van Der Vleuten, & Scherpbiert, 2011; Johnston, 2009). Exposure to partially dissected, prepared specimens, and cadaver dissections has been strongly recommended in the medical education literature.
(Bowsher, 1976; Collett & McLachlan, 2005; Dyer & Thorndike, 2000; Nnodim, 1990; Pandey & Zimitat, 2007; Winkelmann, 2007). Publications regarding drawings as a teaching tool in anatomy classrooms were also researched (Clavert, Bouchaïb, Duparc, & Kahn, 2012; Kotzé, Mole, & Greyling, 2012; Naug, Colson, & Donner, 2011). One article was located using constructivist methods for the teaching of the human digestive system (Mota et al, 2010). No articles were located that discussed osteology and the incorporation of constructivism or Andreas Vesalius within lessons.

Based on the background knowledge regarding historicality of cognition, constructivism, active and meaningful learning; there appears to be a gap in the literature that would benefit not only human anatomy students but educators as well. This study will examine knowledge retention rates after teaching lessons based on the techniques of Vesalius. Student will be provided osteology lessons in which they use different memory routes through traditional lecture, drawing, and blindfolded activities.
CHAPTER 3
METHODOLOGY AND PROCEDURE

Purpose

The purpose of this study was to determine the effectiveness of incorporating constructive learning activities in Human Anatomy and Physiology (A&P) laboratories to teach long bone anatomy and how undergraduate students may benefit from these activities. The study attempted to answer the following question:

How do historically based constructivist activities within a Human Anatomy and Physiology laboratory affect the retention of long bone anatomy knowledge?

Human Anatomy and Physiology (A&P) students were given instruction regarding historical methods of learning long bone anatomy. These methods include drawing the bones by identifying different shapes, as well as identifying structures and creating mental maps of the bones. A pilot study in Spring 2013 was conducted across three sections of lab students: a control group section of students given typical instruction, one section given typical instruction and a drawing lesson, and one section receiving all three forms of instruction (typical instruction, drawing lesson and ‘creating a mental map’ activity). Each group (treatment) was randomly assigned before the semester began. Throughout the study the researcher refers to the comparison group as the “control”; this class is also identified as Group A. This group was provided direct instruction which was also provided to all treatment groups. A control group could have been used where no instruction was provided; however, as an educator the researcher could not justify such a control. Additionally, the researcher hoped to know if the historically based constructivist activities (independent variable) influenced the participants, hence the control group was provided a lesson that utilized the same typical instruction or direct instruction but without the independent variable. Data collected from the qualitative questions on the
posttest yielded a split among enjoyment within many groups. That data compared to the knowledge gained scores provided insight that the students’ learning style may help explain the findings. Committee members agreed and an online assessment of what type of learner was the participant was added to the Full Research Study.

A Full Research Study was conducted in the Fall of 2013 among four lab sections. The three treatments utilized during the pilot study were applied to a new set of participants and the fourth section included a typical lecture with the ‘creating a mental map’ activity. Again, the groups were assigned at random before the semester started. Figure 3.1 provides an overview of this experiment and addresses the phases involved. The null hypothesis (Ho) stated that the historically based teaching methods would not influence retention of knowledge or study habits. The alternative hypothesis (Ha) stated that historically based teaching methods involving creating mental models and/or drawing bones would increase retention of osteology knowledge and laboratory enjoyment.

Data was collected by pretest and posttest, surveys (within the Full Research Study: Quantitative Phase) and interviews (during the Full Research Study: Qualitative Phase) as displayed in Figure 3.1. Quantitative (QUAN) phase of the Full Research Study occurred in Fall 2013 and consisted of the two treatments that occurred in the Pilot Study as well as an additional treatment which included traditional instruction and the “Creating Mental Maps” activity. Participants were given an additional posttest a few weeks after the activity during the midterm examination and another posttest at the end of the semester (to collect retention data). Participants whose posttest scores increased significantly, decreased, or stay the same were invited to participate in an interview regarding the activity.
The pilot study took place during February 2013 which tested the functionality of the online survey, instructional methods, and pre/posttests.

**Objectives**

The objectives of this study included the following:

1. To complete a pilot study:
   a. Test instruments;
   b. Test activities;
   c. Compare pretest and posttest assessments.

2. To describe the sample population of the full research study:
   a. Gender;
   b. Race;
   c. Classification.

3. To compare pretest and posttest scores among four treatments (including a control):
   a. Whether or not treatments influence knowledge gained at different intervals
      i. Day of activity;
      ii. Four weeks later;
iii. Twelve weeks after activity.

4. To explore students perception of activity
   a. Enjoyment;
   b. As a study tool;
   c. Benefits;
   d. Overall student perceptions through interviews.

**Research Design**

To understand the research problem more completely, this study used a mixed methods design; a procedure for collecting, analyzing, and “mixing” both quantitative and qualitative data at some stage of the research process within a single study (Creswell & Clark, 2011). With regards to reasoning, qualitative is inductive and quantitative is deductive (Daly, 2008) and a blending of data would allow for both inductive and deductive approaches. One could view qualitative as exploring the depth of a topic and quantitative as the breadth (Keele, 2012). Therefore, the results of quantitative are generalized and can be applied to other populations; whereas, qualitative results are specialized or particular and less-likely to be generalized. For a researcher to generalize a sample statistic with confidence he must have a large, randomly selected sample that falls within the confidence interval (Dereshiwsky, 1999). With statistical analysis, a larger sample (n) increases both the statistical “power” because of reduced error and the probability that this generalization could be accurate. Hence, a mixed methods approach makes up for the weaknesses of one approach by incorporating the strengths of the two approaches (Creswell & Clark, 2011).

The explanatory sequential mixed methods design was used to address student learning when constructivist methods generated from historical teachings were provided within the
laboratory. The explanatory sequential design, a popular design of education research, consists of two distinct phases (Creswell, 2002, 2003; Creswell, Clark, Guttmann, & Hanson, 2003): collecting quantitative data followed by collecting qualitative data to better understand the quantitative statistical results (Teddlie & Tashakkori, 2009).

In order to fulfill Objective 1, a pilot study was conducted in the Spring of 2013. Objectives 2, 3, and 4 were utilized during the full research study that took place in the Fall of 2013. The pilot study included a control group that was provided direct instruction and two treatment groups. The treatment groups participated in historically based constructivist activities; one group had a drawing activity and the other used the drawing activity along with a blindfold exercise. In the pilot study, Group A was the control, Group B was the Blindfold/Drawing, and Group C was the Drawing group (Table 3.1). These groups were randomly assigned to each laboratory section.

The full research study utilized four laboratory sections that were randomly assigned a treatment activity before the semester began. Three sections occurred on the same weekday (Wednesday) and the fourth section was the following day (Thursday). Lab sections met for one hour and 50 minutes once a week. The first class was randomly chosen to be Group B (Blindfold treatment), second class Group C (Drawing treatment), third class Group A (Control), and class four which met the day after these was selected as Group D (Blindfold/Drawing treatment) as displayed in Table 3.1. All sections were provided direct lecture and the control group (Group A) only received this type of instruction, Group B created mental maps by feeling the structures of natural long bones, Group C participated in drawing the bones by correlating shapes to anatomical structures, and the last treatment group, Group D, utilized a combination of drawing and mental mapping lessons.
Table 3.1  Group Name and Treatment

<table>
<thead>
<tr>
<th>Study</th>
<th>Group Name</th>
<th>Type of Group</th>
<th>Type of Treatment</th>
<th>Reason Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot</td>
<td>Group A</td>
<td>Control</td>
<td>Direct Instruction</td>
<td>Baseline for Comparison</td>
</tr>
<tr>
<td></td>
<td>Group B</td>
<td>Treatment</td>
<td>Blindfold/Drawing</td>
<td>Combination Group</td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td>Treatment</td>
<td>Drawing</td>
<td>Hands-on/Active Learning</td>
</tr>
<tr>
<td>Full Research Study</td>
<td>Group A</td>
<td>Control</td>
<td>Direct Instruction</td>
<td>Baseline for Comparison</td>
</tr>
<tr>
<td></td>
<td>Group B</td>
<td>Treatment</td>
<td>Blindfold</td>
<td>Creating Mental Maps</td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td>Treatment</td>
<td>Drawing</td>
<td>Hands-on/Active Learning</td>
</tr>
<tr>
<td></td>
<td>Group D</td>
<td>Treatment</td>
<td>Blindfold/Drawing</td>
<td>Combination Group</td>
</tr>
</tbody>
</table>

In the quantitative phase, a pretest were given to Human Anatomy and Physiology students within the A&P laboratory at a southern region university, followed by three posttests at different time intervals (Figure 3.2). These posttests were given within four weeks of the activity and again at the end of the semester to collect data regarding knowledge retention. See Figure 3.3 in regards to the time line for this project.

The second phase of this study was a qualitative phase in which the students who dramatically increase knowledge and those who show no growth or regressed were interviewed regarding benefits, disadvantages, and possible changes within the activity.
Figure 3.2. Overview of research design. Figure shows Phase of study, Procedure for data collection and Product from collection.
Figure 3.3. Flow chart of research. This figure provides steps and time line for completion of this dissertation.
Population and Sample

The target population of this study was undergraduate students at a southeastern regional university who were enrolled in the first semester laboratory for Human Anatomy and Physiology. Typically, those students are majoring in nursing or kinesiology, and all participants were over the age of 18 years. A survey instrument was designed and used to gather additional demographic information (Appendix C). The Quantitative Phase of the Full Research Study utilized the cluster sampling technique in which convenient and captive sample of participants are studied within the classroom (Teddlie & Tashakkori, 2009). Creswell and Clark (2011) identify this type of sample as “nonprobabilistic.” Three treatment groups (n= 72) and a control group (n= 21) were examined.

Qualitative research will have smaller samples which may contain one or two individuals as in a case study, or several hundred individuals. A sample of 30-50 has been recommended by Morse (1994) and Bernard (2000). Teddlie and Tashakkori (2009) recommend a sample size that large among ethnography studies; however, this research study would be identified as a case study and had a smaller sample. Rossman and Rallis (2012) state that “case studies are complex and multilayered” (p. 103). These studies are useful for their heuristic value and area often explanatory (Rossman and Rallis, 2012). However, they require multiple sources of data collection (Creswell, 1998). Creswell (2009) identifies a case study as a qualitative strategy in which participants are bound by time and activity and the researcher explores the event, program, process, or activity of one or more individuals over a period of time. Case studies are also frequently used in when evaluating a program and can employ quantitative and qualitative methods (Fitzpatrick, Sanders, & Worthen, 2004). Teddlie and Tashakkori (2009) state that the case study strategy as the qualitative component of an overall design is often utilized in mixed
method studies. The researcher believed a case study inquiry would best fit the qualitative aspects of the study and through observation, short answer questions, and interviews she would have a better understanding of the quantitative data of this bounded system.

Case studies of individuals may range between six to twenty-four participants (Teddlie & Tashakkori, 2009). Creswell and Clark (2011) suggest a smaller sample of four to ten participants. The ability to deeply understand a topic or the impact upon participants may be a desire among qualitative researchers. For this desire to be met, each researcher must select a purposive sample which is often non-representative of the population. This sample could be the outliers that quantitative researchers would have discarded; however, these may be unique and provide valuable information. Teddlie and Tashakkori (2009) identify this category of purposive sampling for providing valuable information when one examines extreme successes or failures of individuals. This type of sampling is known as outlier, extreme, or deviant case sampling (Teddlie & Tashakkori, 2009).

In the Qualitative Phase of the Full Research Study of this research project, an outlier sample was examined from the quantitative analyses. The researcher hoped that this analysis would yield a bell curve with three or more students falling into the low and high tails (extremes). The Unit of Analysis consisted of students who fell into the tails. They were identified as outliers of the pretest and posttests analysis and became the potential sample for the qualitative study. Those individuals were asked to participate in a short interview outside of class. It was the hope of the researcher that saturation of themes would be reached among a sample of nine or more individuals; hence, thirteen students were asked to participate. Among each treatment and the control, the two lowest scores and the three or four highest scores were asked to participate in a one-on-one interview. That provided a possible sample of 24
individuals for the qualitative phase; with a minimum sample of twelve subjects. One participant from each lower-end group was interviewed and prior to the study, it was determined that depending on the number of willing participants, one or two individuals from each high-end group would be interviewed. Those participants were chosen based on who “volunteered” first. Once the participant had agreed to complete the interview, they were informed that they would be given a gift-card worth $5 for assisting with the qualitative study. The researcher interviewed thirteen participants; one low scoring interviewee was selected from each group resulting in four low participants and two high participants from each group were interviewed. An additional high scoring participant was interviewed from the control group resulting in a total of thirteen interviews.

**Ethical Considerations and Study Approval**

The current study was approved by the Institutional Review Boards at Southeastern Louisiana University, number 2013-073 (Appendix D) on November 15, 2012 and by Louisiana State University, number E8058, on November 27, 2012 (Appendix E). All participants volunteered and signed forms of consent (Appendix F). An overview of the research protocol is outlined in Figure 3.1 and Figure 3.2 of this chapter.

**Instrumentation**

The qualitative researcher will study behavior in the natural environment since she views behavior as social, situational, and dynamic (Myerhoff, 1978). However, as a biological scientist, I understand the importance of generalizing information; hence, quantitative and qualitative data was collected during the study. This section of Chapter 3 is organized based upon each of the instruments used in the study: an online survey, pretest and posttests, and interviews. Within each section is a description of the instrument, including its development and
appropriateness; the sampling strategy used for data collection; and for the survey, methods regarding reliability and validity testing.

The university used in the study typically has 16 week semesters. Within the laboratory, midterm exams fall on week 7 and final exams are given during week 15 (week 16 is reserved as “Finals Week” for lecture exams). The layout of the study and administering of these instruments has been correlated to the week in which it occurred.

**Online Survey**

An online survey was created in Survey Monkey (http://www.surveymonkey.com) and was piloted the first day (week 1) of class in January 2013 to improve readability, test the skip logic, and refine the number of items included. The 72 pilot participants were students enrolled among three sections of Human Anatomy and Physiology Lab I course for which I taught. The survey contained 32 questions which encompass demographic information and study habits (Appendix C).

Small changes were made to the survey dealing with skip logic issues and readability. After reviewing the answers, the researcher felt the survey should be given during Week 2 or Week 3 since study habits were not utilized by many of the pilot students. Cronbach’s Alpha score for specific sections of the survey measured the reliability of the questionnaire since that test is an instrument that determines the internal consistency or average correlation as discussed in Chapter 4. Questions which yielded a Cronbach’s Alpha score of 0.7 or less were not examined further. There was also test-retest reliability among the instrument.

**Pretest and Posttests**

A pretest and posttest (Appendix G) was administered to students during the pilot phase of this study. At the beginning of class during Week 3, students answered the pretest, performed
the activity/treatment and then completed the posttest. Retention data was not collected during the pilot study. In the summer 2013 the pilot data was analyzed and the instrument was adjusted and perfected based on student responses. At that time, the researcher increased the number of questions for the assessment from ten to 12 (See Appendix H). Increasing allowed for two content questions per bone and providing a better understanding of which long bones students have more/less difficulty learning.

The Full Research Study contained three posttests to measure knowledge retention. The first posttest was administered the same day as the activity (Week 3), the second test occurred during the midterm exam (Week 7), and a final posttest was given during the final exam (Week 15). ANCOVA was used to analyze the pretest/posttest differences or gain scores. The researcher noted that an ANCOVA would be a logical choice since age, sex, classification and major could be co-variables that influence the within-group error. Additionally, pretest scores could also be a covariate within that statistical test.

The posttest assessment also contained a Likert-type questionnaire and two short answer questions. The Likert-type questionnaire was analyzed for reliability using Cronbach’s Alpha and analyzed further through Kruskal-Wallis test due to outliers, non-normally distributed data, and samples being unequal. The short answer responses were coded and incorporated with field note, observation and interview codes during the meta-inference stage of the study.

**Learning Style Assessment**

All students completed two online assessments to determine their primary learning style or learning modality. These were completed through free websites that used the Index of Learning Styles to generate a questionnaire. One website was through North Carolina State University and the other was associated with the University of South Dakota. Students were
provided the links below, instructed to complete the questionnaires and submit a printed copy of the results.

First assessment:  http://www.engr.ncsu.edu/learningstyles/ilsweb.html

Second assessment: http://sunburst.usd.edu/~bwjames/tut/learning-style/stylest.html

Felder and Spurlin (2005) examined the reliability and validity of the Index of Learning Styles and found Test-retest correlation coefficients consistently yielded significant p-values of 0.05 or better. Hence, these websites were chosen because they used the Index of Learning Styles, provided a free assessment, and generated a results page that students could print.

**Interview**

Interviews were conducted in Fall 2013 during the Qualitative Phase of the Full Research Study among thirteen participants. These participants were those who increased dramatically or did not improve/ slightly improved between the pretest and first posttest. The method for selecting participants has been discussed in Section 3.3

Tashakkori and Teddlie (1998) explain pros and cons to interviews; stating that this method “provides an opportunity to ask for clarification” but has drawbacks because they are “time consuming and expensive” (p 102). The researcher believes this aspect of the study is essential and would help explain the statistical data.

Interview questions (Appendix I) were designed with the hope to validate why a treatment did or did not work. After the participants were interviewed, transcription and coding occurred. The transcripts were coded multiple times by the researcher and reviewed by a team of trained inter-rates to increase reliability. The research then gathered each participants’ survey data and merged their information with the interview and pre/posttest information to create a description of each interviewee. Questionnaires, field notes, coded interviews, narrative
participant descriptions, and concept maps were examined to provide insight for how quantitative outliers perceive each teaching strategy.

Validity, Reliability, and Biases

Qualitative research has many purposes such as uncovering trends in thought, gaining knowledge regarding motivations, allowing one to understand social interactions, or providing data so one may generate a hypothesis to explore using quantitative research (Slife & Williams, 1995). Quantitative approaches will focus on testing the hypothesis, looking at cause and effect, and ultimately measuring the number of incidences in which different views or opinions are chosen. Sometimes qualitative research will follow this approach and is conducted over and over to maximize validity; hence, replication is critical. Replication within Quantitative Phase of the Full Research Study occurred because of the increased sample size and within Qualitative Phase of the Full Research Study since multiple participants within each treatment were interviewed. That should decrease the chance of error; hence, those methods enhance the validity and reliability of the study.

Another benefit of Mixed Methods is the difference among variables; qualitative researchers study the whole and quantitative researchers study specific variables and must include a control (which provides a baseline for comparison). One may notice the use of “participants” within qualitative studies verses “subjects” within quantitative ones. Within this chapter, I have identified my students and both “subjects” and “participants” because of the methodology I have chosen. Of course the question(s) asked by any researcher influences the methods. Essentially, the typical research objective for quantitative is describe, explain, and predict; whereas, explore, discover, and construct would be the objective for qualitative research. This study helped to explain why students increase knowledge when historical methods are
provided and also explored how variation in teaching affects the student’s understanding of long bone anatomy.

Becoming immersed in the study, knowing your participants, and stating biases occurs among subjective (qualitative) researchers (Myerhoff, 1978; Slife and Williams, 1995; Daly, 2008). As an educator, the researcher values the depth qualitative data can provide. She believes this data can enhance a classroom activity and is beneficial when evaluating a program. Her bias is that she is also a scientist. She holds a Bachelors and Master’s degree in Biological Science and has utilized statistical analysis to gain understanding and to generalize knowledge. She also loves to teach and educate. Therefore, she will go to great lengths to breakdown a topic or teach in a variety of ways so her students can understand. To help minimize her personal biases, she has incorporated an “Audit Trail” as Daly (2008) recommends. This allows others to follow the methodology while providing credibility to the study as seen previously in Figures 3.2 and 3.3.

Creswell and Clark (2011) have identified several potential threats to validity when merging qualitative and quantitative data. This chapter provided those pieces and will allow others to mimic this study. I have documented each part of the study including the proposal stage, data collection and analysis, and integration of data sets. Lesson plans and photographs of the lesson are displayed in Appendix J. Triangulation techniques within data collection methods are used with mixed method studies. This study relies on triangulation of data as well as methodologies as a mixed-method study. The researcher has minimized the potential threats to validity by using methods suggested by Creswell and Clark (2011). Within data collection, these strategies include using the same participants within the QUAL and QUAN phases and having a larger quantitative sample size and smaller qualitative sample. The data sets complement one
another and provide both depth and breadth of the topic. Triangulation of investigators can be achieved by using inter-raters, Creswell refers to several methods that ensure internal validity which were utilized in this study, including triangulation of data, long term observations, and peer examination (Creswell, 2009, p199-200). Inter-rater reliability during coding of transcriptions allowed the calculation of the correlation of agreement between ratings (Teddlie & Tashakkori, 2009).
CHAPTER 4
RESULTS

Overview

The design for this study included both quantitative and qualitative data as part of a mixed methods design. The quantitative data were collected through student questionnaires, pretest, and posttests. The qualitative data were collected through short answer questions, field notes, and student interviews. Transcripts and qualitative short answer questions were coded and categorized to identify the composition of the target population and their individual experiences with the osteology activities. That data provided three emerging themes which are discussed in Chapter 6. Triangulation of the data sources strengthened the research design and validity of the findings.

This chapter includes an overview of the study participants using demographics and characteristics of the sample population, descriptive statistics, and data analyses used to answer each of the research objectives. The chapter includes both the quantitative and qualitative findings from four groups of individuals: control group (direct instruction), mental map group (direct and blindfold instruction), drawing group (direct instruction and drawing activity), and a combination group (blindfold, drawing, and direct instruction).

As discussed in previous chapters, the purpose of this study was to gain understanding of how historically based constructivist activities affect osteology knowledge retention of undergraduate students in the Human Anatomy and Physiology laboratory and to explore students’ perception of those activities. The results of the study will be presented under the objectives of this study that guided the research.
Review of Objectives

The purpose of this study was to gain understanding of how historically based constructivist activities within a Human Anatomy and Physiology laboratory affect osteology knowledge retention of undergraduate students and to explore students’ perception of those activities. Specific objectives were derived in order to answer the research question. The objectives of this study included the following:

1. To complete a pilot study:
   a. Test instruments;
   b. Test activities;
   c. Compare pretest and posttest assessments.

2. To describe the sample population of the full research study:
   a. Gender;
   b. Race;
   c. Major.

3. To compare pretest and posttest scores among four treatments (including a control):
   a. Whether or not treatments influence knowledge gained at different intervals
      i. Day of activity;
      ii. Four weeks later;
      iii. Twelve weeks after activity.

4. To explore students perception of activity
   a. Enjoyment;
   b. As a study tool;
   c. Benefits;
   d. Overall student perceptions through interviews.
Objective One

Objective 1 was designed to ensure the instruments and activities worked properly. To answer this objective, a pilot study was conducted during the spring semester of 2013. The pilot study utilized the online survey, treatment activities for the control, drawing, and combination of blindfold and drawing groups, as well as the pretest, first posttest and posttest questionnaire. The control group was provided direct instruction and identified as Group A. The combination group was provided an activity that used both the blindfold exercise and drawing activity; this group was labeled Group B. And the last treatment was the drawing activity that was referred to as Group C. The preliminary study slightly varied in design from that of the full research study since it contained one less treatment and did not collect knowledge retention data via two additional posttest assessments. Additionally, the pilot data provided insight that learning modality may affect students’ perception of the activity; hence, two additional assessments were added to the full research study that assessed students’ learning style. Three laboratory sections were utilized to test the osteology activities, which consisted of direct instruction among all groups, the drawing activity and a combination of mental maps and drawing. Lesson plan were designed for each activity (Appendix J) and no changes were made to the lesson plans or study protocol/treatment activities after the pilot study. Based on students’ responses, the online survey (Appendix C) did not require modifications.

The instruments used for the full research study were adjusted based on results from the pilot study. Changes included the addition of two questions to the pretest and posttest and the adjustment of the Likert-like scale on the posttest questionnaire as seen in Appendix G and Appendix H. The two additional questions were added to the pretest and posttest of the full research study so that data could be collected regarding the identification of each bone and one
structure of said long bone. It appeared that several students marked “No Opinion” on the posttest questionnaire so for the full research study this assessment was changed by moving the “No Opinion” column from the far right (Appendix G) to the first response column on the left (Appendix H). This seemed to occur more often among those that explained in their short answer statements that they enjoyed the activity, leading the researcher to believe that students did not notice the “No Opinion” wording at the top of the column. By adjusting the location and making the “No Opinion” option bold, fewer students in the full research study selected this choice. Pilot study data from pretests and posttests were compared using an ANCOVA test. The difference between scores (i.e., the gain score) was examined and students’ pretest score was used as the covariable during the analysis. This analysis in SPSS version 21 also provided a pairwise comparison among pretest and posttests score differences from the day of the activity compared across treatments. After this test was conducted, post hoc analysis was utilized to determine if a significant difference was located between groups. The use of Bonferroni as a post hoc test is displayed in Table 4.1 to demonstrate that significance was found between the control and treatment groups (p< 0.05). Therefore, the researcher was able to conclude that the teaching method did affect the knowledge gained during the long-bone anatomy laboratory of the preliminary study.

Table 4.1 Post Hoc Bonferroni of Difference from Pretest and Posttests

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Drawing</th>
<th>Blindfold/Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>---</td>
<td>0.008*</td>
<td>0.017*</td>
</tr>
<tr>
<td>Drawing</td>
<td>0.008*</td>
<td>---</td>
<td>1.000</td>
</tr>
<tr>
<td>Blindfold/Drawing</td>
<td>0.017*</td>
<td>1.000</td>
<td>---</td>
</tr>
</tbody>
</table>

Note: significance values identified by asterisk *

66
**Test Instruments**

Cronbach’s alphas were calculated for survey questions and the posttest Likert-type scale questionnaire. Results suggested the posttest questionnaire statement regarding the use of the activity as a study tool should be eliminated from future analysis. Additionally, the “No Opinion” response was the last option on the Likert scale and this choice was sometimes selected by a student who explained in their short answer statement that they enjoyed the activity, would use it outside of class, or provided other positive accounts. Since this occurred within every treatment the Likert survey was adjusted and the “No Opinion” choice was moved to the first column resulting in fewer students selecting this choice in the full research study.

The pretest and posttest (Appendix G) asked ten questions to determine long bone knowledge. Six bones were examined in the study and used to gather a better understanding of each participant’s knowledge. Those assessments were increased from ten to twelve questions for the full research study. Increasing to twelve questions provided the researcher with six questions asking for the name of the bone when presented and six questions naming a specific structure on said bone (Appendix H).

The online survey was conducted within the laboratory. Students did not have problems navigating through the survey and the only problem that arose was the need to delete the browser history and cookies on each laboratory computer before the next student attempted the survey. This was due to SurveyMonkey.com not allowing the survey to be completed by a different user on the same computer. To help reduce this issue and speed up the time required for this part of the study, students were allowed to complete the survey within the laboratory on a computer, smart phone, or other personal electronic device during the Full Research Study that took place in the Fall of 2013.
**Compare Pretest and Posttest Assessments**

The pretest and posttest assessments were analyzed using an ANCOVA test and post hoc Bonferroni. There was significant difference (p<0.05) between the control and treatment groups; hence, the historically based constructivist osteology activities differ than that of the direct instruction with respect to knowledge gained the day of the activity as seen previously in Table 4.1.

**Demographics of Pilot Students**

The online survey was used to gather demographic data regarding each group. Six individuals were removed from the sample since they did not provide their confidential identification code; therefore, the researcher could not correlate their demographic information to their pretest and posttest or to which treatment group they belonged.

Data from the survey identified the majority of students as nursing majors for each group (Figure 4.1). The control group (Group A) contained 18 students; ten were nursing majors accounting for 55.6% of the sample, four were kinesiology which made up 22.2% of the class, and four were classified as “Other” which included Biology and Communication and Science Disorders (CSD) and accounted for the remaining 22.2% of the sample. Twenty-two students were in the Blindfold Drawing group (Group B); 59.1% of the sample or thirteen students were majoring in nursing, six students or 27.3% of the class was identified as “Other”, and three students or 13.6% of the class was Kinesiology. The Drawing group (Group C) had the lowest percentage of nursing students and the highest percentage of kinesiology majors and students who were identified as “Other” that were majoring in Biology or Communication and Science Disorders. This group also contained 22 students; nine or 40.9% were majoring in nursing, seven or 31.8% were “Other” and six or 27.3% were majoring in Kinesiology.
Figure 4.1. Students' Major for Pilot Study across Treatments. Graphic shows the majority of students within each treatment are majoring in nursing.

The majority of students were sophomore classification. The control group (Group A) contained one freshman, ten sophomores, five juniors and one senior. The Blindfold Drawing (Group B) group had two freshman, twelve sophomores, four juniors and for seniors. The Drawing group (Group C) consisted of one freshman, eleven sophomores, seven juniors, and
three seniors (Table 4.2). The male to female ratio for the control group was 11 females to seven males. For the other two treatments it was 15 females to 7 males.

Table 4.2 Classification of Students per Group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Current classification</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Freshman</td>
<td>Junior</td>
</tr>
<tr>
<td>Blindfold/Draw</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Control</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Draw</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>16</td>
</tr>
</tbody>
</table>

Seventy-one percent of students identified “to earn more money or have a better job” as the primary reason for attending college; sixteen students accounting for 72.7% of the Drawing group (Group C), 68.2% (15 students) of the Blindfold Drawing group (Group B) and 72.2% (13 students) of the Control group (Group A) as displayed in Figure 4.2. A desire to “gain knowledge” was selected by fifteen students; six in the Blindfold Drawing group or 27.3% of the responses from that group, five in the Drawing group or 22.7% of the group and four students or 22.2% of the Control group. One student in the Blindfold Drawing group making up 4.5% of that group selected “parents” as their main reason for deciding to go to college. In the Control group one student selected “Other” and responded “to be a role model for children” and this accounted for 5.6% of the responses for said group. One student in the Drawing group selected “Other” and responded “Multiple reasons” and this individual response accounted for 4.5% of the Drawing group responses.

Figure 4.3 shows the number of students responses for attending college based on major. Students majoring in nursing selected “To earn more money or have a better job” more often than other majors with this choice selected 78.1% of the time among those students. When
compared to other classifications, this response was selected 58.8% among students identified as “Other” majors and 69.2% among Kinesiology majors. Overall, this response was selected by 71.0% of all students. “To gain more knowledge” was most frequently selected among students identified as “Other” majors, accounting for 35.3% of the responses within that major. This response was selected by 21.9% of Nursing majors and 15.4% of Kinesiology majors chose this response. This response was selected by 24.2% of the entire sample.

![Bar chart showing reasons for attending college by group.]

Figure 4.2. Main Reason Students in Each Treatment Decided to Attend College

The online survey also identified the educational level of the students’ parents or influential male and/or female role model (Figure 4.4). The majority (50.0%) of students in the Blindfold Drawing group (Group B) selected that their maternal education level as “She attended
but did not complete college.” This response was selected by 22.2% of students in the Control group (Group A) and 27.3% of students in the Drawing group (Group C). In the Control group the majority of students at 44.4% answered “She has a Bachelor’s degree.” Among the Drawing group this response was selected by 22.7% of the participants and accounted for 27.3% of the Blindfold Drawing group responses. And in the Drawing group the majority at 31.8% picked “She never attended college.” Among the Control group and Blindfold Drawing group that response was selected by 27.8% and 22.7% of the participants, respectfully.

Figure 4.3. Major vs Reason Student is Attending College
Paternal educational level was also explored with the survey. The highest response among all groups was “He never attended college” which had a total response rate of 46.8%. This response was selected by 59.1% of the Control (Group A) students, 44.4% of students in the Blindfold Drawing group (Group B), and 36.4% of the students in the Drawing group (Group C). The Blindfold Drawing group had the highest percentage of students who selected “He attended but did not complete college” at 38.9%. The other two groups had 18.2% of the students select that choice. The highest percent of responses among the choice “He has a Bachelors degree” was within the Drawing group where 27.3% of participants selected that response. The Control group had 18.2% of students select that choice and only 11.1% of students in the Blindfold
Drawing group chose that response. Figure 4.5 provides the percentage of selected answers across treatments.

![Figure 4.5](image)

**Figure 4.5. Educational Level of Students' Paternal Influence across Treatments**

**Posttest Questionnaire**

The posttest questionnaire was answered by 62 participants the day of the activity; 18 in Group C (the direct instruction/control group) and 22 in each treatment group (Groups A and B). It contained Likert-like questions and short answer questions. After analyzing the data from the questionnaire, it was found that 100% of participants within the treatment groups “agreed” or “strongly agreed” to enjoying the laboratory activity; whereas, only 81.8% of the control group enjoyed the direct instruction. Enjoyment levels among the “strongly agreed” individuals varied among groups. In Group A (Control) 59.1% of the participants “strongly agreed” to enjoying the
direct instruction lesson. The blindfold and drawing (Group B) had 66.7% of the participants select the choice “strongly agreed” to enjoying the combination activity. The intermediate group for high levels of enjoyment was Group C (Drawing) at 63.6% (Figure 4.6). Among the entire sample, only two students stated they “strongly disagreed” or “disagreed” with enjoying the lesson and both participants were in the control class (Group A). Group A also had the highest percentage (9.1%) of students select “No Opinion” as their response to this question.

Figure 4.6. Lab activity enjoyment level based on posttest questionnaire.

With regards to how well the students felt they learned the material, 77.3% of Group C (Drawing) participants strongly agreed they benefited and learned from the drawing activity; compared to 77.8% in Group B (Blindfold/Drawing) and 59.1% in Group A the control (Figure
4.7). Among all treatments, no student selected that they “Highly Disagreed” with this question. There was 9.1% of the Control group and 5.6% of the Blindfold Drawing participants that selected they “Disagree” with the statement that they learned more because of the activity.

Figure 4.7. Responses based on question regarding students’ perceived learning.

The third question analyzed on the posttest questionnaire asked students if they needed to study the material in detail in order to understand it. Among the control group, 13.6% of the participants selected “No Opinion” as their response. When examining the remainder of the responses among the direct instruction class, all the other participants “Agreed” or “Strongly Agreed” that they would need to study the material in detail to understand it. None of the students in the treatment groups selected “No Opinion” as their response to this question. In
Group B (Blindfold Drawing) 88.9% of the students selected “Agreed” or “Highly Agreed” and 81.2% of the students in the Drawing group (Group C) picked those choices. The Drawing group had the highest percentage of students that “Disagreed” with the statement at 18.2%, followed by 11.1% in the Blindfold Drawing group and 0.0% within the Control group (Figure 4.8).

![Bar chart showing percentage of students' responses](image)

Figure 4.8. Responses from post assessment regarding need to study.

A comparative analysis was conducted for the treatments and participants pretest and posttests scores gathered the day of the experiment. This test was conducted utilizing an ANCOVA and Post Hoc Bonferroni. All tests (Table 4.3) showed significant differences between the control and treatment groups (p<0.05).
Table 4.3. Post Hoc Bonferroni of Difference (Gain Scores) from Pretest and Posttests

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Drawing</th>
<th>Blindfold/Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>---</td>
<td>0.008*</td>
<td>0.017*</td>
</tr>
<tr>
<td>Drawing</td>
<td>0.008*</td>
<td>---</td>
<td>1.000</td>
</tr>
<tr>
<td>Blindfold/Drawing</td>
<td>0.017*</td>
<td>1.000</td>
<td>---</td>
</tr>
</tbody>
</table>

* significant at p<0.05

Eight weeks after the activity students were asked to identify a structure and bone; 66.7% of the participants in Group B (Blindfold Drawing) could correctly answer one or both questions, Group A (Control) participants did not answer any questions correctly which resulted in 0% knowledge retention, and 55% of Group C (Drawing) participants could answer one or both questions accurately.

**Objective Two**

Objective 2 seeks to describe the full research study participants on the following demographic characteristics: a) gender, b) race, and c) classification. These data were collected to provide descriptive statistics and account for them as confounding variables. When used as a covariable within the ANCOVA analysis they did not yield significant difference from that of the ANCOVA conducted with the pretest scores as a covariate. The survey also yielded information regarding the major of the participants. Although this was not an initial objective, it is an important aspect to understand about this population and will be discussed in this section.

**Demographic Data**

The full research study was completed by 92 students: 22 students in the control group (direct instruction), 22 students in the drawing group, 24 students in the blindfold (mental map) group, and 24 students in the combination group (blindfold with drawing). These groups have been identified with a letter throughout this chapter; the control group was assigned as (Group A), the Blindfold group (Group B), the Drawing group (Group C) and the Drawing/Blindfold
group (Group D). Among every treatment the majority of students were sophomore level, and
the only group that contained a participant who had already earned a degree was the drawing
treatment (Table 4.4 and Figure 4.9). As displayed in Figures 4.10 and 4.11, the majority of
students were Caucasian and females outnumbered males.

Classification. Sophomore level classification accounted for 59.9% of the students
within the study. The classification varied among treatments; the control group (Group A) had
the lowest number of sophomore students at 45.5% and the highest number of freshman (9.1%)
and juniors (27.3%). The drawing group (Group C) contained the highest number of
sophomores at 77.3% and was the only group that had a student who had already earned a
degree. It seemed logical that the majority of students would be sophomore level since this
course is a 200 level (sophomore) class. Students who had already earned a degree made up the
minority of overall participants at 1.1% or one out of 92 students. Freshman accounted for 5.4
percent of the overall sample and consisted of one student per treatment group and two freshmen
within the control group. The highest percentage of students classified as junior-standing was
within the control group at 27.3% as seen in Table 4.4 and Figure 4.9.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Drawing</th>
<th>Blindfold</th>
<th>Blindfold/Drawing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>9.1%</td>
<td>4.5%</td>
<td>4.2%</td>
<td>4.2%</td>
<td>5.4%</td>
</tr>
<tr>
<td>Sophomore</td>
<td>45.5%</td>
<td>77.3%</td>
<td>50.0%</td>
<td>66.7%</td>
<td>59.8%</td>
</tr>
<tr>
<td>Junior</td>
<td>27.3%</td>
<td>9.1%</td>
<td>25.0%</td>
<td>16.7%</td>
<td>19.6%</td>
</tr>
<tr>
<td>Senior</td>
<td>18.2%</td>
<td>4.5%</td>
<td>20.8%</td>
<td>12.5%</td>
<td>14.1%</td>
</tr>
<tr>
<td>Graduate</td>
<td>0%</td>
<td>4.5%</td>
<td>0%</td>
<td>0%</td>
<td>1.1%</td>
</tr>
</tbody>
</table>

Ethnicity. The online survey asked students to select which ethnicity best described
them and provided an option for students to select “other” and explain. Caucasian or white was
selected by 71.7% of the participants, 21.7% were African American or Black, 3.3% were Asian
or Pacific Islander, 1.1% was Hispanic American, and 2.2% identified themselves as “Other.”

Figure 4.10 and Table 4.5 provide the demographic data gathered regarding ethnicity.

![Chart showing percentage of classification within each treatment group.]

Figure 4.9. Percentage of classification within each treatment

The majority of students classified themselves as white or Caucasian when asked on the online demographic survey to select what ethnicity best describes them. Among the control group, blindfold, and blindfold with drawing group Caucasian students made up 72.7-79.2% of the class. The drawing group had the lowest number of Caucasian students per group at 54.5%. The drawing treatment also had the highest number of students that identified themselves as Black or African American at 31.8%. Two students identified themselves as “Other”. One student in the control group stated she was “French Indian” and in the drawing group a student
explained that she was “American and Asian.” Table 4.5 and Figure 4.10 display the percentages of each group with respect to ethnicity.

Table 4.5. Ethnicity Percentages among Groups

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Control</th>
<th>Drawing</th>
<th>Blindfold</th>
<th>Blindfold/ Drawing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White/Caucasian</td>
<td>72.7%</td>
<td>54.5%</td>
<td>79.2%</td>
<td>79.2%</td>
<td>71.7%</td>
</tr>
<tr>
<td>Black/African American</td>
<td>22.7%</td>
<td>31.8%</td>
<td>16.7%</td>
<td>16.7%</td>
<td>21.7%</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>0%</td>
<td>4.5%</td>
<td>4.2%</td>
<td>4.2%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Hispanic American</td>
<td>0%</td>
<td>4.5%</td>
<td>0%</td>
<td>0%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Other</td>
<td>4.5%</td>
<td>4.5%</td>
<td>0%</td>
<td>0%</td>
<td>2.2%</td>
</tr>
</tbody>
</table>

Figure 4.10. Percentage of students within each treatment based on ethnicity.
Gender. The majority of students within the study were female, which comprised 75% of the participants (Figure 4.11 and Table 4.6). Males were the minority at 25%. The control group had the most equal distribution of male to female ratio with 45.5% males and 54.5% females in the class. Among the other treatments the drawing group had the most males at 27.3% and the blindfold/drawing group had the least number of males at 12.5%. The control group (Group A) seemed to have more males because several student athletes enrolled in that section; three of which were male baseball players and one male track member. Those students stated the class time fit their schedules best since the lab was right before practice, they had no issues enrolling in the class because they register for courses before other students, and they often take courses together because they are provided weekly tutoring if needed.

Figure 4.11. Gender of Participants within Treatments.
Table 4.6. Gender Percentages among Groups

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Drawing</th>
<th>Blindfold</th>
<th>Blindfold/Drawing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>54.5%</td>
<td>72.7%</td>
<td>83.3%</td>
<td>87.5%</td>
<td>75.0%</td>
</tr>
<tr>
<td>Male</td>
<td>45.5%</td>
<td>27.3%</td>
<td>16.7%</td>
<td>12.5%</td>
<td>25.0%</td>
</tr>
</tbody>
</table>

Major. The majority of participants at 52.2% were majoring in nursing, 32.6% of participants were kinesiology majors, 3.3% of students were majoring in biology, and 12.0% identified themselves as another major and listed a major within Communications and Science Disorders (CSD) as displayed in Table 4.7. Nursing majors made up the majority of all treatment groups except the control, where kinesiology majors were the bulk of the class (Figure 4.12). In the Control group (Group A) 31.8% of the class were nursing majors, 45.5% were majoring in kinesiology, 22.7% were “Other” and no students were identified as Biology majors. The Blindfold group (Group B) had 4.2% of the class as “Other” and also 4.2% were Biology majors, 41.7% were majoring in kinesiology and half the class (50.0%) was nursing majors. The Drawing group (Group C) consisted of 13.6% “Other” majors, no biology majors, 36.4% kinesiology majors, and half (50.0%) were nursing majors. In the Blindfold Drawing group (Group D), 8.3% of the class was Kinesiology, Biology, and “Other” and the remaining 75.0% were nursing majors.

Table 4.7. Percentage of Students’ Major Across Treatment Groups

<table>
<thead>
<tr>
<th></th>
<th>Blindfold</th>
<th>Blindfold/Drawing</th>
<th>Control</th>
<th>Drawing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursing</td>
<td>50.0%</td>
<td>75.0%</td>
<td>31.8%</td>
<td>50.0%</td>
<td>52.2%</td>
</tr>
<tr>
<td>Kinesiology</td>
<td>41.7%</td>
<td>8.3%</td>
<td>45.5%</td>
<td>36.4%</td>
<td>32.6%</td>
</tr>
<tr>
<td>Biology</td>
<td>4.2%</td>
<td>8.3%</td>
<td>0%</td>
<td>0%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Other (e.g. CSD)</td>
<td>4.2%</td>
<td>8.3%</td>
<td>22.7%</td>
<td>13.6%</td>
<td>12.0%</td>
</tr>
</tbody>
</table>
The number of kinesiology majors in that course was not significantly greater than that of the blindfold or drawing groups; however, it was much greater than the combination group where only 8.3% of the students were kinesiology majors. The control group also had the highest percentage of students who identified themselves as having a major not within nursing, kinesiology, or biology; those students were identified as CSD majors and constituted 22.7% of the control group.

**Objective Three**

The third research objective seeks to compare pretest and posttest scores among the four groups; specifically addressing whether or not treatments influence knowledge gained at different intervals: a) day of activity (Posttest 1), b) four weeks later (Posttest 2), and c) twelve
weeks after activity (Posttest 3). A pretest was given the day of the activity and knowledge retention was measured using three posttest assessments that asked twelve osteology questions. The first posttest was given directly after the activity, the second was four weeks after the activity during the midterm exam, and the third was twelve weeks after the activity during a final. The final exam does not cover osteology material; hence, students were unaware that these questions would appear on the test and had not prepared or reviewed the long bones information.

To analyze the pretest and posttest scores, first all tests were graded and scores were recorded in Microsoft Excel. Then the difference between each pretest and posttest was calculated to represent a gain score. Finally, data was imported into SPSS version 21 and ANCOVA tests were ran using the gain score and pretest scores were identified as the covariate. With regards to the first posttest assessment the control group was not significantly different than the blindfold group and the drawing group was not significantly different than that blindfold with drawing group; however, all other treatments were significantly different from one another (Table 4.8). The second set of knowledge retention gathered during the midterm exam showed no significant difference among the groups and this was probably due to students preparing for the midterm exam. The third posttest assessment yielded a significant difference between the drawing/blindfold group and the control but no other significance was identified.

**Quantitative Analysis of Pre/Posttests**

To determine if any statistical significance existed between treatments an ANCOVA test was conducted using pretest scores as the covariate and exploring the p-values from a pairwise comparison using post hoc Bonferroni (Table 4.8). The alpha level was set at 0.05 for all statistical tests. Alpha inflation was fixed by utilizing Bonferroni correction. This test determined for the first posttest set of data that the control group (Group A) to be significantly
different than the drawing (Group C) and blindfold/drawing groups (Group D) but not
significantly different than the blindfold group (Group B). There was no significant difference
between treatments (alpha among the second posttest data collected during the midterm exam.
Posttest 3 yielded only a significant difference among Group D (Drawing with Blindfold
Activity) and the Control (Group A) (Table 4.8).

Table 4.8. Pairwise Comparison from ANCOVA using post hoc Bonferroni for treatments
using posttest means

<table>
<thead>
<tr>
<th>Source</th>
<th>Group A (Control)</th>
<th>Group B (Blindfold)</th>
<th>Group C (Drawing)</th>
<th>Group D (Drawing/Blindfold)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Posttest 1</td>
<td>--</td>
<td>1.00</td>
<td>0.000020*</td>
<td>&lt; 0.00*</td>
</tr>
<tr>
<td>Group B Posttest 1</td>
<td>1.00</td>
<td>--</td>
<td>0.035*</td>
<td>0.002*</td>
</tr>
<tr>
<td>Group C Posttest 1</td>
<td>0.000020*</td>
<td>0.035*</td>
<td>--</td>
<td>0.848</td>
</tr>
<tr>
<td>Group D Posttest 1</td>
<td>&lt; 0.00*</td>
<td>0.002*</td>
<td>0.848</td>
<td>--</td>
</tr>
<tr>
<td>Group A Posttest 2</td>
<td>--</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Group B Posttest 2</td>
<td>1.00</td>
<td>--</td>
<td>1.00</td>
<td>0.389</td>
</tr>
<tr>
<td>Group C Posttest 2</td>
<td>1.00</td>
<td>1.00</td>
<td>--</td>
<td>1.00</td>
</tr>
<tr>
<td>Group D Posttest 2</td>
<td>1.00</td>
<td>0.389</td>
<td>1.00</td>
<td>--</td>
</tr>
<tr>
<td>Group A Posttest 3</td>
<td>--</td>
<td>1.00</td>
<td>1.00</td>
<td>0.017*</td>
</tr>
<tr>
<td>Group B Posttest 3</td>
<td>1.00</td>
<td>--</td>
<td>0.929</td>
<td>0.056</td>
</tr>
<tr>
<td>Group C Posttest 3</td>
<td>1.00</td>
<td>0.929</td>
<td>--</td>
<td>0.334</td>
</tr>
<tr>
<td>Group D Posttest 3</td>
<td>0.017*</td>
<td>0.056</td>
<td>0.344</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: Alpha level set at 0.05 and significant p-values identified with an asterisk *

Knowledge gained the day of the activity. All laboratory sections showed
improvement from the pretest to the posttest provided after the activity. The blindfold group had
the highest average pretest score and the blindfold with drawing group had the lowest average
(Table 4.9). To account for these variations, the difference was calculated and the pretest score was used as a covariate within the ANCOVA analysis. The average score for the first posttest was very similar among the treatments and lowest among the control group.

Table 4.9. Means for Pretest and Posttests (Out of 12 points)

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest 1 (after activity)</th>
<th>Posttest 2 (after 4 weeks)</th>
<th>Posttest 3 (after 12 weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.6</td>
<td>6.4</td>
<td>10.4</td>
<td>7.9</td>
</tr>
<tr>
<td>Blindfold</td>
<td>4.8</td>
<td>9.8</td>
<td>10.6</td>
<td>8.2</td>
</tr>
<tr>
<td>Blindfold/Drawing</td>
<td>0.7</td>
<td>9.9</td>
<td>11.0</td>
<td>9.5</td>
</tr>
<tr>
<td>Drawing</td>
<td>1.1</td>
<td>9.0</td>
<td>10.5</td>
<td>8.6</td>
</tr>
</tbody>
</table>

**Knowledge retention four weeks after the activity.** Analysis of posttest 2 showed no significant difference among the groups. As displayed in Table 4.9, the average score for each participant was between 10.4 and 11.0 points out of 12 possible points regardless of treatment or control group. Since this data was collected during the midterm exam, students could have utilized the techniques provided in class and also their own study methods to reinforce the material for the exam.

**Knowledge retention twelve weeks after the activity.** The last posttest was administered during the final exam and students were not aware that posttest data would be collected during the examination. The final exam covers material discussed after the midterm and does not include any osteology stations or questions. Students within each section expressed surprise or confusion when they arrived at a table that had bones and osteology questions; and at least one student in each class verbally questioned the researcher regarding why the bones were used. The drawing group and the blindfold/drawing group had scores on the third posttest collected 12 weeks after the activity that were nearly the same as the posttest scores the day of the activity.
Objective Four

Objective 4 seeks to explore the students’ perception of activity. This includes enjoyment, use of activity as a study tool, benefits of activity and overall perception of the interviewed participants. The posttest also contained a questionnaire with Likert-type scale questions and short answer questions. Once the pretest and posttests were graded, the outliers within the tails were identified and invited to participate in an interview. The purposive sample yielded 13 participants; two high scorers and one lower scorer from each experimental treatment and three high scorers and one lower scorer from the control group. The interviews were recorded, transcribed, and coded to yield themes. Participant descriptions were then created and those and field notes were also coded. The data from all previously mentioned resources was then merged to have a holistic understanding of the students’ perceptions.

Survey Reliability

Cronbach’s Alpha was used to determine the reliability of the survey questions. Items were removed from the data spreadsheet to enhance the overall reliability of the survey. For example when comparing the educational background of the students’ parents, the Cronbach’s Alpha was very low as seen Table 4.10 (0.386); hence, this data was not explored further. Questions that resulted in a Cronbach’s Alpha near or greater than 0.7; such as those provided in Tables 4.11 and 4.12, were kept within the spreadsheet in case the researcher decided to investigate that aspect of the data further.

Table 4.10.  Cronbach’s Alpha Results for Questions 2 and 3 of Survey Regarding Parental Education

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>Cronbach’s Alpha Based on Standardized Items</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.386</td>
<td>.404</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 4.11. Reliability of Question 5 (A&P Courses Taken) of Survey

<table>
<thead>
<tr>
<th></th>
<th>Cronbach's Alpha</th>
<th>Cronbach's Alpha Based on Standardized Items</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.751</td>
<td>.739</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 4.12. Specific Cronbach’s Alpha if Portions of Question 5 Were Deleted

<table>
<thead>
<tr>
<th>Question</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Squared Multiple Correlation</th>
<th>Cronbach's Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q5A</td>
<td>13.67</td>
<td>30.438</td>
<td>.339</td>
<td>.670</td>
<td>.760</td>
</tr>
<tr>
<td>Q5B</td>
<td>13.48</td>
<td>31.284</td>
<td>.267</td>
<td>.663</td>
<td>.777</td>
</tr>
<tr>
<td>Q5C</td>
<td>11.35</td>
<td>20.682</td>
<td>.656</td>
<td>.713</td>
<td>.648</td>
</tr>
<tr>
<td>Q5D</td>
<td>11.06</td>
<td>20.878</td>
<td>.757</td>
<td>.787</td>
<td>.606</td>
</tr>
<tr>
<td>Q5E</td>
<td>11.33</td>
<td>21.600</td>
<td>.584</td>
<td>.529</td>
<td>.681</td>
</tr>
</tbody>
</table>

After students completed the first posttest on the day of the class activity, they were asked four Likert scale questions regarding their perception of the experiment (Appendix H). The Cronbach’s Alpha coefficient for those questions was 0.580 (Table 4.13); however, when the data was removed for the question where students were asked if they needed to study the material in more detail the overall statistic increased to 0.827 (Tables 4.14, 4.15 and 4.16). Once “Need to Study” question was removed all scores were greater than 0.7 (Table 4.17).

Table 4.13. Original Statistic When All Treatments Were Included in Posttest Survey

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.580</td>
<td>4</td>
</tr>
</tbody>
</table>

Those questions were explored for each treatment to determine if the survey questions worked better for one class than another. All three experimental treatments required the removal of the question regarding the need to study in order to increase that reliability statistic. The control class was the only group which yielded a Cronbach’s Alpha greater than 0.7 when using all four posttest survey questions (Table 4.18). The researcher believed that the survey question
that asked if the student feels like they need to review outside of class to learn the material was actually a beneficial question because the control group shows reliability; however, the treatment groups do not and that could be related to their classroom activity.

Table 4.14. Cronbach Alpha’s Test for Deleted Items of Posttest Survey

<table>
<thead>
<tr>
<th>Question Topic</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyed</td>
<td>10.141</td>
<td>2.194</td>
<td>.544</td>
<td>.368</td>
</tr>
<tr>
<td>Learned</td>
<td>9.976</td>
<td>2.142</td>
<td>.489</td>
<td>.400</td>
</tr>
<tr>
<td>Need to Study</td>
<td>10.318</td>
<td>3.434</td>
<td>-.097</td>
<td>.827</td>
</tr>
<tr>
<td>Study Tool</td>
<td>10.118</td>
<td>1.796</td>
<td>.693</td>
<td>.201</td>
</tr>
</tbody>
</table>

Table 4.15. Deleted “Need to Study” from Test and Increased Statistic to 0.827

<table>
<thead>
<tr>
<th>Cases</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td>85</td>
<td>92.4</td>
</tr>
<tr>
<td>Excluded</td>
<td>7</td>
<td>7.6</td>
</tr>
<tr>
<td>Total</td>
<td>92</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 4.16. Reliability Statistics for “Need to Study”

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.827</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 4.17. Item-Total Statistics for Remaining Three Posttest Survey Questions

<table>
<thead>
<tr>
<th>Question Topic</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyed</td>
<td>6.941</td>
<td>1.818</td>
<td>.642</td>
<td>.802</td>
</tr>
<tr>
<td>Learned</td>
<td>6.776</td>
<td>1.604</td>
<td>.696</td>
<td>.748</td>
</tr>
<tr>
<td>Study Tool</td>
<td>6.918</td>
<td>1.553</td>
<td>.717</td>
<td>.726</td>
</tr>
</tbody>
</table>

As stated previously, Cronbach’s Alpha was used to test the reliability of the Likert-type scale posttest survey questions. This was required to determine if the questions asked were reliable. The datum recommended the removal of the “need to study” question and once removed
Cronbach’s Alpha scores were greater than 0.7 for the three remaining posttest survey questions (Table 4.19).

Table 4.18. Cronbach’s Alpha for “Need to Study” Question among Treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Original Cronbach’s Alpha</th>
<th>Statistic if Delete “Need to Study”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blindfold</td>
<td>0.544</td>
<td>0.762</td>
</tr>
<tr>
<td>Blindfold/Drawing</td>
<td>0.490</td>
<td>0.560</td>
</tr>
<tr>
<td>Control</td>
<td>0.743</td>
<td>0.871</td>
</tr>
<tr>
<td>Drawing</td>
<td>0.462</td>
<td>0.819</td>
</tr>
</tbody>
</table>

Table 4.19. Item-Total Statistics for remaining three posttest survey questions

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyed</td>
<td>6.941</td>
<td>1.818</td>
<td>.642</td>
<td>.802</td>
</tr>
<tr>
<td>Learned</td>
<td>6.776</td>
<td>1.604</td>
<td>.696</td>
<td>.748</td>
</tr>
<tr>
<td>Study Tool</td>
<td>6.918</td>
<td>1.553</td>
<td>.717</td>
<td>.726</td>
</tr>
</tbody>
</table>

The questions regarding enjoyment, belief of learning, and use as a study tool were explored for each treatment to determine if the survey questions worked better for one class than another. All three experimental treatments required the removal of the question regarding the need to study in order to increase that reliability statistic. The Control class (Group A) was the only group that yielded a Cronbach’s Alpha greater than 0.7 when using all four posttest survey questions (Table 4.20). The researcher believed that the survey question that asked students if they feel they need to review the material outside of class in order to learn the osteology information could have been a beneficial survey question even though the Cronbach’s Alpha was below 0.7. This is because the Control group shows reliability among that question; however, the treatment groups do not, and that could be related to their classroom activity. As shown in Table 4.21, the mean rank is highest for the control group which means more students within that group felt they needed to review outside of class in order to understand the material.
Table 4.20. Cronbach’s Alpha Among Treatments for Posttest survey

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Original Cronbach’s Alpha</th>
<th>Statistic if Delete “Need to Study”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blindfold</td>
<td>0.544</td>
<td>0.762</td>
</tr>
<tr>
<td>Blindfold/Drawing</td>
<td>0.490</td>
<td>0.560</td>
</tr>
<tr>
<td>Control</td>
<td>0.743</td>
<td>0.871</td>
</tr>
<tr>
<td>Drawing</td>
<td>0.462</td>
<td>0.819</td>
</tr>
</tbody>
</table>

Survey Results

An Alpha level set at 0.05 was used for all statistical tests. The mean for each question and treatment is displayed in Table 4.21, but since the posttest survey was designed with a Likert-type scale and group sizes varied, Kruskal-Wallis non-parametric test was used to analyze the data and determine significance. The mean rank in Table 4.21 was calculated from the Kruskal-Wallis test. Each student rated their own level of enjoyment, belief of learning, use of technique as a study tool, and if they felt they needed to study the material in more detail on the posttest survey and then data was input into Microsoft Excel by assigning each question a rating from 0 to 4, with the lowest score of “no opinion” receiving zero points and the highest score, “strongly agree,” receiving four points.

Table 4.21. Posttest Questionnaire Survey Mean Rank

<table>
<thead>
<tr>
<th>Question Topic</th>
<th>Group A (Control)</th>
<th>Group B (Blindfold)</th>
<th>Group C (Drawing)</th>
<th>Group D (Drawing/Blindfold)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyed</td>
<td>35.00</td>
<td>50.21</td>
<td>35.65</td>
<td>56.33</td>
</tr>
<tr>
<td>Learned</td>
<td>29.93</td>
<td>54.17</td>
<td>43.88</td>
<td>52.46</td>
</tr>
<tr>
<td>Need to Study</td>
<td>53.23</td>
<td>46.96</td>
<td>45.45</td>
<td>40.83</td>
</tr>
<tr>
<td>Use as Study Tool</td>
<td>41.75</td>
<td>48.42</td>
<td>42.67</td>
<td>46.75</td>
</tr>
</tbody>
</table>

This analysis found no significant difference between treatments for using the activity as a study tool outside of class ($x^2=1.293$, df=3, $p=.731$) and if students thought they needed to study to understand the material ($x^2=2.988$, df=3, $p=.394$). Cronbach’s alpha had determined previously that the question regarding “Need to Study” should be removed from the
questionnaire. The treatments were statistically significant different with respect to enjoyment level \( (x^2=14.146, \text{df}=3, p=.003) \) and students’ belief they have learned during the activity \( (x^2=17.443, \text{df}=3, p=.001) \) as seen in Table 4.22.

### Table 4.22. Chi-square and p-values from Kruskal-Wallis test

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>n</th>
<th>Mean Rank</th>
<th>( x^2 )</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blindfold</td>
<td>24</td>
<td>50.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blindfold/Drawing</td>
<td>24</td>
<td>56.33</td>
<td></td>
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</tr>
<tr>
<td>Drawing</td>
<td>21</td>
<td>35.00</td>
<td></td>
<td></td>
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<tr>
<td>Control</td>
<td>20</td>
<td>35.65</td>
<td>14.146</td>
<td>3</td>
<td>0.003</td>
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<tr>
<td>Learned</td>
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<td></td>
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</tr>
<tr>
<td>Blindfold</td>
<td>24</td>
<td>54.17</td>
<td></td>
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<tr>
<td>Blindfold/Drawing</td>
<td>24</td>
<td>52.46</td>
<td></td>
<td></td>
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<tr>
<td>Drawing</td>
<td>22</td>
<td>29.93</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>20</td>
<td>43.88</td>
<td>17.443</td>
<td>3</td>
<td>0.001</td>
</tr>
<tr>
<td>Need to Study</td>
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<td></td>
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<td></td>
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<tr>
<td>Blindfold</td>
<td>24</td>
<td>46.96</td>
<td></td>
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<td>Blindfold/Drawing</td>
<td>24</td>
<td>40.83</td>
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<tr>
<td>Drawing</td>
<td>22</td>
<td>53.23</td>
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<tr>
<td>Control</td>
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<td>45.45</td>
<td>2.988</td>
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<td>0.394</td>
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<tr>
<td>Use as Study Tool</td>
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<td></td>
<td></td>
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<tr>
<td>Blindfold</td>
<td>24</td>
<td>48.42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blindfold/Drawing</td>
<td>22</td>
<td>46.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawing</td>
<td>22</td>
<td>41.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>21</td>
<td>42.67</td>
<td>1.293</td>
<td>3</td>
<td>0.731</td>
</tr>
</tbody>
</table>

**Enjoyment.** Enjoyment level varied among the groups. Kruskal-Wallis test provided mean ranks for the enjoyment level as displayed previously in Table 4.21 and Table 4.22. The control group and drawing group had the lowest reported enjoyment; ranked at 35.00 and 35.65, respectfully. The drawing with blindfold group had the highest amount of enjoyment at 56.33 and the blindfold group had an average at 50.21.
**Use as a study tool.** Utilizing the activity as a way to study was determined by a Kruskal-Wallis test as not being significantly different among the groups ($x^2=1.293$, df=3, $p=.731$). The mean ranks varied from as low as 41.75 for the control group to as high as 48.42 among the blindfold group as displayed previously in Table 4.21 and Table 4.22.

**Qualitative Analysis**

As stated previously in the section Population and Sample of Chapter 3, interviews were conducted among 13 participants. These participants were selected because they fell within the quantitative tails of their group. The tails, or outliers, were identified as high scorers and low scorers; hence, high scorers earned the most points on the posttest and low scorers earned the fewest points on the posttest.

All students completed an online learning style assessment which identified their primary learning modality. Interviewed participants were asked what type of learner they believed they were and to explain how they study. Based on the answers they provided during the interview, the qualitative participants were also identified with an assumed learning modality. The result of the online assessment and their assumed learning modality are displayed for each participant in Table 4.23.

Interview transcriptions and field notes were examined through a pre-coding technique of highlighting, circling and underlining statements thought to be significant (Saldaña, 2013). The transcriptions were then analyzed through a holistic coding approach in order to group ideas and basic themes from larger passages of the interviews (Dey, 1993). A few weeks later the transcriptions, field notes, and student questionnaires were coded using a descriptive method where each line of data was analyzed that resulted in a list of codes (Table 4.24). The researcher then merged descriptive coded data from field notes and questionnaires to have a thorough
understanding of each participant and their perception. This resulted in a participant description document for each individual who was interviewed (Chapter 5). An overview of participant information is displayed in Table 4.23. Once descriptions were completed, all resources were reviewed for themes; hence additional validity was gained through the triangulation of data.

Finally, the interviews and codes were examined and discussed with an educational researcher to ensure accuracy and establish inter-rater reliability.

Table 4.23. Participant Information

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Treatment</th>
<th>Type of Scorer</th>
<th>Assumed Learning Modality</th>
<th>Assessed Learning Modality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meegan</td>
<td>Blindfold (Mental Maps)</td>
<td>Low</td>
<td>Visual</td>
<td>Auditory</td>
</tr>
<tr>
<td>Loren</td>
<td>Blindfold (Mental Maps)</td>
<td>High</td>
<td>Kinesthetic/Auditory</td>
<td>Visual</td>
</tr>
<tr>
<td>Michaelyn</td>
<td>Blindfold (Mental Maps)</td>
<td>High</td>
<td>Visual/Kinesthetic</td>
<td>Visual/Auditory</td>
</tr>
<tr>
<td>Christina</td>
<td>Drawing</td>
<td>Low</td>
<td>Visual/Auditory</td>
<td>Auditory</td>
</tr>
<tr>
<td>Becca</td>
<td>Drawing</td>
<td>High</td>
<td>Kinesthetic/Visual</td>
<td>Visual/Auditory</td>
</tr>
<tr>
<td>Abby</td>
<td>Drawing</td>
<td>High</td>
<td>Visual</td>
<td>Visual</td>
</tr>
<tr>
<td>Heather</td>
<td>Blindfold/Drawing</td>
<td>Low</td>
<td>Auditory/Visual</td>
<td>Kinesthetic</td>
</tr>
<tr>
<td>Bianca</td>
<td>Blindfold/Drawing</td>
<td>High</td>
<td>Kinesthetic/Visual</td>
<td>Auditory</td>
</tr>
<tr>
<td>Jenna</td>
<td>Blindfold/Drawing</td>
<td>High</td>
<td>Visual/Kinesthetic</td>
<td>Visual</td>
</tr>
<tr>
<td>Julie</td>
<td>Control</td>
<td>Low</td>
<td>Visual/Kinesthetic</td>
<td>Visual/Auditory</td>
</tr>
<tr>
<td>Michael</td>
<td>Control</td>
<td>High</td>
<td>Auditory</td>
<td>Auditory</td>
</tr>
<tr>
<td>Missy</td>
<td>Control</td>
<td>High</td>
<td>Kinesthetic/Visual</td>
<td>Visual</td>
</tr>
<tr>
<td>Denzel</td>
<td>Control</td>
<td>High</td>
<td>Visual</td>
<td>Visual</td>
</tr>
</tbody>
</table>

Low scorers stated the activity could be used outside of class but none of those participants could provide an example of another course where they would use the technique they were provided in class. Heather from the Blindfold/Drawing Group discussed how she did not realize the benefit of drawing until after the activity and she reports that she has begun to draw charts in the corresponding lecture class. When asked about using the technique as a whole (blindfold and drawing) in another course, she explained the usefulness was limited to the
laboratory because it is hands-on saying, “Uh, blindfolding and um, I’d probably just, it’s more
learning the bones because that’s just like hands on, but not really any of my other classes are as
hands on as that is.”

Table 4.24. Codes Derived from Interviews

<table>
<thead>
<tr>
<th>Category</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity Outside Class</td>
<td>AOC</td>
</tr>
<tr>
<td>Benefits of Activity</td>
<td>BA</td>
</tr>
<tr>
<td>Deficiency of Activity</td>
<td>DA</td>
</tr>
<tr>
<td>Disability</td>
<td>DIS</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>Enj</td>
</tr>
<tr>
<td>Hands-on</td>
<td>HO</td>
</tr>
<tr>
<td>Knowledge Issue</td>
<td>Know-</td>
</tr>
<tr>
<td>Learning Style Type Auditory</td>
<td>LS-Aud</td>
</tr>
<tr>
<td>Learning Style Conflict</td>
<td>LSC</td>
</tr>
<tr>
<td>Learning Style Example</td>
<td>LSE</td>
</tr>
<tr>
<td>Learning Style Type Kinestetic</td>
<td>LS-KIN</td>
</tr>
<tr>
<td>Learning Style Type Mixed</td>
<td>LS-Mix</td>
</tr>
<tr>
<td>Learning Style Type Visual</td>
<td>LS-Visual</td>
</tr>
<tr>
<td>Other Courses</td>
<td>OC</td>
</tr>
<tr>
<td>Outside Study Partner</td>
<td>OSP</td>
</tr>
<tr>
<td>Negative Partner Interaction in Lab</td>
<td>PILab-</td>
</tr>
<tr>
<td>Positive Partner Interaction In Lab</td>
<td>PILab+</td>
</tr>
<tr>
<td>Science Course</td>
<td>SC</td>
</tr>
<tr>
<td>Study Location</td>
<td>SL</td>
</tr>
<tr>
<td>Study Time- Afternoon</td>
<td>ST-A</td>
</tr>
<tr>
<td>Study Time- All Day</td>
<td>ST-AD</td>
</tr>
<tr>
<td>Study Time- Cram Info</td>
<td>ST-CI</td>
</tr>
<tr>
<td>Study Time- Evening</td>
<td>ST-E</td>
</tr>
<tr>
<td>Study Tools</td>
<td>ST-Ex</td>
</tr>
<tr>
<td>Study Time- Morning</td>
<td>ST-M</td>
</tr>
<tr>
<td>Study Time- Weekday</td>
<td>ST-WkD</td>
</tr>
<tr>
<td>Study Time- Weekend</td>
<td>ST-WkE</td>
</tr>
<tr>
<td>Technology/Electronics</td>
<td>TE</td>
</tr>
<tr>
<td>Use of Activity Outside Class</td>
<td>UAOC</td>
</tr>
</tbody>
</table>

High scorers also felt the technique they were provided could be used outside of class but
these students were more likely to provide an example where it could be used in another course.

These participants named science courses including the second anatomy laboratory and lecture,
biomechanics and various kinesiology courses as possible courses in which they could use this study technique.

All participants within the constructive learning treatments (Blindfold, Blindfold/Drawing, and Drawing) stated they enjoyed the activity. Low scorers comments included:

Meegan (Blindfold): I like the way it was done, it was, it was nice instead of just looking at it and watching you hold it up and point it out, it was nice to actually feel it and then try to figure out what it is, you know by touch what is it and then after you take off the blindfold you actually look at it and have the visual part and I, I feel like that was a better way of learning and an easier way to understand.

Christina (Drawing): Yeah, I did enjoy it. I like how, um, you did it on the board and we could follow you too. And I felt like it kind of gave me a minute to refresh on everything that we did that class. I, kind of like I could recap on everything.

Heather (Blindfold/Drawing): …I liked it, I feel like I learned more from that activity than like previous, ah, classes.

Additional themes that emerged included the student perception and misconception of learning style or learning modality, the influence of a lab partner affecting a student’s enjoyment of the lesson, and, interestingly, the belief among high scoring participants in the control group which received direct instruction and was the comparison group, that they would not have benefited from other strategies or teaching techniques. The data used that supports the learning style them included the qualitative codes, and comparing interviews with learning assessments. Table 4.25 identifies which participants had a misunderstood learning modality.

The assumed learning modality emerged from data collected during the interview and the assessed modality was provided through two online assessments discussed previously. Comparing those resources provided a new column of data identified as “Correctness of Modality.” During the interview, if a student provided a learning style that differed than their
assessed modality, they were labeled as “Incorrect” or “Moderately Incorrect.” “Moderately Incorrect” was used because the student had two assessed learning styles and they failed to name one but did mention the other. “Moderately Correct” labeling occurred among students who identified two assumed learning modalities but their assessment showed only one learning style. Further explanation of this theme and other themes previously mentioned are discussed in Chapter 6. The next chapter will provide the reader with a better understanding of the interviewed participants.

Table 4.25. Comparing Assumed and Assessed Learning Modalities

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Assumed Learning Modality</th>
<th>Assessed Learning Modality</th>
<th>Correctness of Modality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meegan</td>
<td>Visual</td>
<td>Auditory</td>
<td>Incorrect</td>
</tr>
<tr>
<td>Loren</td>
<td>Kinesthetic/Auditory</td>
<td>Visual</td>
<td>Incorrect</td>
</tr>
<tr>
<td>Michaelyn</td>
<td>Visual/Kinesthetic</td>
<td>Visual/Auditory</td>
<td>Moderately Incorrect</td>
</tr>
<tr>
<td>Christina</td>
<td>Visual/Auditory</td>
<td>Auditory</td>
<td>Moderately Correct</td>
</tr>
<tr>
<td>Becca</td>
<td>Kinesthetic/Visual</td>
<td>Visual/Auditory</td>
<td>Moderately Incorrect</td>
</tr>
<tr>
<td>Abby</td>
<td>Visual</td>
<td>Visual</td>
<td>Correct</td>
</tr>
<tr>
<td>Heather</td>
<td>Auditory/Visual</td>
<td>Kinesthetic</td>
<td>Incorrect</td>
</tr>
<tr>
<td>Bianca</td>
<td>Kinesthetic/Visual</td>
<td>Auditory</td>
<td>Incorrect</td>
</tr>
<tr>
<td>Jenna</td>
<td>Visual/Kinesthetic</td>
<td>Visual</td>
<td>Correct</td>
</tr>
<tr>
<td>Julie</td>
<td>Visual/Kinesthetic</td>
<td>Visual/Auditory</td>
<td>Moderately Correct</td>
</tr>
<tr>
<td>Michael</td>
<td>Auditory</td>
<td>Auditory</td>
<td>Correct</td>
</tr>
<tr>
<td>Missy</td>
<td>Kinesthetic/Visual</td>
<td>Visual</td>
<td>Moderately Correct</td>
</tr>
<tr>
<td>Denzel</td>
<td>Visual</td>
<td>Visual</td>
<td>Correct</td>
</tr>
</tbody>
</table>

Attrition Rate

The attrition rate is typically around 25% for this laboratory. During the semesters that the historically based constructivist activities were used the attrition rates decreased (Table 4.26). In the pilot study the Blindfold/Drawing group had the lowest percentage of students drop the course at 8.3%. The control group and drawing group both had an attrition rate of 20.8%. The
drawing group had the lowest number of students withdraw during the full research study. The attrition rate for that group was 4.2% since only one student dropped the course. The control group had four students drop the course and resulted in the highest attrition rate at 16.7%. The group that utilized the blindfold and drawing had only two students withdraw which yielded an attrition rate of 8.3%. The group that used only the blindfold activity had three students withdraw; hence, the attrition rate was calculated at 12.5%.

Table 4.26. Attrition Rates

<table>
<thead>
<tr>
<th>Technique</th>
<th>Pilot Study</th>
<th></th>
<th>Full Research Study</th>
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<tr>
<td></td>
<td>Count</td>
<td>Percentage</td>
<td>Count</td>
<td>Percentage</td>
</tr>
<tr>
<td>Direct Instruction (Control)</td>
<td>5</td>
<td>20.8%</td>
<td>4</td>
<td>16.7%</td>
</tr>
<tr>
<td>Mental Maps (Blindfold)</td>
<td>---</td>
<td>---</td>
<td>3</td>
<td>12.5%</td>
</tr>
<tr>
<td>Drawing</td>
<td>5</td>
<td>20.8%</td>
<td>1</td>
<td>4.2%</td>
</tr>
<tr>
<td>Combination (Blindfold/Drawing)</td>
<td>2</td>
<td>8.3%</td>
<td>2</td>
<td>8.3%</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>16.7%</td>
<td></td>
<td>11.5%</td>
</tr>
</tbody>
</table>
CHAPTER 5
PRESENTATION OF THE PARTICIPANTS

Introduction

Sequential explanatory mixed methods design allows a researcher to collect quantitative and then qualitative data. This section describes the participants who were interviewed within the qualitative phase of this study. Each participant fell into the tails of the first quantitative pretest-posttest assessment that was administered the day of the constructivist osteology activity. Information from the participants’ online surveys, quantitative assessments, and interviews has been merged to provide the descriptions within this chapter. The rationale for this chapter is to allow the reader to better understand the students who were interviewed and provide a detailed description of those interviewees. Participants have been given pseudonyms and are organized by the class activity (treatment) they attended as displayed previously in Table 4.23. The qualitative groups were arranged to include two high scorers and one low scorer from each treatment. The control interviews consisted of three high scorers and one low scorer; hence, 13 participants total. All interviews were conducted within the building where the activity took place. The majority of the interviews were recorded in my faculty office. A few of the interviews were conducted in a laboratory prep-room that is adjacent to the laboratory classroom and one interview was conducted in the laboratory after class was dismissed. The participants were emailed and asked to participate in a 15-20 minute interview regarding the activity and their personal study habits; those that replied and scheduled an appointment time were used in the qualitative interview aspect of this study. The end of this chapter provides a group summary of the interviews.
The Individual Participants

This section was created to help the reader understand each interviewed participant and to provide a written account of the interview. These descriptions consist of information merged from field notes and observations, the participants’ interviewed transcriptions, pretest and posttest data, and data from the online demographic survey. The participants are presented below based on the group activity they participated in and within each description identified as the high or slow scorers within said treatment.

Blindfold Group

“Meegan”. Meegan, a low scorer in the blindfold group, scheduled an early morning appointment at my faculty office on campus for her interview. She arrived on time and knocked softly on the closed wooden door while I worked. She entered the small room which is probably eight feet deep and six feet wide and sat across the desk from me. Her long dark hair was pulled back from her heart-shaped face and she looked nervous as she adjusted her glasses on the bridge of her nose. I explained that the interview was voluntary and, throughout the interview, she was very polite often saying “Yes ma’am.”

Meegan is in her junior year at the university, twenty years old, and a kinesiology major. Her current GPA is 2.45. She has no children. She attended a private high school where she took honors English and Math in additional to other courses. Her mother never attended college and she is unsure of her father’s educational history. In lab, she sits to the far right of the class; her lab partner is also a white female. The subjects she studies most are Chemistry and Zoology. Studying in her room with no sound, she flips through the book to review charts and figures but also creates flashcards throughout the week. She considers herself a visual learner and prefers to
study in the morning stating that she will even wake up early to study. A learning style assessment placed Meegan as being an auditory learner.

Meegan was part of the blindfold treatment and scored low on the knowledge retention assessment. Her pretest/posttest difference or gain score was +3; of the 12 questions asked she initially knew five and after the lesson answered eight correctly. The questionnaire after the lesson shows that Meegan strongly enjoyed the blindfold activity, strongly felt she learned more because of the activity, and strongly felt she could use the method as a study tool. When asked if she would need to study the material in detail to understand it, she strongly disagreed.

The responses Meegan provided on the posttest questionnaire identifying the part of the activity that best helped her gain knowledge of these bones and if the method was difficulty or easy, she says: “Yes, it helped. I was able to think more about what I was feeling. There was no distraction. I could focus better on one single item at a time. Easy, because I could focus better.”

“Loren”. Loren scheduled an interview appointment right before her lab and arrived early. She was a high scorer in the blindfold group. She sat across from me and pulled the chair close to the table in the same faculty office that Meegan’s interview had occurred. Loren’s chin length blonde hair was pulled back tight from her fair-skinned face. Loren has an athletic build and wore basketball jersey shorts and t-shirt. She seemed very direct and to-the-point. Occasionally, she would glance over my right shoulder and I assumed someone had walked past the window and distracted her. The windowsill is wooden and on it sits two ivy plants that have attached themselves to the wall and grow up the side of the window along the cream painted drywall. Metal blinds hang in the window but remain open to let in sunlight. Above drapes a light blue, silver, and light olive green swag with tassels. She may have been observing the
plants or possibly the other items near the window. About 18 inches below the window is a short black two drawer filing cabinet that holds lesson plans, exams, and many years of graded scantrons. On top of the cabinet is a large coffee pot, coffee cup, decorative tea pot with four matching coasters.

Loren is in her senior year at the university, twenty-two years old, and a kinesiology major. After graduating she hopes to work in a school where she can teach and coach. Her current GPA is 2.68. She has no children. She attended a public high school and took honors English and Math courses. Her mother never attended college and her father attended college but did not earn a degree. In lab she sits to the far left of the class at the front table; her lab partner is a white male. She studies best with a partner by repeating information and taking tests her partner creates. She considers herself a kinesthetic learner that also benefits from auditory. Loren studies most in the evening but stated that she studies all the time, which includes the morning as well. A learning style assessment placed Loren as being a somewhat neural learner but more visual and kinesthetic was her lowest learning style.

Loren was part of the blindfold treatment and scored high on the knowledge retention assessment. Her pretest/posttest difference or gain score was +6; of the 12 questions asked she initially knew six and after the lesson answered all twelve correctly. The questionnaire after the lesson shows that Loren enjoyed the blindfold activity, strongly felt she learned more because of the activity, and felt she could use the method as a study tool. When asked if she would need to study the material in detail to understand it, she agreed. During the interview Loren stated that she thought the activity was helpful but that it was not her “cup of tea” because she did not like being blindfolded.
The posttest questionnaire asked students to explain how the activity helped them gain knowledge of the bones. On Loren’s questionnaire she answered this question by writing, “Having to go off of feel and not being able to glance at my notes.” When asked to explain if the activity was difficult or hard, Loren writes, “A little bit of both. I think it will help me on the midterm because I will be able to visualize the bone in my head.”

“Michaelyn”. Michaelyn scheduled an interview appointment immediately before her lab. She was a high scorer among the blindfold group. We met in the same faculty office as the previous participants and she sat across the table from me. She had medium length curly blonde hair that was pulled tight into a ponytail. Michaelyn seemed very casual and easy going. She placed her backpack next to the chair and glanced to her right, observing the silk flower arrangement at the edge of my desk. The yellow tulips and Louisiana irises brightly contrast against the cream colored wall. They sit in a glass ginger vase which is about 12 inches tall and hold potpourri that at one time smelled similar to apple pie but has lost most of its fragrance. She may have been looking at my family photos on the wall near the arrangement; I wasn’t exactly sure since I was jotting down some demographic information.

Michaelyn is a sophomore at the university, nineteen years old, and a kinesiology major. After graduating she wants to pursue graduate school and become an Occupational Therapist. Her current GPA is 3.00. She has no children. She did not take honor or Dual Enrollment courses while attending a public high school. Her mother has a master’s degree and her father attended college but did not earn a degree. In lab she sits at a table on the front row in the center of the class; her lab partner is a white male. She studies best using flashcards. She considers herself a visual learner that also benefits from kinesthetic. Michaelyn studies in the afternoon for
two or three hours per day. A learning style assessment placed Michaelyn as being an equally visual and auditory learner.

Michaelyn was in the blindfold treatment group and scored high on the knowledge retention assessment. Her pretest/posttest difference was +8; of the 12 questions asked, she initially knew four and after the lesson answered all twelve correctly. The questionnaire after the lesson shows that Michaelyn strongly agreed that she enjoyed the activity, strongly felt she learned more because of the activity, and strongly felt she could use the method as a study tool. When asked if she would need to study the material in detail to understand it, she strongly agreed.

The response Michaelyn provided on the posttest questionnaire regarding the part of the activity she thought best helped her gain knowledge of the bones was, “Blindfold and having to feel each bone.” When asked to explain if the activity was difficult or hard, Michaelyn writes “Difficult. But glad I did it, now I know it better!”

**Drawing Group**

“Christina”. Christina scheduled an interview appointment right before her lab class. She was a low scorer in the drawing group. Again, this interview occurred in a faculty office and she sat across the desk from me. She had medium brown hair that was slightly below her shoulders in length. Christina seemed shy and slightly nervous. To her right is a small brown dormitory fridge and on top of the fridge is a white microwave, she places a smoothie on the edge of fridge. Next to the fridge is a seven foot tall black metal bookshelf and Christina quickly looks up at the shelf and then her eyes track the ceiling edge along that wall. The book shelf is probably 42 inches long but easily eight feet tall. Every shelf from waist up contains science, nursing and methodology books. The bottom shelves hold Rubbermaid containers that have
outreach materials. The wall behind her is cream painted cinderblocks. The building is often cold; a space heater had been on for a few minutes behind my desk in hopes to take the chill out of the air before she arrived. As she crosses are arms, I notice the thermostat above her head near the light. It shows that it is 83 degrees outside, 65 degrees within the office and set on 78 degrees; it has never seemed to work. I would have liked to continue to warm the office with the space heater; however, to decrease noise while recording the interview the heater was turned off.

Christina is a sophomore at the university, nineteen years old, and a nursing major. After graduating she wants to enter the workforce. Her current GPA is 3.50. She has no children. She did take college level Biology, Physics, English and Math courses while attending a public high school and earned college credit for those courses. Neither of her parents attended college. In lab she sits at a table on the last row in the middle of class; her lab partner is a white female. She studies throughout the day while doing other tasks; such as cleaning house, working out or at work. Christina explained that she uses photo memorization and writing as study techniques. She considered herself a visual learner that also benefits from auditory. A learning style assessment placed Christina as being an auditory learner and her lowest score was in visual strategies.

Christina was in the drawing treatment group and scored low on the knowledge retention assessment. Her pretest/posttest gain score was +4; of the 12 questions asked, she initially knew zero and after the lesson answered four correctly. The questionnaire after the lesson shows that Christina strongly agreed that she enjoyed the drawing activity, strongly felt she learned more because of the activity, and strongly felt she could use the method as a study tool. When asked if she would need to study the material in detail to understand it, she strongly agreed.
The responses Christina provided on the posttest questionnaire regarding what part of the activity did she think best helped her gain knowledge of these bones, she answered, “The part where teacher made jokes… I’ll remember hearing the jokes when studying.” When asked to explain if the activity was difficult or hard, Christina writes “I found it difficult because it’s a lot at one time but feel like little remembering tricks will help. Easy as well because they all relate.” Christina’s responses seem to correlate with her auditory learning style.

“Becca”. Becca scheduled an interview appointment right before her lab and arrived on time. She was a high scorer in the drawing group. She sat across from me in a faculty office. She had very long dark hair and part of it was pulled back. Her large dark eyes were staring at books on the shelf next to her. She seemed very friendly but slightly nervous. Becca often would make eye contact and from time to time I noticed her look above my head and examine the bookshelf behind my desk. It sits next to the window. This one contains Anatomy and Physiology textbooks on the second to top shelf. The next shelf down has a metal tree with family pictures, a shadow box with a figure of the university mascot, and some university pins and bookmarks. The shelf below that contains a molecular chemistry model kit, two bags of Community coffee and one plastic container of Folgers coffee, glass jar labeled “Equal” with white powder inside, and coffee filters. The two shelves below that contain stacks of paper. On the wall next to the bookshelf is a Cystic Fibrosis calendar with roses turned to the month of October. Above it is a wooden frame containing artwork from a local artist and above that is a poster of eyeglasses which says “Prevent Plant Blindness”. I never asked her what she was looking at but something behind me caught her attention several times during the interview.

Becca is a sophomore at the university, nineteen years old, and a nursing major. After graduating she wants to enter the workforce and work with children. Her current GPA is 2.98.
She has no children. She attended a public high school and earned college credit through an IB (International Baccalaureate) program. Neither of her parents attended college. She seems very close to her twin sister who is also pursuing a degree within the same major. In lab she sits at a table in the middle of the class; her lab partner is an African American male. Becca classified herself as Asian but has also stated that she’s half Asian and half white. She studies best either alone by retyping her notes or by teaching the material to her twin sister. She initially considered herself a kinesthetic learner but stated she also benefits from visuals. She felt she was definitely not an auditory learner. Becca studies most in the afternoon and usually at her kitchen table or a coffee shop. A learning style assessment placed Becca as being a visual and auditory learner and kinesthetic was her lowest learning style.

Becca participated in the drawing treatment and scored high on the knowledge retention assessment. Her pretest/posttest difference was +11; of the 12 questions asked she initially knew one and after the lesson answered all twelve correctly. The questionnaire after the lesson shows that Becca enjoyed the drawing activity, strongly felt she learned more because of the activity, and felt she could strongly use the method as a study tool. When asked if she would need to study the material in detail to understand it, she agreed. During the interview Becca stated that she thought the activity was helpful because she could remember the way it looked on the paper.

The responses Becca provided on the posttest questionnaire regarding the activity that she thought best helped her gain knowledge of the bones, she answered, “The shapes we did on the board helped me the most.” When asked to explain if the activity was difficult or hard, Becca writes “I thought it was kind of in the middle. It was a lot to remember.” During the interview Becca stated that after the activity she knew the information but that that knowledge would be lost if she did not continue to review the material.
“Abby”. Abby scheduled an interview appointment right before her lab and arrived on time. She was a high scorer in the drawing group. She sat across the table from me in the same faculty office and throughout the interview sat on the edge of the seat. The chair is an office chair with padded back and seat, plastic arms and will roll. My first impression was that Abby was nervous and she appeared uncomfortable in the chair. She had medium length light brown hair with blonde highlights that was worn down and tucked behind her left ear. She spoke very softly and her interview was one of the more difficult ones to transcribe.

Abby is a sophomore at the university, nineteen years old, and a kinesiology major. After graduating she wants to enter professional school. Her current GPA is 2.84. She has no children. She did not take honor courses previously at the private high school she attended. Both of her parents attended college; however, her mother is the only parent with a Bachelor’s degree. In lab she sits at a table in the front and center of the class; her lab partner is a white male. She studies best using flashcards, which is her primary tool for studying. She considers herself a visual learner. Abby studies in the morning but only two or three hours a week. A learning style assessment placed Abby as being a very neutral learner and only slightly more visual than auditory or kinesthetic.

Abby was in the drawing treatment group and scored high on the knowledge retention assessment. Her pretest/posttest difference or gain score was +11; of the 12 questions asked she initially knew one and after the lesson answered all twelve correctly. The questionnaire after the lesson shows that Abby strongly agreed that she enjoyed the drawing activity, strongly felt she learned more because of the activity, and strongly felt she could use the method as a study tool. When asked if she would need to study the material in detail to understand it, she disagreed.
During the interview she stated using shapes to understand the bone structures really helped and that she redid the activity outside of class.

The responses Abby provided on the posttest questionnaire regarding what part of the activity did she think best helped her gain knowledge of these bones, she answered, “The shapes in the bones.” When asked to explain if the activity was difficult or hard, Abby writes “Easy, because she [the teacher] helped us the whole way through.”

**Blindfold and Drawing Group**

“**Heather**”. Heather scheduled an interview appointment the day before her lab since that time better fit her schedule. She was a low scorer within the blindfold/drawing treatment. We met in a faculty office early in the morning and she sat across the table from me. She had long dark hair and her bangs swept across her forehead and were tucked behind her ear. Heather seemed happy and excited to talk.

Heather is a sophomore at the university, twenty years old, and a nursing major. After graduating she wants to enter the workforce. Her current GPA is 3.48. She has no children. She did not take honor nor Dual Enrollment courses while in high school. Most of her high school education was at a private school; however, she graduated from a public school. Both of her parents attended college but neither earned a degree. In lab she sits at a table on the far right in the middle row; her lab partner is a white male. She studies best using flashcards. She considered herself a mixture of auditory and visual when asked what kind of learning style fits her best. Heather studies in the morning and afternoons and mentioned that because of dyslexia and auditory processing disabilities she has to study a lot. A learning style assessment placed Heather as being a kinesthetic learner; she ranked lowest among the visual questions.
Heather was in the blindfold/drawing treatment group and scored low on the knowledge retention assessment. Her pretest/posttest difference was +5; of the 12 questions asked she initially knew one and after the lesson answered six correctly. The questionnaire after the lesson shows that Heather agreed that she enjoyed the activity, strongly felt she learned more because of the activity, and felt she could use the method as a study tool. When asked if she would need to study the material in detail to understand it, she disagreed.

Heather’s posttest questionnaire showed the following response with respect to how she benefited from the activity, “Writing pictures down with the shapes.” When asked to explain if the activity was difficult or hard, Heather writes “It was easy because it helped you identify.”

“Bianca”. Bianca scheduled an interview appointment an hour and half before her lab class. She was a high scorer among the blindfold/drawing technique. We met in a faculty office and she sat across the L-shaped desk from the researcher. She had long dark hair that was pulled up in a ponytail. Bianca seemed eager to participate, but laughed throughout the interview and the researcher noted that she may be nervous.

Bianca is a sophomore at the university, nineteen years old, and a nursing major. After graduating she wants to enter the workforce. Her current GPA is 3.03. She has no children. She did not take honor or Dual Enrollment while attending a public high school. Her father never attended college and her mother attended but never earned a degree. In lab she sits at a table in the center of the class but on the back row; her lab partner is a white female. She studies best using flashcards, rewriting her notes, reading over the material and also utilizes a cellphone app that provides flashcards. She considered herself a kinesthetic learner that also benefits from visuals. Bianca studies in the afternoon and evening for a few hours per day. A learning style
assessment placed Bianca as being a primarily auditory learner and she ranked lowest among the kinesthetic questions.

Bianca was in the drawing/blindfold treatment group and scored high on the knowledge retention assessment. Her pretest/posttest difference was +11; of the 12 questions asked she initially knew one and after the lesson answered all twelve correctly. The questionnaire after the lesson shows that Bianca agreed that she enjoyed the activity, felt she learned more because of the activity, and felt she could use the method as a study tool. When asked if she would need to study the material in detail to understand it, she disagreed.

The responses Bianca provided on the posttest questionnaire regarding what part of the activity did she think best helped her gain knowledge of these bones, she answered, “The part where I was blindfolded.” When asked to explain if the activity was difficult or hard, Bianca writes “I felt it was easy and very different to become familiar with the bones.”

“Jenna”. Jenna scheduled an interview appointment directly before her lab. She was a high scorer in the blindfold/drawing treatment group. We met in a faculty office and she sat across the table from me. She had medium length wavy dirty blonde hair with blonde highlights that was worn down. Jenna seemed eager to participate.

Jenna is a sophomore at the university, nineteen years old, and a nursing major. After graduating she wants to enter the workforce. Her current GPA is 4.00. She has no children. She did take honors English while attending a private high school. Her mother has a Bachelor’s degree and her father attended college but did not earn a degree. In lab she sits at a table in the center of the class; her lab partner is a black female. She studies best using flashcards, reading, and finds repetition beneficial. She considered herself a visual learner that also benefits from
kinesthetic. Jenna studies at least a couple hours each night. A learning style assessment placed Jenna as being a very visual learner; she ranked lowest among the kinesthetic questions.

Jenna was in the blindfold/drawing treatment group and scored high on the knowledge retention assessment. Her pretest/posttest difference or gain score was +11; of the 12 questions asked she initially knew one and after the lesson answered all twelve correctly. The questionnaire after the lesson shows that Jenna strongly agreed that she enjoyed the activity, strongly felt she learned more because of the activity, and felt she could use the method as a study tool. When asked if she would need to study the material in detail to understand it, she agreed.

On the posttest questionnaire Jenna wrote, “The blindfolding and feeling” was the part of the activity that she thought helped her gain knowledge of the bones. When asked to explain if the activity was difficult or hard, Jenna writes “Easy because of the comparison of the shapes to the parts of the bones.”

**Control Group**

“Julie”. Julie scheduled an interview appointment directly after her lab. She was a low scorer among the control group. After the students left the room, she and I sat at a laboratory table in the front of the class for the interview. The lab holds 12 tables, three per row and there are four rows. Each table has two stations with a rolling plastic chair. Models of the muscle system were on each desk. She had long medium brown hair that was pulled back out of her face by a thin headband. Julie was always quiet in class and I had never noticed her British accent until she started answering the interview questions.

Julie is a junior at the university, twenty-one years old, and a kinesiology major. After graduating she wants to pursue graduate school and eventually become a Physical Therapist.
Her current GPA is 2.88. She has no children. She did take history as a Dual Enrollment course in high school. Her high school education varied--she spent some time in a private school, was also home schooled at one point, but graduated from a public high school. Her father attended college but did not earn a degree and her mother has pursued coursework past a master’s degree.

In lab she sits on the last row to the far right of the class; her lab partner is a French/Native American female. She studies best by rewriting notes. She considered herself a visual learner that also benefits from kinesthetic. Julie studies in the afternoon at the library for at least an hour per day. A learning style assessment placed Julie as being equally visual and auditory for learning.

Julie was in the control treatment group and scored low on the knowledge retention assessment. Her pretest/posttest difference was zero; of the 12 questions asked she initially knew zero and after the lesson answered none correctly. The questionnaire after the lesson shows that Julie strongly disagreed that she enjoyed the drawing activity, strongly felt she did not learn more because of the direct instruction, and strongly felt she would not use the method as a study tool. When asked if she would need to study the material in detail to understand it, she agreed. During the interview the researcher asked Julie if she thought she would have benefited from drawing the bones and correlating shapes to the structures; the participant felt that method would have been more beneficial, “Because that’s visual and it’s breaking, like, its parts, it’s not the whole thing given straight to you.”

“I’m lost.” was Julie’s response on the posttest questionnaire when asked to explain what part of the lesson helped her gain knowledge. When asked to explain if the lesson was difficult or hard, Julie writes “difficult! We had to remember too much stuff at one time.”
“Michael”. Michael scheduled an interview appointment time right after his lab. He was a high scorer among the control group. We stood in the laboratory prep room at an empty counter; he occasionally would lean on the counter but most of the interview he stood with his shoulders back and the researcher noted that he was at least six and half feet tall. Michael is always well dressed and today his dress shirt sleeves were rolled up his forearm and he wore a light blue tie.

Michael is in his junior year at the university, twenty years old, and is a nursing major. After graduating he wants to enter graduate school. His current GPA is 2.69. He has no children. Michael did take honors Biology while attending a private high school. Both of his parents have bachelors’ degrees. In lab he sits at a table on the far left in the middle; his lab partner is an African American female. He studies best by repetition and reading through his notes. He considered himself an auditory learner. The amount of time spent studying varies for Michael. He said if he’s serious he will study a few hours but if he just wants to review then only 30 minutes is required. His study sessions occur on the weekend at various times of the day. A learning style assessment placed Michael as being extremely auditory.

Michael was in the control treatment group and scored high on the knowledge retention assessment. His pretest/posttest difference was +7; of the 12 questions asked he initially knew zero and after the lesson answered seven correctly. The questionnaire after the lesson shows that Michael strongly agreed that he enjoyed the lesson, strongly felt he learned more because of the direct instruction, and he strongly agreed that he felt he could use the method as a study tool. When asked if he would need to study the material in detail to understand it, he strongly agreed. During the interview the researcher asked Michael if he thought he would have benefited from
drawing the bones and correlating shapes to the structures; the participant felt he would not have benefited from the drawing because he is not good at drawing.

Michael’s responses on the posttest questionnaire regarding how he gained knowledge of the bones, he answered, “Relating the names of the bones to real life things.” When asked to explain if the lesson was difficult or hard, Michael writes “Somewhat easy. I liked… that the bones were available for hands-on learning.”

“Missy”. Missy scheduled an interview appointment directly after her lab. She was a high scorer within the control group. We stood in a laboratory prep room at an empty counter for the interview. The prep room contains many cabinets which hold anatomical models. There is a sink in the front and back of the room. A window in the back allows some natural light to enter the room. In the front of the room, next to the door are two skeletons; one is natural bone and the other is plastic. Missy has medium length blonde hair. She seemed eager to participate and quickly replied to questions.

Missy is a sophomore at the university, nineteen years old, and a nursing major. After graduating she wants to pursue graduate school. Her current GPA is 3.11. She has no children. She did take honor and Dual Enrollment English and Math courses while attending a public high school. Neither of her parents attended college. In lab she sits at a table in the center of the class; her lab partner is a white female. She studies best using flashcards, rewriting her notes and using study guides. She considered herself a kinesthetic learner that also benefits from visuals. Missy studies in the morning for two or three hours per day. A learning style assessment placed Missy as being a visual learner and also somewhat auditory; she ranked lowest among the kinesthetic questions.
Missy was in the control treatment group and scored high on the knowledge retention assessment. Her pretest/posttest difference was +9; of the 12 questions asked she initially knew zero and after the lesson answered nine correctly. The questionnaire after the lesson shows that Missy strongly agreed that she enjoyed the lesson, strongly felt she learned more because of the direct instruction, and strongly felt she could use the method as a study tool. When asked if she would need to study the material in detail to understand it, she strongly agreed. During the interview the researcher asked Missy if she thought she would have benefited from drawing the bones and correlating shapes to the structures; the participant felt having the bones in front of her was more beneficial.

In the responses Missy provided on the posttest questionnaire regarding what part of the lesson did she think best helped her gain knowledge of these bones, she answered, “Actually having the bones in front of me.” When asked to explain if the lesson was difficult or hard, Missy writes, “Easy because I could touch the bones.”

“Denzel”. Denzel scheduled an interview appointment not on his lab day but during a time when he had a break between lecture courses. He was a high scorer in the control group. He arrived early to a faculty office and sat comfortably in the chair across the desk from myself. He placed his book sack to his right on the floor and seemed casual and excited.

Denzel is a senior at the university, twenty-two years old, and is majoring in general studies. After graduating he wants to pursue dental hygiene school. His current GPA is 2.39. He has no children. Denzel took honors Biology, Chemistry, English, Physics and Math courses while attending a public high school. His father never attended college and his mother attended but never earned a degree. In lab he sits at a table on the back row but center of the class; his lab partner is a white female. He studies best by rewriting and reading over his notes. He considered
himself a visual learner. When asked how often he studies, Denzel opened his bag and began reviewing a calendar. He explained that he recently put himself on a new schedule and he studies four hours a day in the afternoon. A learning style assessment placed Denzel as being primarily a visual learner.

Denzel was in the control treatment group and scored high on the knowledge retention assessment. His pretest/posttest difference was +7; of the 12 questions asked he initially knew zero and after the lesson answered seven correctly. The questionnaire after the lesson shows that Denzel agreed that he enjoyed the direct instruction, strongly felt he learned more because of the lesson, and felt he could use the method as a study tool. When asked if he would need to study the material in detail to understand it, he agreed. During the interview the researcher asked Denzel if he thought he would have benefited from drawing the bones and correlating shapes to the structures; the participant felt he would have benefited from the drawing but thought having the bones in front of him was more beneficial.

The responses Denzel provided on the posttest questionnaire regarding the part of the lesson that he thought best helped him gain knowledge of these bones, he answered, “Being done orally by the professor.” When asked to explain if the lesson was difficult or hard, Denzel writes, “Easy. It just made sense.”

**Group Summary**

All participants volunteered for the interview after they were contacted via email. When I met with each individually at their scheduled time, they were then given a $5 gift card as compensation for their time.

Ten of the thirteen participants were Caucasian females. Denzel and Michael were African American males and Becca identified herself as Asian American since one parent is
Asian and the other is Caucasian. All participants are young adults and do not have children. Many participants identified a learning style and/or study strategy that differed from their learning style assessment. Enjoyment or engagement during the lab seemed be influenced by their interaction with their lab partner. These themes are discussed later in Chapter 6.

The coded interview transcriptions, observations, survey information and the descriptions within this chapter were used to create and overall understanding each participant. Those resources allowed for a variety of themes to emerge and provided findings for a qualitative article.
CHAPTER 6
DISCUSSION AND CONCLUSIONS

Summary

Chapter 6 presents the major findings, limitations, and conclusions of the study as well as discussion and recommendations for future research. The purpose of this study was to gain understanding of how historically based constructivist activities affect osteology knowledge retention of undergraduate students in the Human Anatomy and Physiology and to explore students’ perception of those activities. The study design included the incorporation of both quantitative and qualitative data as a sequential explanatory mixed methods study to answer the following question:

How do historically based constructivist activities within a Human Anatomy and Physiology laboratory affect the retention of long bone anatomy knowledge?

A mixed methods approach was chosen as the design for this study because it could best answer the research question and provided a stronger study. This is because as Creswell and Clark (2011) explain, a mixed methods approach incorporates the strengths of two approaches which make up for the weaknesses of one method. This combination allows for a more thorough analysis (Green, Caracelli, & Graham, 1989; Tashakkori & Teddlie, 1998) and understanding of what works (Menand, 2002) through the final blending phase termed the meta-inferencing stage. During this blending phase data and conclusions from one method are compared and contrasted to that of the other method in order to strengthen the overall design and generate a stronger conclusion. Tashakkori and Teddlie (2008) identify the meta-inference stage as the point where integration of inferences derived from the quantitative and qualitative parts are merged to yield an overall explanation and understanding of the problem.

The study contained 92 participants among three treatment groups (n= 22 among the drawing group, n=24 for the drawing group, and n= 24 for the blindfold/drawing group) and one
controlled comparison group (n= 22). All groups were provided quantitative assessments via an online demographic survey, pre and posttests the day of the experimental lesson, two online learning style assessments, a Likert-type questionnaire regarding enjoyment and utilization of the activity, and two additional posttests given four and twelve weeks after the activity that were used to determine knowledge retention. Qualitative data were gathered through coded interviews, field notes, observations, and posttest short answer questions. Thirteen participants who fell within the quantitative tails of the first posttest assessment were interviewed regarding the activity. Coding of interviews yield three themes that were then merged with coded field notes, observations and quantitative data for the meta-inferencing stage of the study.

**Findings**

**Pilot Findings**

Knowledge retention appears to be correlated with the type of teaching activity in which osteology knowledge retention is greatest when lessons utilize constructivist learning activities and active and meaningful learning. During the class meeting eight weeks after the activity students conversed about the osteology lesson during a classroom discussion session. Five participants in Group B agreed that the drawings seemed to help but only two students utilized them outside of class and nearly three-fourths of the students felt the blindfold with the drawing activity was not beneficial. Outside of class none of the students used the technique with a blindfold or creating a mental map by feeling. Half of Group A participants stated they looked at the drawing outside of class and some felt it benefited them as a study tool.

Based on all data, one treatment did not outrank the other treatments. Although the quantitative data suggests Group B--with direct teaching, drawing and blindfolding--would be the best approach since it yields higher enjoyment rates, knowledge retention rates, and the students’ feeling more confident about the topic, the qualitative data suggests that the drawing
activity among Group A would be the best choice. In the time frame allowed (just under two hours) students within Group B had limited time for each aspect of the three-phased activity. Jumping from activity to activity was enjoyable; however, weeks later when asked about the experience and knowledge retention, the participants were unsure of their answers and felt they did not benefit from the entire experience. Students in Group A utilized the activity as a study tool and sought out additional visual aids; therefore, this yielded more self-directed learning outside the classroom.

The questionnaire given the day of the activity provided students a chance to express their thoughts about the activity in the form of a short answer. Most students answered this section with a few sentences that were coded by the researcher. Two primary themes emerged among the treatment groups A and B, which were “utilization of drawing” and “ease of the activity.” Participants commented that they felt the drawing activity was very helpful and several participants stated they could utilize the drawings as a visual study tool. These themes appeared more frequently among Group B participants. A third theme emerged from Group B participants, some of whom felt the blindfold was not needed.

When asked on the posttest questionnaire if the activity was easy or difficult and to explain, one student from the drawing groups responds that the activity was “very easy. The repetition and fun study aids helped me to remember and the drawings of shapes for each bone made it simple & less intimidating.” Another student in that group who scored zero points on the pretest and answered nine questions correctly on the posttest says the part of the activity she liked best was “Going through the individual structures after I had no idea what they were” and “This activity challenged me but thoroughly enjoyed it.” The activity was “easy. She [teacher]
was very thorough and this is a great way to learn hard material” was a statement provided from another student.

The blindfold drawing group also had many responses that stated the activity was easy, enjoyable and allowed them to learn the material quicker. One replies, “Fun-easy. Loved being blindfolded- really helped to learn by touch.” Another student writes that the activity was “easy, the way the bones parts was broken down really helped me recognize the shape and how the parts of the bone feel.” A student who increased their score from three to seven points says, “I found this activity & it was fun.” Some responses were very similar and came from students at different lab tables; for example, one student says the activity was easy and “it help me learn the bones faster” and another students says it was “easy and helpful! The visual aspect helped me learn faster.”

The field observations taken the day of the activity noted confusion and frustration among Group A while participating in the lesson. The researcher noted that students often pointed to the wrong structure and seemed irritated by the fast pace. The participants among that group asked fewer questions and seemed less engaged with their partner. Observations recorded by the researcher noted students interacting by complaining to their partner about not finding the location of the previous structure. The researcher also noted that both Groups A and B laughed during the activity and that partner interaction and discussions were greatest among Group B. Based on students’ short answer responses Group B enjoyed the blindfold and drawing activity because they were able to work with a partner and they indicated that holding the bone and relating shapes to structures made it easier to understand the anatomy. A couple of Group B participants commented that there was too much information covered within the time frame allowed. Almost all Group A participants (91.8%) commented on their short answer
questionnaire that the activity was helpful, enjoyable, or easy to understand. Several students within Groups A and B noted they would utilize the drawing strategy outside of class. Group C participants’ responses showed that many thought the direct teaching activity was helpful; however, several respondents within this group noted that there was too much information discussed and a few stated they were “lost” or “confused.”

The students short answer responses from the posttest verified the researcher’s notation of confusion. One student in the control group (Group C) wrote that the lesson was “difficult- so many different names/words to recall.” Another student also stated the lesson was difficult and when asked to explain she says “I was still a little confused.”

**Full Research Study Findings**

The demographic data showed that most students were sophomore level (59.8%), Caucasian ethnicity (71.7%) and female (75.0%) as discussed in Chapter 4. Kruskal-Wallis test showed the treatments were statistically significant among enjoyment level and the students’ belief they had learned during the activity. It found no significant difference between treatments for using the activity as study tool and if students thought they needed to study to understand the material. An ANCOVA test was conducted using pretests as the covariate and examining the p-values from a pairwise comparison. The alpha level was set at 0.05 for all statistical tests. Alpha inflation was fixed by utilizing the Bonferroni correction. This analysis determined for the first posttest set of data that the control group (Group A) to be significantly different than the drawing (Group C) and blindfold/drawing groups (Group D) but not significantly different than the blindfold group (Group B). As discussed in Chapter 4, there was no significant difference between treatments (alpha at 0.05) among the second posttest data collected during the midterm exam. Posttest 3 yielded only a significant difference among Group D (Drawing with Blindfold
Activity) and the Control (Group A) as displayed previously in Table 4.5 of Chapter 4. Based on the data the utilization of drawing seems beneficial with respect to knowledge retention and incorporating that technique with the blindfold increases enjoyment and long term knowledge retention.

Three main themes emerged from the qualitative analysis including enjoyment/lack of enjoyment due to lab partner, control group lesson was beneficial, and misconception of learning modality as discussed in later section of this chapter titled “Overall perception via interviews.” With respect to the posttest Likert-scale results, interviews from low scorers thought the lesson could be used outside of class but could not provide an example of another course where they would utilize the technique. High scorers also felt the technique they were provided could be used outside of class and were more likely to provide an example where it could be used in another course. These participants named science courses including the second anatomy laboratory and lecture, biomechanics and various kinesiology courses.

All participants within the constructive learning treatments (Groups B, C, and D) stated they enjoyed the activity. The researcher expected such results from high scores; however, low scores explained they enjoyed the activity because it was beneficial and they learned.

**Direct instruction group (Group A; the control).** The control group was provided direct instruction where the instructor identified the bone, each structure on the bone, and asked students to point the structures while they were discussed. In the control group one student answers “It really didn’t help me. I have to go back and actually study the material.” Another control group student says that the lesson helped them by “relating the names of the bones to real life things.” The high scorers within the control group that were interviewed all felt they benefited from the direct instruction. When asked if they might have benefited from another
technique, such as drawing, the three participants stated they felt the method used was best.
Based on the second posttest assessment, it appears students in this group gained knowledge independently and increased scores to a level that showed no significant difference among this group and the treatments. Direct lecture may not increase laboratory enjoyment or knowledge retention in the short term; however, it looks as if students who seek to succeed will learn the material outside of class in order to pass the exam.

**Blindfold group (Group B).** The ANCOVA analysis of pretest 1 showed the blindfold group as not significantly different from the control but it was found to be significantly different than the other treatments with respect to knowledge retention as determined from the gain scores from the day of the activity. Long term knowledge retention showed no significant difference between the blindfold group and other groups. From a knowledge retention standpoint the blindfold activity is not beneficial.

This activity was designed in hopes to increase knowledge retention and facilitate laboratory interaction and enjoyment. The enjoyment level among this group that reported by the participants was determined to be higher than the other groups as previously discussed. Analysis of students’ short answer statements shows that some students found the activity to be challenging while other students thought it was easy. One blindfold participant writes “It helped. I was able to think more about what I was feeling. There was no distraction. I could focus better on one single item at a time.” Another student explains the benefits of this activity as “having to go off of feel and not being able to glance at my notes… I think it will help me on the midterm because I will be able to visualize the bone in my head.” And a response from a student who thought the activity was difficult explains “But glad I did it, now I know it better!” It seems that
students within this group enjoy the lab and feel they benefit from the activity; however, the assessments show poor long term knowledge retention.

**Drawing group (Group C).** The drawing activity was designed to enhance learning and provide a tool that students could use outside of class. Correlating shapes to bone structures seemed to be beneficial for many of these students within both the drawing and blindfold with drawing groups. One drawing participant writes that the activity was easy and “the shapes helped to locate the parts.” Another student explains that the activity “helped me put a picture in my head of the bones.” During the interview of the low scorer, Christina says, “just drawing simplified images and labeling it. So, [I] just remember placement and go back and remember exact detail of it. Just to get it down in my head.” Becca, a high scorer, stated during the interview that she “redid” the activity outside of class and used it as a study tool. She continued to explain she liked the activity saying:

> I guess just like to visually see like what shapes I should be looking for because like I had a lot of trouble determining, I already took this before *(laughs)* and I had to drop it *(Interviewer: ok)* so it like helped me, seeing the shapes of what I should be looking for, it helped me decide where it would be, like determining what is what.

With respect to long term knowledge retention gathered at the midterm and also twelve weeks after the activity there was no significant difference among the drawing group and any of the other groups as discussed in Chapter 4. The drawing group knowledge retention was significantly different than the control and blindfold group but not significantly different than the combination group the day of the activity which was the other group that used drawing. Therefore, the drawing aspect may be the key to short term knowledge gained in this study.

**Blindfold/Drawing group (Group D).** The benefit to this method is that it increases laboratory enjoyment and knowledge retention. This group used a combination of the blindfold
and drawing activities and had the most significant p-value when examining twelve week long term knowledge retention on the pre and post tests and also the greatest significance difference the day of the activity when compared to the control group.

Participant responses from the short answer questions varied among this group. Some users felt both methods were beneficial while other students commented that one technique was more beneficial than the other. One student says the method was “easy because of the comparison of the shapes to the parts of the bones.” But in another short answer section that asks what part of the activity helped them, this student writes “the blindfolding and feeling.” These contradicting answers appear multiple times among the twenty-four participants within this group. Another student says the most helpful aspect was “using shapes that corresponded with parts of the bone.” And again, explains the opposite activity when asked about the difficulty of the activity saying, “I found this activity easy and I learned the parts of the bone. The blindfolding part helped me fell the parts instead of looking.”

Enjoyment level was ranked high among this group. Interview data shows that the interaction between lab partners helped facilitate enjoyment as discussed in Chapter 4. Based on the long term knowledge retention and high enjoyment level, this activity seems to be the most beneficial for students in this study.

**Overall perception via interviews.** Participates within the blindfold and drawing groups often thought the technique was unique to hands-on learning. Some participants thought these techniques could possibly be incorporated into other science courses but struggled with identifying additional classes that could use the methods taught in lab. Additionally, three themes emerged from the interview transcriptions, these included high scorers from the control group believing that their instructional method was the most beneficial, a misconception about
learning modality, and a correlation between laboratory enjoyment level and the participants’ partner.

**I think I learn this way but I don’t.** The following theme emerged from reviewing the data from all four groups. Each participant completed two online learning style assessments through free websites to determine their primary learning modality as visual, auditory, or kinesthetic learner. During the interview participants readily identified the type of learner they thought they were and provided examples of how they study. Only three of the thirteen participants correctly knew their learning modality (Table 4.25). Three provided two assumed modalities but assessed as being only one modality. Five of the thirteen participants identified a learning modality that was only partially accurate when compared to their assessed modality. For example, Michealyn and Jenna both said they thought they were a combination of Visual and Kinesthetic; however, Michaelyn was assessed as Visual/Auditory and Jenna’s assessment placed her as only a Visual learner. Five other students identified themselves as having a different primary learning style than what was identified by the assessments, and several provided study strategies different from their learning style (Table 4.10). As an example, Loren identified herself as a kinesthetic and auditory learner who studies best verbally with a partner; however, the results of her learning style assessment shows she’s a visual learner. She scored very high on the posttest, but the lab activity “wasn’t her cup of tea” because she was not able to see. Loren expressed that she did not enjoy that part of the lab since she does not like to be blindfolded.

**It’s because of my lab partner.** Analysis of qualitative codes from interviews among all treatments yielded a theme regarding enjoyment level and the participants’ interaction with their lab partner. This theme is easily seen in the transcripts of Bianca and Julie. Bianca had a
positive laboratory experience; however, Julie explains how unenjoyable the direct instruction lesson was for her.

On the post-activity survey Bianca marked that she strongly agreed with enjoying the blindfold activity. She explained during the interview that it was due to the interaction with her lab partner.

*Bianca*: The blind fold was cool, it was funny. *(laughs)*

*Interviewer*: Why do you say that?

*Bianca*: I don’t know *(laughs)* because my partner, like I didn’t know her and she was, *(laughing continues)* I don’t know, it was just funny.

Closer to the end of the semester Bianca was asked by the researcher if her current lab partner was the one she had for the blindfold activity. She replied, “I have a different partner now. My regular partner actually was not there on the day of that experiment. I definitely think the blindfold put me out of my comfort zone especially because I did not know my partner.” Bianca utilized humor to hide her fear of being uncomfortable and this also came across during the interview. She often would laugh or giggle. She explained that the interaction with the lab partner enhanced her enjoyment of the activity and she also liked it because “Um, I mean it was better than just going, I don’t know, something different. A different way to learn them.”

Julie had a completely different experience during the direct teaching lesson. She felt the controlled comparison lab lesson was not enjoyable. Julie says she did not benefit from it because “I didn’t get to, like, hold the bone because my partner kept having the bone in her hands.” Julie’s partner rarely attended class and dropped the course before the midterm exam. Julie was aware that her partner was going to withdraw and had informed me a couple weeks before midterm that she ran into her in another building and was told she planned to drop. Julie said she told her that she understood. She then smiled at me before returning to her desk in the
back of the room and I noted that she seemed relieved or glad. Instead of working at a table alone the rest of the semester, Julie ended up becoming friends with a classmate and they moved to an empty table in the middle of the room the week after the midterm exam.

**That won’t help.** This theme is different from previous two themes because it resonated with just the control group. Since students did not score as high in the controlled comparison group, the researcher felt interviewing three of the highest scorers might yield a better understanding of their experience and insight as to why they scored well when only direct instruction was provided. All participants felt they benefited from the direct instruction. When asked if anything could have been done differently to enhance the lesson, the only participant that provided a tip was Michael. He seemed unsure of himself and said, “Maybe, like a video?” The two other participants could not provide an example for enhancing the direct instruction lesson.

Each interviewee was specifically asked if incorporation of drawing the bones and identifying the structures while drawing or via shapes would have help their understanding of anatomical locations and all three high scoring participants felt it would not be beneficial.

*Missy:* I think having the structures there were better than having drawings.

*Denzel:* You actually pointing out the bone, rotated it and all that, the 3-D effect to the actual structures, I think that’s better…

*Michael:* Not for me because I’m not a good drawer. I’m good at like, someone else that’s good at drawing drawing it and me looking at it then applying it that way, not me drawing, because if I draw it looks like stick people and it doesn’t sink in like that.

Michael brought up a valid point when he said the drawings would not “sink in.” Since Michael is an auditory learner the drawing activity may not have been beneficial; however, Denzel’s assessment identified him as a visual learner. During his interview he also said that he learns best through visuals and often studies by reading through and rewriting his notes.
**Benefits.** In addition to understanding which treatment yielded the greatest amount of knowledge retention at different time intervals, this study explored the students’ perception of the benefits of the activity they participated in through a short answer questionnaire given the day of the activity and also in more detail through interviews of 13 participants. Benefits were also examined by comparing participants Likert-type scale choices. It appears students benefited from the activities in different ways. Some students commented that their activity facilitated learning in an easier way and others thought their activity was difficult and not beneficial. This difference appears to be correlated to their learning modality and enjoyment level.

**Limitations**

There are limitations within this study; specifically with the sample population and sample size. The main limitation is the group of participants used in both the quantitative and qualitative phases and the affects this has to external validity. The students were not randomly assigned to the laboratory sections as they picked and scheduled their own courses. All participants were from the same university, most majoring in nursing or kinesiology, the majority being Caucasian, 75 percent of the participants were female and 97.8% were traditional students between the ages of 18 and 23. The small sample size (four treatments and 92 total participants) and the sampling method (purposive and convenience) decrease the generalizability or inference transferability of this study to other laboratory classrooms. Inference transferability was increased via other methods; such as, in depth descriptions of the interviews, lesson plans, detailed accounts of data collection methods, and photographs.

Purposive sampling involves deliberately selecting participants and the setting to gather important information to answer the research questions (Teddlie & Tashakkori, 2009). This type of sampling was used in this study because of its explanatory nature. Students enrolled within a laboratory section and the treatments were randomly assigned to each section, so the sample
itself is not a true random sample. The use of random assignment was not possible since each laboratory section is scheduled for one hour and fifty minutes; limiting the time allowed to teach activities. Moving students to another section was not feasible since students have other courses, work, or extracurricular meetings that would conflict; hence, using each section as a treatment was the best method for this study. Additionally, due to possible validity issues when using other instructors and their laboratory sections, a smaller sample was chosen where the researcher taught all laboratory sections and collected all data. The sample size could be larger if multiple class sections had been used but that also increases the likelihood of validity issues since one or more instructors would be required to teach the labs as each lab is capped at a maximum of 24 students.

Convenience sampling utilizes samples that are both easily accessible and willing to participate (Teddlie & Tashakkori, 2009). This type of sampling was used in the study because it assisted in capturing the authentic laboratory experience although it limited the external validity of the study.

Interviewing of only one low scoring student within each treatment is another limitation of this study. If this study were to be conducted again, one should interview several low scoring students regarding why the different methods do not enhance knowledge for them. Within the control group Julie felt she did not learn the material well the day of the activity because she did not interact well with her lab partner. But some of the low scoring participants in the treatment groups felt the activity was fine even though their knowledge retention only increased slightly. Interviews could also be conducted the day of the activity or while the students are performing the activity to examine their perceptions at the time of lesson; if individual interviews are not possible then a focus group or class discussion after the activity might yield different results.
Finally, the control group participants thought the lesson was helpful, but it would be interesting to see if any of the treatment group participants thought the use of a direct instruction only method would have been as beneficial. The techniques used can also be utilized in other courses and lessons to determine if they enhance knowledge retention and the classroom experience.

Teddlie and Tashakkori (2009) explain internal validity as the degree to which alternative conclusions and/or interpretations based on the data may be ruled out. Within this study, the pretest helped rule out alternative explanations by providing a baseline of long bone knowledge. Additionally, the online survey provided demographic information about each participant and could be used during statistical analysis to reduce confounding variables.

**Discussion**

Students within the lab are typically sophomore level, Caucasian females as discussed previously. Since the anatomy and physiology courses are 200 level classes it makes sense that the majority of students would be sophomores. Students within this lab are almost always majoring in nursing, kinesiology, biology, or communication and science disorders (CSD). Occasionally a student will enroll in the course as an elective but that is extremely rare among the laboratory sections since the lecture is required and students typically do not wish to take four hours of elective courses outside their major, especially since the lab is only worth one credit hour. During the last eight years that the researcher has taught human anatomy and physiology courses, she has had only three or four students enrolled in the lecture as an elective and can only recall one student enrolled the laboratory who was not one of the majors listed above.
The lab is required among students majoring in nursing, kinesiology, and communication and science disorders and since the nursing department is larger than the other departments, nursing majors are often the majority within each section. When compared to previous semesters and other laboratory sections taught by other instructors, the gender ratio varies; however, females almost always outnumber males. Although the gap between the numbers of females to males is beginning to equalize; nursing has been a female dominated field for decades which explains the large number of females in the study. Additionally, students’ reasoning for attending college as seen in Figure 4.3 appears to influence their choice of major.

The meta-inference stage of this study suggests those osteology activities among post-secondary students which incorporate historical and constructivist aspects resulting in active and meaningful learning increase students’ enjoyment and knowledge retention. Moreover, this study found students’ enjoyment was also influenced by their lab partner and some students’ perception of their preferred learning style is different than their assessed modality. The enjoyment level seemed to increase among the groups that utilized the blindfold because the activity facilitated partner interaction. Qualitative findings showed that all participants within the constructive learning treatments enjoyed the activity. The researcher expected such results from high scores; however, low scores also reported that they enjoyed the activity because it was beneficial and they learned. It was also determined that one’s learning style(s) influenced the enjoyment of an activity as explained through the blending of Loren’s qualitative and quantitative strands.

Using the activity outside of class as a study tool was another hope of this study. The quantitative results were not what were expected because the drawing activity seemed like the easiest tool to use outside of class and the blindfold technique which had the highest mean rank
would have required the bones to be available and students studying during laboratory class time. The qualitative data suggests that both techniques could be used as study tools; however, students did not prefer one method over the other. In addition, students had difficulty explaining how they could use the activity for other courses and often thought they could only be used within science classes.

The laboratory setting provides an excellent medium to harvest active and meaningful learning in a constructivist environment. As discussed in Chapter 2, when a student is responsible for their own learning and engaged in that process, that is classified as active learning. Meaningful learning occurs when a student links new knowledge with previous information. The activities for this study were created in hopes to increase both active and meaningful learning by utilizing historicality of cognition. The goal of this study was to promote an enjoyable atmosphere where learning could take place and hopefully be stored in long term memory areas of the brain.

As stated in the conclusion section of this chapter, this study fills a gap in the literature in which the incorporation of constructivist activities designed using historicality of cognition, active and meaningful learning have not been explored with regards to knowledge retention within an osteology laboratory setting. This research supports Wandersee, Mintzes and Novak’s (1994) notion that hands-on learning and constructivism was beneficial in correcting mental maps and Mota, Mata and Aversi-Ferreira’s (2010) research regarding constructivist pedagogic methodology as an ideal instruction format within Anatomy and Physiology courses. This study also agrees with Apps’ (1991) idea that the incorporation of drawing and 3-D models allows adults to understand a concept; however, the data presented here show that when drawing and...
direct instruction are the only methods utilized, understanding or knowledge gained is limited to a few weeks or while the student is required to know the information.

The drawing activity was beneficial with respect to knowledge gained the day of the activity and this could be because of the high number of visual learners within the study, which supports Barbe and Milone’s (1981) reporting that visual modality is more common among adults. The reason the drawing activity yielded less long term knowledge retention when compared to the group that participated in the drawing activity with the blindfold may be due to the technique incorporating different learning styles. As discussed in Chapter 2, utilizing multiple neuronal networks within the brain allows for information to be stored and retrieved differently; hence, different types of memory methods such as procedural and semantic (Sprenger, 1999) are used.

This study also demonstrates the benefits of an active learning environment and facilitation of meaningful learning. The results somewhat align with the findings and recommendations discussed in Chapter 2 of Michel, Cater, and Varela (2009), as well as, Bronwell and Eison (1991), Michael (2006), and Michael and Modell (2003). Students were responsible for their learning but interestingly, students within the control group that were presented direct instruction and provided a more passive environment did not significantly differ from their active learning cohorts at midterm. It appears that an active learning environment does yield a more engaged student who uses higher order thinking skills as Bonwell and Eison (1991) explain; however, that only manifested the day of the activity. It is especially interesting that the control group increased greatly from the day of the activity to the midterm exam. Although there was only a significant difference between the control group and the combination group that used blindfolds and drawing; there is interesting data when the means are examined
from the third posttest at twelve weeks. The control group was the only section that showed knowledge retention greater than the day of the lesson. This suggested that these students learned the material on their own and retained some of that information. That group also had the greatest decrease in knowledge retention between the midterm and final exam. Students may have utilized other techniques outside of class in order to understand the information for the midterm exam, showing their competitiveness and determination to pass the course regardless of instruction type and that knowledge appears to have some longevity. Meaningful learning that is generated through explanations to others (Michael, 2006) yields higher levels of learning via connecting new information with previous knowledge. This study showed the technique that used the blindfold and drawing activity which provided the most meaningful-type of environment, yielded the best long term knowledge retention. These results also support Michael and Modell’s (2003) explanation of meaningful learning benefits in which a learner is provided more opportunity to create bonds between new information and their past knowledge.

Finally, when comparing this study to works regarding the benefits of incorporating history and historical approaches to classroom activities, this study shows the utilization of historical ideas within the laboratory setting are beneficial to students. The incorporation of history within a science classroom has been documented for several decades as seen by Conant in the 1950s. Wandersee coined the phrase historicality of cognition because of how scientific knowledge was gained by past scholars. Wandersee (1985) claimed historicality of cognition would allow students to understand their own misconceptions and gain scientific knowledge. Many students answered pretest questions incorrect and among the groups that participated in these historically derived lessons, they corrected that misconception at a greater rate showing higher numbers of correct answers when compared to those within the control group. This study
also supports the 1992 assertions for incorporating historical lessons by Matthews which include engaging students and allowing students to comprehend a topic. Using the knowledge provided by our past mentors and merging that information with various teaching strategies to enhance our students’ experience and performance appears to the goal of many of the authors identified in this study… for it was also the goal of Andreas Vesalius, Father of Modern Anatomy.

Conclusions

The meta-inference of the pilot data suggests that a more beneficial teaching method for post-secondary human anatomy students would involve utilization of historical approaches that lend themselves to a constructivist learning environment where active and meaningful learning will take place. The full research data also supports this claim; however, with respect to long term knowledge, which was measured twelve weeks after the activity, this study shows the most beneficial learning environment incorporates activities that utilize multiple learning modalities in addition to historically based constructivist derived lessons that integrate meaningful and active learning.

This study fills a gap in literature by understanding how incorporation of historically based constructivist lessons that facilitate active and meaningful learning benefit students with respect to long bone anatomy knowledge. The posttest data collected after the activity suggest that all treatments that incorporated drawing (Groups C and D) yielded better understanding of the long bone structures; however, there was no significant difference between these groups at the second posttest collection date. This could be due to students studying for the midterm exam during which the data was collected. The last data collection date was at the final exam. Since the final exam is not cumulative, students assumed there would be no osteology questions on the test. The data from Posttest 3 shows the group that used the blindfold with the drawing (Group
D) as the only group with a significant p-value; hence, if one wanted to increase knowledge retention, this study recommends using multiple learning modalities, active and constructive learning through incorporating the use of drawing and creating mental maps through meaningful learning.

Enjoyment within the laboratory was highest during the combination activity that used blindfolds to create mental maps and incorporated drawing. Those students and the blindfold class had the highest means for enjoyment. The qualitative data gathered in this study helped explain why the enjoyment level was greater in the blindfold groups. Those activities required more interaction between partners and for some interviewed participants this increased enjoyment. Additionally, participants in those two treatments felt they learned more than the other groups, which could have also influence their perception of enjoyment. This demonstrates that active and meaningful learning occurred within the groups that used the blindfold to create mental maps. The data gathered from the posttest surveys and interviews also provides insight that students’ enjoyment is dependent on their laboratory partner. Since meaningful learning is facilitated through articulation and can lead to longer retention of information (Michael & Modell, 2003) it would seem logical that there is a correlation between ones’ lab partner, enjoyment level and knowledge retention.

The use of a mixed methods approach was crucial in understanding how these historically based constructivist osteology activities influenced knowledge retention within a laboratory classroom setting. The integration or meta-inference of qualitative data gathered from short answer questions, field notes, and interviews and quantitative data from pretest, posttest and posttest survey assessments yields an understanding of this study that suggests student benefit from various types of learning activities differently with respect to knowledge retention. The
enjoyment level they perceive during class may affect how they store or process new information. Their primary learning modality also affects their perception and enjoyment of an activity. Meta-inference of data suggests that enjoyment level is affected by partner interaction and there appears to be a correlation between enjoyment levels and if students felt they benefited or learned from the activity.

Quantitative data provided insight about the amount of knowledge gained among each group and the retention of said knowledge; however, qualitative data provided an understanding of how students perceived the lessons. Qualitative exploration can provide a multifaceted view of how an event or concept appears to a student and helps explain the quantitative data collected through pre/posttests and learning style assessments. Many of the students explained learning strategies that were different than their assessed modality, and this variation could play a factor among their laboratory enjoyment and knowledge retention. Utilizing lessons which target the primary learning modes would be beneficial within the classroom. Dunn and DeBello (1999) stated primary through college level students’ academic performance can increase significantly when educators focus lessons that respond to diverse students’ learning styles. Additionally, forming and correcting mental maps and models through constructivism and hands-on learning is extremely advantageous (Wandersee, Mintzes, & Novak, 1994).

Finally, this study demonstrates the benefits of a mixed methods design within an educational setting and provides a methodology that could be utilized by other educators and researchers. The use of multiple assessments and blending of data provided an understanding that could not have been gained through purely quantitative or qualitative research alone. The use of mixed methods designs should be a tool utilized more often within educational research since it helps explain the “how” and “why” of topics that ponder us.
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APPENDIX C
ONLINE SURVEY

Introduction

A study is being conducted to understand how students retain information regarding long bone anatomy and their utilization of different learning strategies. Hence, we are conducting a survey to determine the type of learning strategies used by students within Human Anatomy and Physiology laboratory courses.

In order to progress through this survey, please use the following navigation buttons:

• Click the Next button to continue to the next page.
• Click the Previous button to return to the previous page.
• Click the Done/Submit button to submit your survey.

The survey should take about 5-10 minutes to complete and can be accessed at ____________

Thank you for participating in this survey. Your participation is voluntary. Completion of this survey will serve as voluntary consent to participate in this study. Participants’ identities will remain confidential and you may opt out of completing the survey at any time. If you are unsure or feel uncomfortable answering a question, you may elect to not respond to those questions. This study is approved by Louisiana State University Institutional Review Board #____ as well as Southeastern Louisiana University Institutional Review Board #____. If you have questions regarding subjects’ rights or other concerns, you may contact either Dr. Mathews at irb@lsu.edu or Dr. Michelle Hall at mhall@selu.edu

Thank you again for your participation.

Jennifer F. Tynes, M.S.
Instructor of Biological Sciences Southeastern Louisiana University
Louisiana State University Doctoral Candidate
Jennifer.Tynes@selu.edu
JTynes2@lsu.edu
1. What is the main reason you decided to attend college?
- To earn more money or have a better job
- Was not ready to enter workforce
- Parents
- Want to gain additional knowledge
- Other (please specify)

2. Which of the following best represents your mother's (or the female who raised you) education? (Please mark all that apply.)
- She never attended college
- She attended but did not complete college
- She has a Bachelors degree (i.e. BS, BA)
- She has Masters degree (i.e. MSci, MBA)
- She has Masters degree and +30
- She has Doctorate degree (i.e. MD, EdD, PhD, DDS)
- I am not sure

3. Which statement best identifies your father's (or the male most involved in raising you) educational status? (Please mark all that apply.)
- He never attended college
- He attended but did not complete college
- He has a Bachelors degree (i.e. BS, BA)
- He has Masters degree (i.e. MSci, MBA)
- He has Masters degree and +30
- He has Doctorate degree (i.e. MD, EdD, PhD, DDS)
- I am not sure
4. Rank the following choices from 1 to 6 based on how important they are to you this semester. 1 is most important (must have) and 6 is least important (could do without).

<table>
<thead>
<tr>
<th>#</th>
<th>Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Earning money</td>
</tr>
<tr>
<td>2</td>
<td>Spending time with family</td>
</tr>
<tr>
<td>3</td>
<td>Attending or watching sports</td>
</tr>
<tr>
<td>4</td>
<td>Making good grades</td>
</tr>
<tr>
<td>5</td>
<td>Enjoying your hobby</td>
</tr>
<tr>
<td>6</td>
<td>Spending time with friends/socializing</td>
</tr>
</tbody>
</table>
### A&P Study Habits

5. Have you taken any Human Anatomy and/or Physiology Courses (including Labs) at the college level in the past?

<table>
<thead>
<tr>
<th>Course</th>
<th>First time</th>
<th>Second time</th>
<th>Third time</th>
<th>More than 3 attempts</th>
<th>I have not taken this class</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZOO 250 (Lecture I)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZOO 252 (Lab I)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZOO 251 (Lecture II)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZOO 253 (Lab II)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other A&amp;P Course</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Are you currently taking the lecture course (ZOO 250) associated with this lab? (Check all that apply)

- [ ] YES- online
- [ ] YES- face-to-face lecture
- [ ] NO- I have taken it in the past ONLINE
- [ ] NO- I have taken it in the past Face-to-Face
- [ ] NO- I do not need it
- [ ] NO- I will take it in the future

7. How much time per week do you typically spend studying/reviewing for your A&P lecture (ZOO 250)?

- [ ] Less than 1 hour
- [ ] More than 1 hour but less than 2 hours
- [ ] More than 2 hours but less than 3 hours
- [ ] More than 3 hours but less than 4 hours
- [ ] More than 4 hours but less than 6 hours
- [ ] More than 6 hours but less than 8 hours
- [ ] More than 8 hours but less than 10 hours
- [ ] Not taking lecture
- [ ] Other (please specify)
8. How much time do you spend reviewing/studying for only the laboratory (ZOOL 252)?

- Less than 1 hour
- More than 1 hour but less than 2 hours
- More than 2 hours but less than 3 hours
- More than 3 hours but less than 4 hours
- More than 4 hours but less than 6 hours
- More than 6 hours but less than 8 hours
- More than 8 hours but less than 10 hours
- Not taking lecture
- Other (please specify)

9. Of the following, which one(s) do you use for studying A&P outside of lab. (Please mark all that apply.)

- Draw images
- Flashcards
- Review photos
- Rewrite notes
- Creating physical images from mental images (i.e. draw, write, or create objects from memory)
- Memorizing structures from the manual
- Study with a partner
- Study in a small group
- Use app on cellphone
- Use online resources
- Creating mnemonic devices (songs, poems, rhymes to remember information)
- Other (please specify)
10. What is your current cumulative GPA?
- □ Less than 2.0
- □ 2.0-2.49
- □ 2.5-2.99
- □ 3.0-3.49
- □ 3.5-4.0
- □ No current GPA (first semester freshman)

11. Select all that apply: What type of high school did you attend for grades 9-12?
If you attended a variety of school types (for example, freshman year was public but grades 10-12 were at a private school) please explain what grades were public, private, home-school, etc within the box below.
- □ All 4 years were at a Private School
- □ Mostly Private (but not all 4 years)
- □ 1 or 2 years Private
- □ All 4 years were at a Public School
- □ Mostly Public (but not all 4 years)
- □ 1 or 2 years Public
- □ All 4 years were at Home-school
- □ Mostly Home-school (but not all 4 years)
- □ 1 or 2 years Home-school
- □ Did not attend
- □ Other (please specify)

12. From which type of high school did you graduate?
- □ Private
- □ Public
- □ Home-school
- □ GED
- □ Other (please specify)
13. Were all four years of high school (grades 9-12) attended within Louisiana?

- [ ] YES
- [ ] NO
- [ ] Did not attend high school
14. Which grades were completed outside of Louisiana? (Select all that apply)

- 9
- 10
- 11
- 12

15. Please type the location (state or country) outside of Louisiana where you attended high school.
16. What was your high school GPA at the time of graduation?
- less than 2.0
- 2.0-2.49
- 2.5-2.99
- 3.0-3.49
- 3.5-4.0
- I don't know

17. Did you participate in any of the following while in high school? (Please select all that apply.)
- Advance Placement Courses (AP Examination taken)
- Advance Placement (AP Examination was not taken)
- Dual Enrollment or IB Program (College credit course)
- Honors classes (No AP test given but is an advanced class)
- None of the above
18. In high school which AP courses did you take? (Please select all that apply.)

- [ ] Biology
- [ ] Chemistry
- [ ] English
- [ ] Math
- [ ] Physics
- [ ] Environmental Science
- [ ] I did not take AP courses
- [ ] Other (please specify)

19. While in high school which AP courses did you earn college credit? (Please select all that apply.)

- [ ] Biology
- [ ] Chemistry
- [ ] English
- [ ] Math
- [ ] Physics
- [ ] Environmental Science
- [ ] I did not take AP courses
- [ ] Other (please specify)
20. While in high school which AP course(s) did you take (but did not take the exam for)?
(Please select all that apply.)

- Biology
- Chemistry
- English
- Math
- Physics
- Environmental Science
- I did not take AP courses

Other (please specify):
21. What honor classes did you complete within grades 9th-12th? (Please select all that apply.)

- Biology
- Chemistry
- English
- Math
- Physics
- Environmental Science
- I did not take honor classes
- Other (please specify)
22. Which Dual Enrollment or IB courses did you take in high school? (Please select all that apply.)
Note: these are courses offered by a university/college for college credit and taught within a high school classroom
- Biology
- Chemistry
- English
- Math
- Physics
- Environmental Science
- I did not take Dual Enrollment or IB courses
- Other (please specify)

23. Which classes did you earn college credit?
- Biology
- Chemistry
- English
- Math
- I did not take Dual Enrollment or IB courses
- Other (please specify)
24. Your major is within which department?
- Biology
- Nursing
- Kinesiology
- Other (please specify)

25. Do you have a major concentration?
- Yes (provide below)
- No
Concentration Is:

26. What is your plan immediately after completing this degree? What will you do the year after you complete college?
- Enter Graduate School
- Enter Professional School
- Enter the Workforce
- Stay at Home Parent
- Other (please specify)

27. Did either of your parents/caregivers major or pursue a career in the same field you chose?
- Yes- my mother
- Yes- my father
- Yes- both parents
- Yes- another caregiver (grandparent, aunt/uncle, or sibling)
- No
Demographic Information

28. Age as of your last birthday?

29. Are you male or female?
- Male
- Female
- I do not wish to respond

30. Which race/ethnicity best describes you? (Please choose only one.)
- American Indian or Alaskan Native
- Asian / Pacific Islander
- Black or African American
- Hispanic American
- White / Caucasian
- Do not wish to respond
- Other (please specify)

31. Current classification
- Freshman
- Sophomore
- Junior
- Senior
- Non-Matriculating Student
- Graduate Student

32. Do you have any children or dependents (under the age of 18)?
- Yes
- No

33. Please provide the participant code that was given to you.
APPENDIX D
SOUTHEASTERN LOUISIANA UNIVERSITY INSTITUTIONAL REVIEW BOARD
APPROVAL WITH HUMAN SUBJECTS VERIFICATION

Institutional Review Board
Box 11851
Phone: 549-2077

Campus Correspondence
www.selu.edu/irb
Fax: 549-3640

DATE: November 15, 2012

TO: Jennifer Tynes
Biology

FROM: Dr. Michelle Hall, Chair

RE: IRB Action on Proposed Project

This memo is to inform you of the IRB action with regard to your proposal:

Title: How Students Increase Knowledge of Long Bone Anatomy through Constructivism and the Works of Vesalius: An Explanatory Study

This proposal was given: Expedited Review: 

Full Committee Review: X

Exempt: 

The result was: Full Approval: X

Denied Approval: 

If anything other than Full Approval is recommended, it is your responsibility, as investigator, to submit changes/corrections or plans to accommodate conditions listed below to the Institutional Review Board prior to initiating the project. This approval is valid for one year from the date above, if data is to be collected after that time frame, the PI must submit a Continuation of Research Form.

Failure to acquire full approval by IRB before implementation for any project which involves humans means that the PI is not acting in "good faith" with university policy and is not, therefore, guaranteed the protection of the university.

Committee Comments:

IRB Number: 2013-073
Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that Jennifer Tynes successfully completed the NIH Web-based training course “Protecting Human Research Participants”.

Date of completion: 10/19/2012

Certification Number: 1032898
APPENDIX E

LOUISIANA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD APPROVAL

Application for Exemption from Institutional Oversight

Unless qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/ projects using living humans as subjects, or samples, or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the IRB determine if a project may be exempted, and is used to request an exemption.

-- Applicant, please fill out the application in its entirety and include the completed application as well as parts A-F, listed below, when submitting to the IRB. Once the application is completed, please submit two copies of the completed application to the IRB Office or to a member of the Human Subjects Screening Committee. Members of this committee can be found at [http://research.lsu.edu/Compliance/Policies/Procedures/InstitutionalReviewBoard%28IRB%29/item24737.html](http://research.lsu.edu/Compliance/Policies/Procedures/InstitutionalReviewBoard%28IRB%29/item24737.html).

-- A Complete Application Includes All of the Following:
(A) Two copies of this completed form and two copies of parts B thru F.
(B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1&2)
(C) Copies of all instruments to be used.

*If this proposal is part of a grant proposal, include a copy of the proposal and all recruitment material.
(D) The consent form that you will use in the study (see part 3 for more information)
(E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing or handling data, unless already on file with the IRB. Training link: [http://nihtraining.com/users/login.php](http://nihtraining.com/users/login.php)
(F) IRB Security of Data Agreement: [http://research.lsu.edu/files/item26774.pdf](http://research.lsu.edu/files/item26774.pdf)

1) Principal Investigator: Jennifer F. Tyner
   Dept: Education: Curriculum/instruct
   Ph: 225/505-9401 (cell)
   E-mail: Jennifer.Tyner@lsu.edu
   Rank: Doctoral Candidate

2) Co-Investigator(s): please include department, rank, phone and e-mail for each
   *If student, please identify and name supervisor or professor in this space
   Pamela Blanchard, LSU School of Education, 225/578-3297

3) Project Title: New Students Increase Knowledge of Long Bone Anatomy through Constructivism and the Works of Vesalius: An Explanatory Study

4) Proposal? (yes or no)  No
   If Yes, LSU Proposal Number
   Also, if YES, either
   O This application completely matches the scope of work in the grant
   OR
   O More IRB Applications will be filed later

5) Subject pool (e.g. Psychology students) Human Anatomy & Physiology Students, over age 18

*Circle any "vulnerable populations" to be used: (children <18; the mentally impaired, pregnant women, the ages, other). Projects with incarcerated persons cannot be exempted.

6) PI Signature
   Date 10 Nov 2012 (no need for signatures)

** I certify my responses are accurate and complete. If the project scope or design is later changes, I will resubmit for review. I will obtain written approval from the Authorized Representatives of all non-LSU Institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at LSU for three years after completion of the study. If I leave LSU before that time the consent forms should be preserved in the Departmental Office.

Screening Committee Action: Exempted √ Not Exempted ______ Category/Paragraph ______
Signed Consent Waived? Yes / No
Reviewer: Dr. Robert Mathews
Signature: Date: 11/26/12
Consent Form for Study Involving Only Minimal Risk

How Students Increase Knowledge of Long Bone Anatomy through Constructivism and the Works of Vesalius: An Explanatory Study

Introduction
I, _______________________, have been asked to participate in this study. Jennifer F. Tynes, who is conducting this research to fulfill the requirements for a doctoral dissertation in the Department of Education at Louisiana State University, has explained the study to me.

Purpose of the Study
The purpose of this research project is to understand how different teaching methods can enhance student understanding of long bone anatomy.

Description of Procedures
This study will be performed at Southeastern Louisiana University. I will be asked to complete a set of questionnaires and tests which take 5-10 minutes each (40-60 minutes total), participate in a 90-110 minute in-classroom activity during my regular lab time and I may be asked to participate in a 30-60 minute interview. The total amount of time for this study will be three or four hours. Approximately 150 participants will be in this study.

Risks and Discomforts
There are no known or expected risks from participating in this study.

Benefits
Enhanced teaching practices within the course; as well as, possibly enhancing student study/learning styles and knowledge. I understand that this study may not benefit me but the knowledge gained may be of benefit to others.
Contact Persons
For more information about this research, I can contact Jennifer F. Tynes at 985/549-3507 or her supervisor, Dr. Pamela Blanchard, LSU School of Education, 225/578-2297.

For information regarding my rights as a research participant, I may contact the Chair of the Institutional Review Board at 985/549-2077.

Confidentiality
I understand that any information obtained as a result of my participation in this research will be kept as confidential as legally possible. Neither my name nor any information from which I might be identified will be published without my consent. I understand that these research records, just like hospital records, may be subpoenaed by court order or may be inspected by federal authorities.

Voluntary Participation
Participation in this study is voluntary. I understand that I may withdraw from this study at any time. Refusal to participate or withdrawal will involve no penalty or loss of benefits for me. I have been given the opportunity to ask questions about the research, and I have received answers concerning areas I did not understand. Upon signing this form, I will receive a copy.

I willingly consent to my participation in this study. By signing below I verify I am 18 years of age or older.

_________________________  ___________  _____________________________  ______
Signature of Participant    Date            Signature of Investigator   Date
Photo, Works, & Audio Release Form

Permission to Use Photograph, Classroom Works, & Audio Clips

Event: Jennifer F. Tynes’ Dissertation Research

Location: A&P Laboratory & Biology Building

I grant to Jennifer Tynes, the right to take and use photographs, audio recordings, and classroom works at the above-identified event. I authorize her use of said images and digital items.

I agree that Jennifer Tynes may use such items above without the use of my name.

I have read and understand the above:

Signature _________________________________

Printed name ______________________________

Date _____________________________________

Code _________________________________
APPENDIX G
PILOT PRE AND POSTTESTS

How Students Increase Knowledge of Long Bone Anatomy through Constructivism and the Works of Vesalius: An Explanatory Study

PILOT: PRETEST

Answer the following questions as your teacher presents each to you.

1. This bone is the __(humerus)______________________________________________

2. The structure identified (A) is called ____ (greater trochanter)______________

3. This bone is the ____ (tibia)_______________________________________________

4. This structure (X) is the ____ (patellar tuberosity)__________________________

5. This structure (Y) is the ____ (inferior articulating surface)__________________

6. This bone is the __ (radius)_______________________________________________

7. The structure identified (B) is called ____ (styloid process)________________

8. This bone is the ____ (fibula)____________________________________________

9. This bone is the _____ (femur)___________________________________________

10. What muscle attach to structure (W) _______ (deltoid)_______________________
How Students Increase Knowledge of Long Bone Anatomy through Constructivism and the Works of Vesalius: An Explanatory Study

PILOT: POSTTEST

Answer the following questions as your teacher presents each to you.

1. This bone is the ____(humerus)____________________

2. The structure identified (A) is called ____ (greater trochanter)________________

3. This bone is the ____ (tibia)___________________________________________

4. This structure (X) is the ____ (patellar tuberosity)_______________________

5. This structure (Y) is the ____ (inferior articulating surface)_____________________

6. This bone is the ____(radius)___________________________________________

7. The structure identified (B) is called ____ (styloid process)_____________________

8. This bone is the ____ (fibula)___________________________________________

9. This bone is the ____ (femur)___________________________________________

10. What muscle attach to structure (W) ______ (deltoid)_____________________

11. What part of this activity do you think best helped you gain knowledge of these bones?

12. Did find this activity difficult or easy? Briefly explain.

13. Rank the following by circling your choice.

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>No opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I enjoyed the lab activity today.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>b. I feel I learned more because of the way the bones were taught.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>c. I will need to study this material in detail to understand it.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>d. I would use this method as a study tool.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
APPENDIX H
PRE AND POST TESTS

How Students Increase Knowledge of Long Bone Anatomy through Constructivism and the Works of Vesalius: An Explanatory Study

FULL RESEARCH STUDY: PRETEST

Answer the following questions as your teacher presents each to you.

1. This bone is the __________ (humerus)__________________________________________

2. What muscle attach to structure (W) _______(deltoid)__________________________

3. This bone is the ___(tibia)_________________________________________________________________

4. This structure (X) is the _____(patellar tuberosity)__________________________________________

5. This structure (Y) is the ___(styloid process of radius)_____________________________________

6. This bone is the __________ (radius)____________________________________________________

7. The structure identified (B) is called _____(lateral malleolus)__________________________

8. This bone is the ______(fibula)_________________________________________________________________

9. This bone is the _______(femur)_________________________________________________________________

10. The structure identified (A) is called _____(greater trochanter)___________________________

11. This structure (K) is the ______(radial notch)___________________________________________

12. This bone is the ______________(ulna)_________________________________________________________________
FULL RESEARCH STUDY POSTTEST:
Answer the following questions as your teacher presents each to you.

1. This bone is the __________(humerus)______________________________
2. What muscle attach to structure (W) ________(deltoid)__________________
3. This bone is the __________(tibia)____________________________________
4. This structure (X) is the ____ (patellar tuberosity)_____________________
5. This structure (Y) is the ______ (styloid process of radius)_______________
6. This bone is the ___(radius)_________________________________________
7. The structure identified (B) is called ____ (lateral malleolus)_____________
8. This bone is the ___(fibula)__________________________________________
9. This bone is the ______(femur)_______________________________________
10. The structure identified (A) is called ____ (greater trochanter)___________
11. This structure (K) is the ______ (radial notch)________________________
12. This bone is the ____________(ulna)______________________________

11. What part of this activity do you think best helped you gain knowledge of these bones?

12. Did find this activity difficult or easy? Briefly explain.

. Rank the following by circling your choice.

<table>
<thead>
<tr>
<th>No opinion</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I enjoyed the lab activity today.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>b. I feel I learned more because of the way the bones were taught.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>c. I will need to study this material in detail to understand it.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>d. I would use this method as a study tool.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
APPENDIX I
INTERVIEW QUESTIONS

Full Research Study: QUAL Phase (Will be Revised After Pilot and Quantitative Phase of Full Research Study)

1. How do you typically study/learn?

2. Would you say you learn best having visuals, listening, or kinesthetically (doing/movement)?

3. Can you give an example of how you usually learn/study?

4. How do you think this technique of creating mental images through the blindfolding activity and/or the drawing lesson help/didn’t help you? Please explain and give an example.

5. Did you enjoy this activity? Why?

6. What could have been different about this activity?

7. Can you provide an example of how this method could be used while studying A&P?

8. Could you use it in other courses and how? Give me an example

9. What are your current study habits? (How much time, when do you study, where do you usually study?)

10. Is there anything you would like to add to this interview?
APPENDIX J
LESSON PLANS

Lesson Plans: Incorporating works of Vesalius into Osteology

Student Learning Goal: To identify the long bones and their anatomical structures with increased retention after a 3 month period.

Objectives:

The Learner will:

1. Draw/sketch long bones and anatomical structures.
2. Create mental images of long bones and anatomical structures.
3. Draw and create mental images of long bone anatomy.

Lesson 1:

Medical drawing can be extremely helpful in aiding students with understanding of anatomical structures. Vesalius (The Father of Modern Anatomy) and Leonardo Da Vinci created superb anatomically accurate drawings during the Renaissance. This lesson will assist students in sketching the structures they see (instead of using rote memory which is the typical technique used within this lab). For this activity, students were asked to examine the bone for 60 seconds with their lab partner. Next, as a group of two, they were asked to draw the bone by identifying and using shapes to represent the anatomical structures. They examined a radius, ulna, humerus, femur, tibia, and fibula. The bones and drawings were then compared to each other and similar and different shapes that were used were discussed in an open discussion. The investigator drew the shapes they saw on the board (Figure K1.1) and then labeled each (Figure K1.2). A sample drawing of the femur was provided to the IRB committees and also displayed in the lesson plans (Figure K1.3).
Figure K1.1: Dry Erase board in lab shows basic shapes identified by students for the human long bones during the pilot study.
Figure K1.2: Students within the full research study identified structures by correlating shapes and the bones with said structure were drawn on the board and labeled.
Figure K1.3: Image from instructor’s lesson plans showing labeled drawing of left femur.
Lesson 2: Mental Images of Long Bone Anatomy

Students will review each bone and structure (condyle, meniscus, tubercle, tuberosity, trochanter, etc) individually. With a blindfold and partner’s help, take one bone at a time and using only your sense of touch create a mental map of the bone. Your partner will now help you identify structures on that bone. Feel for any unique characteristics. Remove the blindfold and again examine each bone. Finally, place the blindfold over your eyes and identify each bone and at least one anatomical structure by touch (Figure K2.1, K2.2, and K2.3).

Figure K2.1: Students of the full research study comparing structures of a humerus and femur while blindfolded.
Figure K2.2: Partners in the blindfold group work together to examine the femur. The blindfolded student uses her sense of touch to understand how the femoral epicondyles and condyles differ from the other structures of this bone. This aids the student in creating a mental map of the bone that she then can examine visually when the blindfold is removed.
Figure K2.3: Two female students within the blindfold/drawing group work together to examine the femur. Students examined the bones visually and identified shapes for each structure. They then blindfolded their partner and identified each structure and shape through touch.

Lesson 3: Drawing and Creating Mental Images of Long Bone Anatomy

Have students sketch the bones and identify structures as presented in Lesson 1. Afterwards, they will work in groups of two and repeat Lesson 2.
VITA

Jennifer F. Tynes graduated high school with honors at the age of 16, during her junior year. She later earned a degree in Biological Sciences with a minor in Chemistry at the age of 20 from Southeastern Louisiana University. At the age of 23 she earned a Master’s degree in Biology and six months later was blessed with the birth of her first child, a daughter- Chloe. Over the next five years, she and her spouse, David, welcomed two sons David Jr. and William “Liam” and also became foster parents. In August 2011 she became a doctoral student under Dr. Jim Wandersee at Louisiana State University. She earned an Education Specialist certification in 2013 and a Ph.D. in Curriculum and Instruction and a minor in Human Resource Education in March 2014. She has taught post-secondary biology and human anatomy and physiology since 2003, serves as the assistant director of Region VIII Science Fair, is on the review board for Quality Matters, is an event coordinator for the State Science Olympiad, and provides guest lectures within the university and at local public schools. Through these efforts, Jennifer hopes to provide positive changes for the community. She plans to continue to teach at the college level within a science or science education department.